Queen Charlotte Goshawk Status Review

U. S. Fish and Wildlife Service
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EXECUTIVE SUMMARY

The Queen Charlotte goshawk (*Accipiter gentilis laingi*) is a subspecies of forest-dwelling hawk that lives in the temperate rainforest archipelagos of Southeast Alaska and coastal British Columbia. The subspecies is smaller and darker than the continental form, which is known as the northern goshawk (*A. g. atricapillus*). Clines of larger and lighter birds are documented north (through Southeast Alaska) and south (on Vancouver Island) of the Queen Charlotte Islands ("Haida Gwaii"). Birds from the islands of British Columbia are reportedly smaller than those from the immediate mainland, but island and mainland birds in Southeast Alaska are morphologically similar. We therefore define the Queen Charlotte goshawk's range as the mainland and islands of Southeast Alaska south of the international border between Mount Fairweather and Mount Foster, and Vancouver Island and the Queen Charlotte Islands in British Columbia, but not the British Columbia mainland. Goshawks on the British Columbia mainland coast, Washington State's Olympic Peninsula, and Cascade Range are considered by some to be Queen Charlotte goshawks, but taxonomists have not included these areas within the range of the subspecies.

Nests are typically located in high-volume forest stands with relatively dense canopies. Nesting pairs are territorial, with nests spaced somewhat uniformly across available habitat. Nest activity (percentage of territories with nesting pairs) varies annually with prey availability and weather. Territory occupancy is lower in fragmented than contiguous forest. Individual nests are frequently not used in subsequent years as pairs often move to an alternate nest. Most alternate nests are clustered within an area of a few hundred hectares (ha). Males have been documented moving up to 3.2 kilometers (km) between subsequent nests, but apparently remain in their established home ranges in subsequent years. Females have been documented leaving the territory altogether and nesting in subsequent years with a new mate in a different territory up to 152 km away.

Habitat use varies widely among individual goshawks in Southeast Alaska, but most use medium and high-volume forests for foraging and other daily activities disproportionately, and avoid non-forested and clearcut areas. Mature second growth and low-productivity forests are used in proportion to their availability, indicating neither preference nor avoidance of these habitats. Breeding season use areas average about 4,500 ha for females and 6,000 ha for males. During winter, Queen Charlotte goshawks typically shift their activity centers away from the nest and range farther, but remain in the region. Females have larger use areas than males during winter, averaging about 34,000 ha for females and 19,000 ha for males.

Goshawks primarily hunt by flying between perches and launching attacks from those perches. They take a variety of prey, depending largely on local availability, which varies markedly among islands in the Queen Charlotte goshawk's range. Red squirrels (*Tamiasciurus hudsonicus*) and sooty grouse (*Dendragopus fuliginosis*) (formerly blue grouse, *D. obscurus*) form the bulk of the diet in many locations, with thrushes, jays, crows, ptarmigan, and woodpeckers frequently taken as well. During winter, many avian prey species migrate from the region, reducing the variety and abundance of prey available. Rabbits and hares are frequently taken by goshawks during winter elsewhere, but are lacking from much of the range of the Queen Charlotte goshawk (exceptions include portions of the mainland, Vancouver Island, and Douglas Island). Also lacking are prey species adapted to open and edge habitats, so clearcut timber harvesting typically results in declines of customary prey.

Forest regeneration following timber harvest usually results in dense second growth stands that may support populations of some prey species, but goshawks avoid these habitats, presumably because they are too dense for the hawks to effectively hunt. As second growth stands approach economic maturity (typically 80 to 110 years on productive forest land within the range of the Queen Charlotte goshawk), the forest structure develops adequately to allow goshawks to forage below the canopy. Prey availability, which appears to limit goshawk productivity in many cases, is determined by both prey abundance and forest structure.

Goshawk populations are difficult to census. Instead, the number of potential nesting territories (habitat capability) has been estimated by extrapolating observed nest area spacing or seasonal use area sizes across available habitat. Such extrapolations by various authors have yielded estimates of 10 to 50 potential nesting territories on the Queen Charlotte Islands, 103 to 300 on Vancouver Island, and 100 to 800 in Southeast Alaska. Differences among estimates for each region are largely due to variation in definitions of suitable habitat.

Not all potential territories are occupied (adults present) or active (eggs laid) in any given year, and some are apparently unoccupied or inactive most years. Some workers therefore use observed territory occupancy rates from a sample of known territories to estimate the number of territorial pairs, or the nest activity rate to estimate recent breeding populations, across portions of the subspecies range. Such calculations suggest there may be about 60 to 165 pairs on Vancouver Island and 4 to 18 pairs on the Queen Charlotte Islands. Southeast Alaska probably supports a few to several hundred pairs. The range-wide population, therefore, is probably about 300 to 700 pairs, with most of those breeding in years with abundant prey and favorable weather and few breeding during years of prey scarcity and inclement spring weather. There is also an unknown number of non-breeding, unpaired goshawks in the population.

Several indicators suggest that Queen Charlotte goshawks are found at lower densities than goshawks studied elsewhere. Population trends are unknown but believed to be downward. Models suggest that habitat capability has declined by about 10 to 30 percent in Southeast Alaska and by 50 percent in Canada.

Goshawks appear to initiate nesting only when prey is adequately available and spring weather is conducive. Given these conditions, nest success (percentage of nests producing at least one fledgling) is typically high, as is productivity (fledglings per nest). Although more difficult to measure, rates of nest occupancy (percentage of nesting stands with adults present during the breeding season) and nesting activity (percentage of nests with adults, eggs, or young) appear to be more sensitive to environmental conditions than nest success or productivity rates. Occupancy rates are lower in southern Southeast Alaska, for example, where prey species are more limited, than in northern Southeast Alaska, and appear to vary with fluctuations in squirrel populations (which vary with cone crops). Nest occupancy rates are also higher in contiguous forests than in fragmented forests on Vancouver Island.

Annual survival rates for adult goshawks in Southeast Alaska are low for males (0.59) and for females that wintered in the same area where they nested (0.57), but high for females that left their breeding areas during the winter (0.96).

Fledglings on Vancouver Island spent about six weeks within an area of 230 ha or less (average 59 ha) in and near their nest stands, learning flight and hunting skills before dispersing. In Southeast Alaska, juveniles moved up to 160 km (some possibly further as their radio-telemetry signals were lost) to areas where they either spent the winter or died. Average distance moved was 63 km. Juvenile dispersal is believed to be important for maintaining regional metapopulations of goshawks elsewhere in North America, and probably functions similarly within the range of *laingi*.

Life-table calculations and population viability analyses indicate that juvenile survival must approach 50 percent, given other vital rates observed and inferred from Southeast Alaska, if goshawk populations are to remain stable in the region. Population viability analyses for goshawks on the Queen Charlotte Islands estimate population survival probability to be between zero and 31 percent, due primarily to small numbers of suitable nesting territories following logging. In Alaska, a 1995 panel of goshawk experts predicted that the current management regime on the Tongass National Forest would probably cause temporary gaps in the species' distribution, with some risk of permanent gaps and a slight risk that populations would ultimately be confined to refugia, but long-term viability was expected.

Genetic relationships among various segments of the goshawk population across Southeast Alaska and coastal British Columbia are unclear at this time. Additional work is underway to evaluate levels of genetic interchange within the range of the Queen Charlotte goshawk and with adjacent areas. We are unaware of any evidence suggesting that genetic deterioration (through loss of genetic diversity, inbreeding depression, founder effects, etc.) threatens the subspecies, although hybridization with the mainland form (*A. g. atricapillus*) may occur on Vancouver Island and in Southeast Alaska.

Timber harvest may limit availability of nest sites in localized cases, especially if adequate mature or old forest is not conserved around nest sites for fledgling development. Effects on prey availability are more likely throughout the range of the Queen Charlotte goshawk. Fragmentation and habitat conversion are more extensive in coastal British Columbia than in Southeast Alaska. In Southeast Alaska, approximately 28 percent (732,000 ha) of the 2.6 million ha of productive forest within the range of the goshawk is expected to be harvested, with about 22 percent of that harvest (160,000 ha) on Native corporation lands. On the coastal islands of British Columbia, 58 percent (2 million ha) of the 3.4 million ha of productive forest is expected to be harvested.

Designated parks, reserves, and other non-development designations will protect about 1.4 million ha (55 percent) of the productive forest in Southeast Alaska and about 313,000 ha (9 percent) in British Columbia. Some productive forest outside designated reserves will be retained on either inoperable ground (too steep, wet, etc.) or in retention areas (e.g., stream buffers) within the harvestable matrix of timber production lands.

Modeling predicts that habitat capability on the Queen Charlotte Islands will continue to decline until about 2050, due to timber harvest, then stabilize at about 20 to 40 percent of historical levels. Modeling of habitat value using discount factors to reflect lower value for low-productivity forests, second growth, fragmented, and vulnerable stands suggest that habitat value has declined 23 percent range-wide and will decline by an additional 14 percent as remaining old growth is harvested. Southeast Alaska is estimated to have originally held 52 percent of the available habitat but now has 61 percent because of more intensive harvest in British Columbia, which originally had 48 percent but now only 39 percent of the range-wide goshawk habitat. After all lands currently available for harvest have been converted to second growth (in about 100 years), we expect Southeast Alaska to have 66 percent of the range-wide habitat, Vancouver to have 23 percent, and the Queen Charlottes to have 11 percent. At that time, British Columbia's habitat value will be reduced by 55 percent from its historical level and Alaska's will be reduced by 20 percent.

Regulatory mechanisms differ between Alaska and British Columbia. In Alaska, the Tongass Land and Resources Management Plan specifies which lands are available for harvest and how harvest will occur on federal lands. Clearcut logging is the predominant method prescribed for timber harvest. Elements designed to reduce impacts to goshawks include old growth reserves linked by corridors (especially beach and stream buffers), nest buffers, canopy retention in harvest units on part of one island, and pre-project goshawk surveys.

In Canada, where the Queen Charlotte goshawk is listed as a Threatened species under the federal *Species at Risk Act*, a recovery team is developing a recovery strategy and action plans. Protected areas cover approximately 9 percent of the productive forest on the islands. Several "Wildlife Habitat Areas" have also been designated by the Province of British Columbia to protect known nest sites and variable amounts of surrounding habitat. Wildlife Habitat Areas for all species of "Identified Wildlife" must not reduce the amount of mature forest available for harvest by more than one percent in each forest district. This limit has already been reached in two of the five forest districts within the range of the Queen Charlotte goshawk. This government policy does not have force of law or regulation, but is likely to interfere with goshawk conservation, on both Vancouver Island and the Queen Charlotte Islands, where several species must be accommodated within the one percent limit.

Predation, disease, natural disasters, competition, pesticides and climate change are not believed to currently affect viability of Queen Charlotte goshawk populations, but any of these could individually or in combination reduce survival or reproductive success. Given the small populations, low survival or reproductive rates could not be sustained long before viability of the subspecies would be at risk. Genetic relationships and security are unclear, but goshawks on the Queen Charlotte Islands may be reproductively isolated, and those on Vancouver Island may be hybridized with or otherwise related to the mainland subspecies. Low prey diversity and susceptibility of some prey populations to population fluctuations could create problems for low-density populations of goshawks in some areas.

INTRODUCTION

The northern goshawk (*Accipiter gentilis*) is a relatively large hawk found in temperate forests throughout the northern hemisphere. The Queen Charlotte goshawk (*A. g. laingi*) is a comparatively small, dark subspecies that nests and forages in coastal rainforests of Southeast Alaska and British Columbia. In recent years, concern for the Queen Charlotte goshawk has increased as a result of logging in the forest habitat of the subspecies.

The U.S. Fish and Wildlife Service was petitioned to list the Queen Charlotte goshawk as endangered in May 1994. In June 1995, the Service published a 12-month finding that listing was not warranted (USFWS 1995). The finding was challenged in U.S. District Court (DC Circuit), which remanded the finding to the USFWS with instructions to base the finding on the existing management plan for the Tongass National Forest, rather than one in development at the time (Southwest Center for Biological Diversity et al. vs. Bruce Babbit et al. 1996). The USFWS released a new finding (also “not warranted”) in August 1997 (USFWS 1997b). This finding was challenged in April 1998, and the court remanded to the USFWS in July 1999, with instructions to provide a reliable population estimate for the subspecies (Southwest Center for Biological Diversity et al. vs. Bruce Babbit et al. 1999). The government appealed this decision in the U. S. Court of Appeals, which overturned the requirement for a population estimate but remanded the case to the District Court for further consideration of the remainder of the finding (Southwest Center for Biological Diversity et al. vs. Bruce Babbit et al. 2000). In May 2004, the District Court remanded the finding to the USFWS with instructions to evaluate whether Vancouver Island is a “significant portion” of the subspecies’ range (within the meaning of the Endangered Species Act’s definition of “endangered” or “threatened”) and, if so, to determine whether the bird should be listed (Southwest Center for Biological Diversity et al. vs. Bruce Babbit et al. 2004).

The U.S. Fish and Wildlife Service must use the best scientific and commercial data available when making listing decisions. A significant amount of research has been completed since our 1997 status review and administrative finding was published. In order to reach an informed decision with respect to the court’s remaining questions on the significance of Vancouver Island, BC, and whether the subspecies should be listed, we are updating in this document our review of the status of the subspecies range-wide. This status review updates our 1997 review (USFWS 1997a), and summarizes the best available information relevant to determining whether the Queen Charlotte goshawk warrants protection under the *Endangered Species Act of 1973*, as amended. This document contains no recommendations or decisions, but is instead intended to be used a basis from which to draw conclusions and make decisions. A separate document, the administrative finding, may review additional information not available at the time this status review was prepared, consider issues beyond the scope of this review (e.g., policy compliance and legal issues), and will contain the rationale used in arriving at conclusions. The finding will include the U. S. Fish and Wildlife Service’s decision and response to the court whether or not Vancouver Island is a “significant portion” of the subspecies' range and whether the subspecies should be listed as threatened or endangered across all or some portion of its range.

This document is presented in four parts. Part I addresses background information and discusses the subspecies's taxonomy, distribution, habitat, food habits, and demography. Part II of the document summarizes what is known of the potential effects of timber harvest on goshawks. Part III describes the current and future condition of the forests within the range of the Queen Charlotte goshawk. Part IV presents a discussion of vulnerability factors.

Technical terms are typically defined on their first use. A glossary is also provided in Appendix B. Acronyms are generally avoided, except in literature citations and tables. Abbreviations are limited to standard units of measure.

PART I - BACKGROUND

Existing Conservation Status Designations

The Convention on International Trade in Endangered Species lists all but a few members of the Order Falconiformes (birds of prey) in Appendix II (including the Queen Charlotte goshawk), indicating that these birds are not necessarily now threatened with extinction but may become so unless trade is closely controlled (CITES 2005).

NatureServe, an international organization that coordinates species rankings among many state-, provincial- and national-level natural heritage programs around the world, lists the Queen Charlotte goshawk as globally imperiled (T2), nationally imperiled in both United States and Canada (N2), and imperiled at the statewide and province-wide levels in both Alaska and British Columbia (S2) due to small range, naturally low populations, and high-level threats to its habitat from logging (NatureServe 2005). These rankings echo those assigned by the Alaska Natural Heritage Program (Gotthardt et al. 2005) and the British Columbia Conservation Data Centre (Manning and Chytyk 2005, BC Conservation Data Centre 2007).

In response to concerns over sensitivity of the bird to timber harvest, the Alaska Region of the U. S. Forest Service designated the Queen Charlotte goshawk a sensitive species in 1994 (USDA Forest Service 1997). The Alaska Department of Fish and Game designated the bird a "species of special concern" (ADF&G 1998) because of threats to its nesting and foraging habitat.

In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses and designates which wild species are in some danger of disappearing from Canada. The Committee is organized into several subcommittees and includes national, provincial and territorial, government and non-government species experts and representatives. In 1995, COSEWIC determined that the Queen Charlotte goshawk was "Vulnerable" (Cooper and Chytyk 2000). In 2000, this status was upgraded to "Threatened" (COSEWIC 2005), and in 2002 the bird was officially listed under Part 3

(Threatened Species) of Schedule 1 (List of Wildlife Species at Risk) of the federal *Species at Risk Act* (Statutes of Canada 2003).

Following assessment by the provincial Conservation Data Centre, the Province of British Columbia added the subspecies to its "Red List" in 1998 (BCMELP1998), and in 2004 the Province included the subspecies in the category of "Species at Risk" under the *Forest and Range Practices Act* (i. e., those species at risk that may be affected by forest management and require protection in addition to that provided by other mechanisms) (Barisoff 2004).

Inclusion in the category of Species at Risk under the Provincial *Forest and Range Practices Act* allows special management for the Queen Charlotte goshawk through establishment of "Wildlife Habitat Areas," which are discussed in greater detail below.

Taxonomy

The northern goshawk (*Accipiter gentilis*) is found in temperate and boreal forests across North America and south into northern Mexico. The same species occurs across Europe and Asia (Brown and Amadon 1968, Mayr and Cottrell 1979, del Hoyo et al. 1994). Historically, taxonomists have placed the species in various genera, including *Falco, Sparvius, Hierofalco, Daedalion, Macagua, Buteo, Astur, Nisus*, and (currently) *Accipiter*. The species name has similarly taken many forms, including *novae-terrae, atricapillus, palumbarius, regalis, pictum, melanops, rutilans,* and (currently) *gentilis* (Friedmann 1950).

The American Ornithologists Union (AOU), the commonly recognized authority on taxonomy of North American birds, adopted the name *Accipiter atricapillus* in 1886, but changed it to *Astur atricapillus* in 1908 (Friedmann 1950). From the late 1800s through the mid-1900s, many taxonomic treatments used the name *Astur atricapillus* for the species (e.g., Coues 1903, Knowlton 1909, Bent 1937, Taverner 1940). In 1944, the AOU reverted to the previously accepted genus *Accipiter,* and adopted the species name *gentilis,* which was first suggested by Linnaeus in 1758 (Friedmann 1950).

Goshawk Subspecies

Five subspecies have been described in North America (Whaley and White 1994). The subspecies *atricapillus*, a "continental" or "eastern" race sometimes given the common name "American goshawk" or "eastern goshawk" was first described in 1873 (Friedmann 1950), and has been universally accepted as the subspecies found across most of North America (e.g., Coues 1903, Bent 1937, Friedmann 1950, Jewett et al. 1953, AOU 1957, Brown and Amadon 1968, Beebe 1974, Godfrey 1979, Palmer 1988, del Hoyo et al. 1994).

A race of goshawks "much darker than true *atricapillus*" was identified in the "Pacific coast region, from southern Arizona to Sitka, Alaska" by Nelson (1884), who proposed the subspecies name *henshawi,* common name Henshaw's goshawk. This treatment was not widely accepted, and did not appear in subsequent editions of the AOU Checklist of North American Birds.

In a review of goshawk specimens from across North America, Taverner (1940) proposed a new subspecies of goshawk (*A. g. laingi*) described as:

> "…faintly to distinctly darker" (than *atricapillus*) "especially in first and second year. Adult, sootier gray ventrally especially across breast, typically with many broad shaft streaks. Dorsally with the black of cap and nape extending over shoulders and the interscapulars. Juvenile, breast stripes very broad and heavy on a light ground that averages deeper in color than in *atricapillus.* Dorsally almost or quite solid rich dark brown with little or no light feather-edging or semi-concealed markings."

The range was described "as far as now known" as "the islands of the British Columbian coast." Birds from the Queen Charlotte Islands were recognized as most typical of the race, with Vancouver Island birds "more variable and less plainly characterized."

In the same article, Taverner (1940) rejected the then-widely accepted subspecies *striatulus*, known commonly as the western goshawk. His work indicated that the finely patterned breast supposed to be characteristic of the subspecies was actually a character of age, indicating physical maturity and advanced age, not race.

In 1957, AOU accepted Taverner's proposals, dropping *striatulus* and including only *atricapillus* and his proposed *laingi* as subspecies of the goshawk in North America. Subsequent taxonomic treatments have generally accepted the *laingi* subspecies (e.g., Jewett et al. 1953, Brown and Amadon 1968, Beebe 1974, Beebe 1976, Godfrey 1979, Mayr and Cottrell 1979, del Hoyo 1994, Palmer 1988).

The only other subspecies currently named in North America is *apache*, described from southwestern United States and northern Mexico in 1938 (Friedmann 1950). The AOU did not recognize *apache* as a subspecies in their subsequent Check-list of North American Birds (AOU 1957), the last edition in which they listed subspecies. Other authoritative treatments of goshawk taxonomy have included *apache* (e.g., Brown and Amadon 1968, Beebe 1976, Mayr and Cottrell 1979) while others have not (e.g., Friedmann 1950, Palmer 1988, del Hoyo 1994).

Although the AOU considered the subspecies a useful and valid taxonomic concept, since 1983 they have chosen to list only to species in the interest of timely completion of their updates (AOU 1983, p. xiii). For purposes of "government agencies dealing with legislation, permits and law enforcement" requiring an authoritative list of subspecies, they recommend the 1957 (5th) edition and related supplements.

Size of the *laingi* subspecies

Taverner (1940) originally described the Queen Charlotte goshawk on the basis of coloration. Others have noted that goshawks from coastal regions of Pacific Northwestern U. S., British Columbia, and Southeast Alaska average smaller than goshawks elsewhere.

Beebe (1974) noted that goshawks "almost as dark as *A. g. laingi*, but fully one-third smaller," resided on Vancouver Island. He later added the Olympic Peninsula of Washington to the range of "these little Island goshawks" (Beebe 1976), which he suggested were distinct from the *laingi* and *atricapillus* subspecies. Subsequent considerations of goshawk taxonomy have placed a greater emphasis on size. Johnson (1989) measured 180 goshawk specimens from British Columbia and found no significant difference in size between Queen Charlotte Island and Vancouver Island goshawks, but insular (island dwelling) goshawks were significantly smaller than goshawks from the adjacent mainland. In a continent-wide analysis, Whaley (1988) found goshawk morphology to vary regionally in North America, with the goshawks from the range of *laingi* averaging smaller than goshawks from other areas. He also concluded that "smaller birds occur on the islands as opposed to the immediate mainland" of British Columbia (p. 48). Whaley and White (1994) noted that goshawks they examined from Vancouver Island were the smallest in North America, but not as small as Beebe (1974) indicated. They found that Vancouver Island goshawks were significantly smaller than goshawks from the "immediate and adjacent mainland" of British Columbia and Washington, with birds becoming progressively larger to the north, east and south beyond British Columbia. They concluded that descriptions of *laingi* should state that the subspecies "averages smaller size than other North American races."

Titus et al. (1994) weighed and measured nine adult males (average mass 827 grams), 10 adult females (average mass 1074 grams) and 15 juveniles from Southeast Alaska, and offered evidence of clinal size variation within Southeast Alaska from smaller to larger, south to north, by documenting that "coastal British Columbia" birds (Whaley's [1988] "*laingi*" specimens) were similar in size to birds from southern Southeast Alaska, slightly smaller than those from central Southeast Alaska, and significantly smaller than those from northern Southeast Alaska. The northern Southeast Alaska birds closely approached the size of Whaley's (1988) "western mainland" birds (from the "immediate mainland of British Columbia and Washington"), which Whaley showed to be larger than insular British Columbia birds.

Southeast Alaska birds were also smaller than Whaley's (1988) specimens from elsewhere in Alaska, further documenting a cline of increasing size from Southeast Alaska northward (Titus et al. 1994).

Titus et al. (1994) recognized shrinkage of museum specimens used for comparison to their live specimens as a potential bias, but concluded that goshawks in southern Southeast Alaska were closest in size to goshawks from the islands of British Columbia, while those from northern Southeast Alaska were larger.

Comparisons of live birds from Alaska and British Columbia indicated that adult goshawks from Southeast Alaska were significantly larger than those from Vancouver Island. Adult males from both locations were smaller than those from central interior British Columbia, Yukon Territory, Olympic Peninsula of Washington, northeast Oregon and northern Arizona. Adult females from Southeast Alaska, Vancouver Island, and the Olympic Peninsula were similar to each other in size but smaller than adult females from interior British Columbia, Yukon, Oregon and Arizona (Flatten et al. 2002, 2001a, Flatten and McClaren 2003).

Genetic Differentiation

Preliminary analyses of microsatellite data could not differentiate goshawks from Southeast Alaska and Vancouver Island, but these birds as a group were significantly differentiated from goshawks in interior and south-central Alaska and interior British Columbia, and appeared to represent a metapopulation (Gust et al. 2003). A single specimen from the Queen Charlotte Islands was similar to the Southeast Alaska/ Vancouver Island birds. A larger genetic study by USGS is nearing completion. Samples for this study are larger in number, cover a more comprehensive geographic area, and utilize a larger suite of genetic markers so the results may help elucidate the taxonomic relationships among goshawks from several areas within and around the reported range of *laingi*. Unpublished preliminary results (Talbot et al. 2005) suggest that birds from the Queen Charlotte Islands are genetically distinct from adjacent mainland and island populations, and that there has been little contemporary gene flow into this population. Talbot (2006) reported that goshawks on Vancouver Island may be genetically closer to *atricapillus* than *laingi*.

Subspecies Definition

Subspecies have traditionally been described on the basis of morphological traits and color variations observed in specific geographic areas (Mayr 1982, Haig et al. 2006). Ideally, subspecies represent isolated or clearly distinct populations that differ from adjacent populations of the same species in several characteristics, rather than points along a continuum of clinal variation in a single characteristic (Barrowclough 1982, Gill 1982, Monroe 1982, Parkes 1982, Storer 1982). Analyses of genetic structure in bird species, however, have shown that established taxonomic treatments often fail to distinguish the evolutionarily significant structure present within species, leading to calls for greater use of genetic criteria in defining species and subspecies (e.g., Ball and Avise 1992, Zink 2004, Haig et al. 2006). Until taxonomists have reviewed new information concerning morphometrics and genetics of goshawks, however, we will rely on existing taxonomic treatments concerning validity of named subspecies.

Distribution

Northern Extent

The American Ornithologists' Union recognized the range of *laingi* as the Queen Charlotte Islands and Vancouver Island, British Columbia (AOU 1957) (Fig. 1), based upon Taverner's (1940) proposed subspecific designation. Taverner, however, qualified his description of the range with the phrase “As far as now known…” likely in recognition of the limited number of specimens he reviewed.

Beebe (1974, 1976) later considered the range of the subspecies to include the Alexander Archipelago of Southeast Alaska, but did not provide evidence to support this northerly range extension. The first data on this topic were presented by Webster (1988), who compared seven adult goshawks from Southeast Alaska with a series of specimens from other regions. He considered two of the Southeast Alaska goshawks, taken during late summer and fall, to be *atricapillus*, but believed the other five to be *laingi*, based upon their dark plumage. He concluded that the range of *laingi* extends as far north as Baranof Island (near Sitka) and Taku Inlet (on the mainland near Juneau) in Southeast Alaska.

Observations of Titus et al. (1994) further support that goshawks in Southeast Alaska are *laingi*. Examinations of 18 adult and 23 juvenile goshawks from various locations in Southeast Alaska showed that although variation exists within the region, with a tendency for birds to be lighter and larger in the northern portion of the region, coloration and measurements were within the range of characteristics considered descriptive of the Queen Charlotte goshawk. They reported goshawks nesting as far north as the Lace River (about 50 miles north of Juneau). Titus et al. (1999) reported a probable nest near Gustavus, on the Chilkat Peninsula, and Flatten et al. (2001b) reported a nest near Skagway. Phenotypes (size and color) of birds from these nests were not reported, but presence of nesting birds suggests that *laingi* goshawks exist throughout Southeast Alaska.

Flatten et al. (1998) analyzed phenotypic and morphometric variation among 55 adult and 58 juvenile goshawks captured at nest sites in Southeast Alaska. They found plumage variation “ranging from the darkest extreme of *laingi* to a form intermediate between *laingi* and *atricapillus*. Some individuals appeared to completely overlap *atricapillus.”* They also found Southeast Alaska birds to be smaller than Alaskan birds from further north, but larger than *laingi* specimens from British Columbia. Flatten et al. (2002) assigned 45 live adult goshawks captured in Southeast Alaska to either *atricapillus* or *laingi*, based on their phenotype. They found 40 percent of the birds displayed *laingi* characteristics, 33 percent *atricapillus*, and 27 percent intermediate between the two. Vancouver Island birds were 38 percent *laingi*, 19 percent *atricapillus* and 43 percent intermediate. Flatten and McClaren (2003) reported that only one third of adult and juvenile birds from Southeast Alaska and Vancouver Island “clearly had the dark phenotype Taverner (1940) described as distinct for this race,” probably reflecting the less-diagnostic appearance of most juvenile birds (Titus et al. 1994). The variation observed in these studies was considered by the authors as consistent with the original descriptions of the subspecies, which noted variation in the plumage color of Vancouver Island birds.

Figure 1. Areas included within the range of the Queen Charlotte goshawk defined by various authors. Dashed red line indicates northern boundary used in USFWS 1997a.

Southern Extent

The southern limit of the range of the Queen Charlotte goshawk is currently considered to be Vancouver Island by most authorities and reviewers (AOU 1957, Brown and Amadon 1968, Godfrey 1979, Mayr and Cottrell 1979, Palmer 1988, Johnsgard 1990, del Hoyo et al. 1994), but the small size and dark coloration characteristic of *laingi* may also be present in the goshawks inhabiting western Washington and Oregon. Jewett et al. (1953) documented several dark or "dusky" specimens from northwest Washington, near and north of Bellingham, Mount Rainier, various locations on the Olympic Peninsula, and along the western coast near Grays Harbor (central Washington coast) and Willapa Bay (near the Washington/Oregon border). He also described a dark specimen from Douglas County, Oregon, and concluded that the breeding range of *laingi* extended "south along the Pacific slopes, including those of Washington and Oregon." This range was not adopted by subsequent authors. Habitat in southwest Washington and western Oregon is described as marginal for the species, and is known to support few goshawks

(Destefano and McCloskey 1997, Desimone 2006, Finn 2006). We do not know what proportion of goshawks in this area exhibit *laingi* characteristics.

Beebe (1974) apparently considered the range of *laingi* to extend no further south than the Queen Charlotte Islands, as he described the dark-colored goshawks of Vancouver Island as distinctly smaller than either *laingi* or *atricapillus*, and apparently a different race or subspecies. He included the Olympic Peninsula within the range of these small goshawks in his 1976 treatment (Beebe 1976), but suggested no taxonomic name for the group.

Flatten et al. (2002) and Flatten and McClaren (2003) found that adult males from Vancouver Island and Southeast Alaska were significantly smaller than those from the Olympic Peninsula. Wing chord lengths (an index of body size) of adult females from Southeast Alaska, Vancouver Island, and Olympic Peninsula were similar to each other, but smaller than females from Yukon, interior British Columbia, northeastern Oregon, or northern Arizona, suggesting that Olympic Peninsula birds may share traits with *laingi* birds to the north. Wing lengths have been found to be unreliable as a measure of size in sparrows (Rising and Somers 1989), but have been recognized by others as a good indicator of size in goshawks (e.g., Whaley and White 1994, p. 169).

Similarity in size of birds, the proximity of Vancouver Island to the Olympic Peninsula and the Northern Cascades, similarity of habitat, and documentation of movement of birds between Vancouver Island and the nearby British Columbian mainland just north of the Washington border (McClaren 2000a, 2000b, 2001) are rationale used by the Canadian Recovery Team for including western Washington within the range of the *laingi* subspecies (McClaren, 2006b), although the southern limit of *laingi* has not been established by the Canadian Recovery Team.

The Washington Department of Fish and Wildlife currently considers *atricapillus* the only subspecies in the state (Desimone and Hays 2004), based on lack of conclusive evidence of *laingi*, although several experts currently believe that goshawks on the Olympic Peninsula and in the Cascade Range could be classified as *laingi* (e.g., Desimone, 2006, Finn 2006, McClaren, 2006b). Descriptions of birds from these areas are not available.

<u>Eastern Extent</u>

Taverner (1940) included only the islands of the British Columbian coast, but not the mainland, in his initial description of the range. This proposal was adopted by the AOU (AOU 1957), and not extended to the mainland by any taxonomic authority until Webster (1988) documented dark goshawks believed to be *laingi* from Southeast Alaska, including the mainland near Taku Inlet. Flatten and McClaren (2003), measured live adult and young goshawks at 42 nest sites across Southeast Alaska and found no difference in size between island and mainland birds.

In contrast, Johnson (1989) found no significant difference in size between Queen Charlotte Island and Vancouver Island goshawks, but these insular goshawks were significantly smaller than goshawks from mainland (presumably both interior and coastal) British Columbia. His samples included 19 museum specimens from the Queen Charlotte Islands, 52 from Vancouver Island, and 108 from the British Columbian mainland, although he did not distinguish between inland and coastal mainland.

Whaley (1988) and Whaley and White (1994) also found adult male goshawks from the purported range of *laingi* (five specimens from Vancouver Island and one bird each from Southeast Alaska and western Washington) significantly smaller than adult males from the "immediate mainland of British Columbia and Washington." A similar comparison with adult females failed to detect a size difference. It is not clear how far inland the "immediate mainland" birds came from.

Radio-tagged goshawks have been documented dispersing from Vancouver Island to the nearby mainland of British Columbia to breed (McClaren 1997) and winter (McClaren 2000a, 2000b, 2001). Observations of such movements, known similarity of habitat, and the apparent lack of barriers to movement have prompted the British Columbia government to consider the coastal mainland of the province and the west slope of the Cascade Mountains in Washington within the range of the *laingi* subspecies (Cooper and Chytyk 2000, McClaren 2006a, 2006b, 2004). The Alaska Department of Fish and Game also recommended that mainland British Columbia west of the Coast Range be included within the range of *laingi* because of the observed pattern of clinal size variation between Southeast Alaska and Vancouver Island, and because of documented dispersal between islands and the mainland (Robus 2006).

<u>Agency Determinations</u>

In 1997, the U. S. Fish and Wildlife Service concluded that while the exact distribution of the Queen Charlotte goshawk was unknown, the best available information indicated that range extended "from Vancouver Island northward, through insular British Columbia, insular and adjacent mainland Alaska, to Icy Strait and Lynn Canal" (USFWS 1997a). This description included "islands and mainland of Southeast Alaska," but only "the Queen Charlotte Islands and Vancouver Island in British Columbia" and not the Canadian mainland (USFWS 1997b).

The "Canadian Northern Goshawk *Accipiter gentilis laingi* Recovery Team" has defined the range of the subspecies to follow "the distribution of the wet Coastal Western Hemlock and Coastal Douglas-fir biogeographic subzone/variants." This definition includes coastal mainland British Columbia, the Olympic Peninsula, parts of western Washington and possibly into Oregon (McClaren 2006a, 2006b), although they have not yet reached a decision concerning the southern boundary.

The Alaska Department of Fish and Game recommended that mainland British Columbia west of the Coast mountain range be included in the range of the goshawk based on similarity of size and color of goshawks from Vancouver and Southeast Alaska, and observed dispersal of goshawks in Southeast Alaska between islands and the mainland (Robus 2006).

The Washington Department of Fish and Wildlife considers *atricapillus* the only subspecies of goshawk known in the state (Desimone and Hays 2004). This determination was based primarily on the lack of evidence of *laingi* presence, but authorities there do not exclude the possibility that *laingi* may be present (Desimone 2006). Experts in Alaska, Canada, and Washington agree that additional work to clarify the boundaries of the subspecies is needed (e.g., USFWS 1997b, Desimone 2006, McClaren 2006b).

<u>Summary</u>

Taxonomists have recognized the *laingi* subspecies on the basis of its darker color for over 50 years. Additional work over the last 30 years has repeatedly shown that these birds are also smaller than goshawks elsewhere in North America, with the smallest birds found on Vancouver and Queen Charlotte Islands. The birds apparently tend to be larger to the north, east and south of those islands.

Within the described range of the subspecies, there appears to be substantial variation in coloration and size, with various authors suggesting that intergrades between *laingi* and *atricapillus* may exist in Southeast Alaska and on Vancouver Island, the Olympic Peninsula, and the coastal mainland of British Columbia. Published analyses of birds from the Queen Charlotte Islands are limited to very few specimens, especially of adult birds, so it is difficult to say with certainty how consistent these characteristics are even there.

Published work (peer reviewed, popular press, and agency reports) makes a compelling case for including the Queen Charlotte Islands, Vancouver Island, and Southeast Alaska in the range of the subspecies. Considerably larger sample sizes from Vancouver Island and Southeast Alaska allow for more complete, if less consistent, descriptions of goshawks there. Analyses of phenotypes have documented that approximately 81% of the goshawks on Vancouver Island and 67% of the goshawks in Southeast Alaska show at least partial expression of *laingi* coloration (Flatten et al. 2002). These birds are also smaller than birds from surrounding regions (Johnson 1989, Whaley 1988, Whaley and White 1994, Titus et al. 1994, Flatten et al. 1998, 2002; Flatten and McClaren 2003).

Data are less conclusive for Washington and coastal mainland British Columbia, although it seems clear that goshawks from interior British Columbia and east of the Cascade Range in Washington are of the *atricapillus* subspecies. Jewett et al. (1953) documented six birds matching the description of *laingi* from northern and western Washington. Goshawks on the Olympic Peninsula are reportedly smaller and darker than those in the Washington Cascades (Finn 2006). Systematic analyses of size, coloration and genetics of adequate samples of goshawks from Washington and coastal mainland British Columbia, however, are lacking.

There are no apparent barriers to dispersal between Vancouver Island and the surrounding mainland, and documented movement of goshawks from Vancouver Island to nearby islands and to the British Columbian mainland demonstrates the potential for the coastal areas surrounding Vancouver Island to harbor *laingi* goshawks. Habitat on the Olympic Peninsula, the west slope of the Cascade Mountains, and the west slope of the Coast Range in British Columbia is similar to that in the "core" of *laingi* range, although dense understory may limit goshawks in the Coast Ranges of Oregon (DeStefano and McCloskey 1997). Goshawks are known from all these areas and knowledgeable goshawk biologists believe that birds with *laingi* characteristics probably breed there (though in extremely limited numbers in western Oregon and southwestern Washington).

No data are currently available, however, to refute Whaley and White's (1994) observation that adult male *laingi* goshawks from Vancouver Island, Southeast Alaska and western Washington were smaller than adult males from the "immediate mainland of British Columbia and Washington." Johnson (1989) also found goshawks from the Queen Charlotte Islands and Vancouver Island significantly smaller than goshawks from mainland British Columbia. Flatten and McClaren (2003), however, found no significant difference between island and mainland goshawks in Southeast Alaska.

Clearly, more work is necessary to clarify the extent of *laingi* representation in these areas that appear to be the margins of (or beyond) the subspecies' range. Particularly lacking are examinations of birds nesting on the mainland coasts of British Columbia, Washington and Oregon.

Given the uncertainty expressed by various authors over the boundaries of the range of the Queen Charlotte goshawk (e.g., Iverson et al. 1996; USFWS 1997a, 1997b; Cooper and Stevens 2000; Cooper and Chytyk 2000; McClaren 2004), differences among published authorities (see Table 1), existence of new genetic and morphometric analyses (e.g., Gust et al. 2003; Talbot et al. 2005, 2006; Flatten and McClaren 2003, Talbot 2006), and the likelihood that additional museum specimens may now be available (and more easily located through online databases) since the last systematic review (Whaley 1988), it appears that an in-depth study by a qualified taxonomist to clarify the boundaries of this taxon is warranted.

<u>Distribution Used in this Review</u>

In the interim, the Service and other agencies must proceed with decisions based upon the best available data. Although one government agency report (Cooper and Chytyk 2000) and other communications (e.g., McClaren 2006a, Robus 2006) have included or recommended including coastal mainland British Columbia and/or portions of western Washington State within the range of the subspecies, we are aware of no reports or other publications by taxonomic authorities that have recommended or accepted this delineation since Jewett et al. (1953) identified several dark specimens from western Washington (and one from Oregon), and described the range of *laingi* to include the "Pacific slopes, including those of Washington and Oregon."

For purposes of this review, we define the range as the area from which we have documentation that the characteristics described for the subspecies are expressed in a majority of the birds present. This includes the Queen Charlotte Islands, Vancouver Island, and Southeast Alaskan islands and mainland south of the international border between Mount Fairweather and Mount Foster. This approach includes all areas for which there appears to be agreement among published works, and eliminates areas for which there is disagreement or uncertainty (largely due to lack of specimens). This delineation expands slightly (to the north) the delineation used in the USFWS Draft Status Review (FWS 1997a) and 12-month Finding (FWS 1997b) for the Queen Charlotte goshawk to include nest sites subsequently reported by Alaska Department of Fish and Game (Titus et al. 1999, Flatten et al. 2001).

Table 1. Described range of the Queen Charlotte goshawk (AK = Alaska, BC=British Columbia, CBC = coastal mainland British Columbia, OP = Olympic Peninsula, OR = Oregon, QCI = Queen Charlotte Islands, SEAK = Southeast Alaska, VI = Vancouver Island, WA = Washington, WC = west slope Cascade Range)

Source	QCI	VI	SEAK	OP	CBC	WC	Range Description from Reference
Journals							
Taverner 1940	X	X					"islands of the BC coast," most typical on QCI, variable on VI
Webster 1988	X		X				"north from the QCI, at least in fall, as far as Baranof Is. and Taku Inlet" (SEAK)
Taxonomies							
Friedmann 1950	X	X					"islands off the coast of BC, from the QCs to Vancouver," intergrades on VI
AOU 1957	X	X					"QCI and VI"
Mayr and Cottrell 1979	X	X					"QCI and VI, BC"
Species Accounts/Natural History Reviews							
Jewett et al. 1953	X	X	X	X	X?	X	"SEAK and QCI, BC, south along the Pacific slopes, incl. those of WA and OR"
Brown and Amadon 1968	X	X					"Islands off coast of BC"
Beebe 1974	X		X				"north coastal islands of BC, SEAK (Alexander Archipelago) and the QCI"
Beebe 1976	X		X				"north coastal islands of BC, SEAK (Alexander Archipelago) and the QCI,"
Godfrey 1979	X	X					"VI and QCI" (addressed only Canadian distribution, not entire subspp range)
Palmer 1988	X	X	?				"QCI, BC…n. along the Pacific coast to the Gulf of Alaska" intergrades on VI
del Hoyo et al. 1994	X	X					"QCI and VI, BC"
Squires and Reynolds 1997	X	X	X				"VI northward thru insular BC, insular (Alex. Arch) and coastal mainland AK"
Agency Reports/Agency Communications							
Iverson et al. 1996	X	X	X				QCI, VI, "may extend north to Baranof Is. in SEAK or Prince William Sound"
USFWS 1997a	X	X	X				"VI northward, thru insular BC, insular and adjacent mainland AK, to Icy Strait and Lynn Canal"
Cooper and Stevens 2000	X	X	X	X?		X?	SEAK, "coastal islands of BC, and, perhaps the OP and even coastal WA and OR"
Cooper and Chytyk 2000	X	X	X	X	X?	X?	SEAK, coastal islands of BC, OP, "perhaps, coastal WA and OR," CBC "likely"
McClaren 2004	X	X	X		X?		SEAK, QCI, VI, and "Most likely…w. side of the Coast Mts throughout CBC"
Robus 2006	X	X	X		X		mainland BC "west of the coast range" along with VI , QCI and SEAK
McClaren 2006a	X	X	X	X	X	X	"follows the distribution of the wet Coastal Western Hemlock and Coastal Douglas fir biogeoclimatic subzones/variants"

Habitat

Regional Topography, Climate and Vegetation

Queen Charlotte goshawks exist in an environment that differs from temperate and boreal forests elsewhere in the range of the northern goshawk. The primary differences are the abundant rainfall and the insular (island-dominated) character of the region, both of which have likely shaped the endemic goshawk through selective pressure. The following section describes the ecology of this region, illustrating the unique challenges facing goshawks in the coastal rainforests and allowing for comparison to other regions within the range of the northern goshawk.

Goshawk habitat in coastal British Columbia and Southeast Alaska is dominated by conifer rainforests interrupted by sphagnum bogs, sedge-dominated fens, alpine areas, and saltwater channels. Southeast Alaska is a narrow strip of mainland and a complex of over 22,000 islands known as the Alexander Archipelago, extending over 500 kilometers (km) from north to south. Islands range in size from a few hundred square meters to more than 6,000 square km. Topography is generally steep and rugged, although extensive low-lying flats occur on some islands and on portions of the mainland. Many island groups are separated by deep, glacially carved fjords, which also penetrate the Coast Mountain Range on the mainland. The mainland supports a narrow forested strip between the marine environment and the steep, high mountains to the east. Several major river drainages transect the Coast Range, connecting coastal Alaska to interior British Columbia and the Yukon. Outside these river corridors, glaciers and ice fields dominate the higher elevations, separating the coastal forest in Southeast Alaska from the adjacent inland forest in Canada to the east (USDA Forest Service 1997).

In British Columbia, coastal temperate rainforest occurs on the Queen Charlotte Islands, Vancouver Island, and (as in Alaska) in a narrow strip along the mainland coast. The Queen Charlotte Islands, which are also known by the Haida (First Nation) name of "Haida Gwaii", are an archipelago of 2 main islands (Graham and Moresby) and about 160 smaller islands. This island complex lies immediately south of the southern tip of Alaska, and covers about 9,500 square km (Pojar and Banner 1984, Doyle 2004b). It lies 50-130 km from the British Columbia mainland and about 50 km from the southern end of the Alexander Archipelago in Alaska (Dall and Prince of Wales Islands). Vancouver Island, which is approximately 450 km long, lies at the southern end of coastal British Columbia near the border with Washington State. This insularity strongly influences the uneven distribution of many potential prey species (discussed further under **Food Habits**) which affects goshawk productivity and survival patterns.

The climate throughout the region (coastal British Columbia and Southeast Alaska) is generally wet and cool, although considerable geographic variation exists. Annual precipitation varies from 65-860 centimeters (cm). Much of this falls as snow in northern portions of the region and at higher elevations (MacKinnon and Eng 1995, Iverson et al. 1996). In general, temperatures are warmer in the southern portions of the region, and precipitation decreases from west to east. Rainshadows exist on the eastern sides of some of the larger islands; average annual precipitation decreases from 860 to 115 cm from the western to eastern sides of the Queen Charlotte Islands (Poulin 1984). Similarly, the western side of Vancouver Island is wetter than the eastern side, with average annual precipitation varying from over 400 to only 65 cm depending on location (MacKinnon and Eng 1995).

In most of the region, dense spruce-hemlock forests grow at low elevations in better-drained areas. These forests are composed largely of western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), although mountain hemlock (*Tsuga mertensiana*), western redcedar (*Thuja plicata*), and Alaska-cedar (*Chamaecyparis nootkatensis*) are also present in varying amounts (Viereck and Little 1972, MacKinnon and Eng 1995). At the southern limit of the region, Douglas-fir (*Pseudotsuga menziesii*) and hardwoods dominate in the low elevation, drier forests on southeast Vancouver Island and adjacent areas (MacKinnon and Eng 1995).

The forests of this region are characterized by fine-scale habitat heterogeneity caused by mountainous terrain, wetlands, drainage, and natural disturbance regimes. Because of considerable precipitation, landform diversity has a significant influence on drainage and thus local vegetation characteristics. Well-drained sites generally have higher forest productivity (often expressed in terms of volume of wood produced per unit area per year, or as a standing volume of wood) whereas nonforested peatlands occur where poorly drained, deep organic soils predominate. Forests of intermediate or low productivity form transitional ecotones between well-drained productive forests and poorly drained nonforested areas.

With increasing elevation, forests grade into subalpine and alpine vegetation zones, and eventually into rock, snow, and ice at the higher elevations. Treeline increases in elevation southward, ranging from 450 to 900 meters in Alaska (Viereck and Little 1972), 1,000 meters in northern British Columbia, to 1,800 meters in southern British Columbia (MacKinnon and Eng 1995).

Disturbance regimes also contribute to this naturally fragmented landscape. An understanding of succession in the temperate rainforest and the time required for each stage to develop is important in evaluating vulnerability of the Queen Charlotte goshawk to logging.

With the exception of southeast Vancouver Island and eastern Queen Charlotte Islands, the region is too wet for fire to play a major role in forest succession. Wind is the primary disturbance agent, but landslides, avalanches, debris flows, tidal waves, insects, fungi, and disease also influence forest structure and thus contribute to fine-scale habitat heterogeneity. Disturbances are generally small scale, where individual or small groups of trees die or are blown down by wind, creating canopy gaps (Brady and Hanley 1984). Occasionally large wind storms cause extensive damage, affecting hundreds of hectares (Nowacki and Kramer 1998).

Following disturbance, including logging, the regrowth of the forest stand progresses through four seral stages (Oliver 1981). Timing of each stage varies with site productivity, with faster succession in warmer, more fertile, and better-drained sites. Stand initiation occurs as new seedlings, often including red alder (*Alnus rubra*), recolonize the area. After 25-35 years on typical forested sites in Southeast Alaska, the canopy closes, blocking light to the forest floor, and the understory is eliminated. The second stage, called stem exclusion, is characterized by severe competition for light among existing trees and no new individuals or species are able to invade the area. In Southeast Alaska, this stage can persist for 100 years or more (Alaback 1982). At roughly 140 to 160 years, the third stage develops, wherein shade-tolerant shrubs gradually colonize the forest floor and mortality of some dominant trees begins to create openings in the forest canopy. There is recent evidence, however, that even-aged stands of mixed red alder and conifers produce a diverse understory of shrubs and forbs much earlier than similar-aged pure conifer stands (Hanley 2005). The final stage, old forest (some prefer the synonymous term “old growth”), develops as overstory trees die in an irregular pattern, making way for understory trees to mature, resulting in diversity in tree age and size. In addition to large trees of varying size and age, other characteristic features of old forest include a diverse understory, downed logs, and a multilayered canopy with gaps (Alaback and Juday 1989).

In Southeast Alaska, trees begin to attain large size (which varies depending on the site) at 150 to 260 years, although dominant trees in old forest usually exceed 300 years. At least two separate cohorts of dominant trees are required to attain maximum vertical and horizontal variation in the canopy. This typically takes 300 to 500 years to develop (Alaback 1982, Alaback 1990), but the rate of forest development varies considerably among sites, with poorly drained and upper elevation areas requiring up to twice as long as more productive sites. Forest succession may be somewhat faster in the warmer climate of the British Columbia temperate rainforest, but old forests require at least 250 years to develop in coastal forests of British Columbia (BCMF 2004a, p. 64).

Nesting Habitat

Goshawk nesting habitat has been described at various scales, including the nest tree, nest site (habitat immediately surrounding the nest), nest area (an 8 to 12 ha area surrounding a nest, including roosts and prey plucking sites), and the nest stand (the stand of trees homogeneous in vegetation composition and structure that contains a nest) (Reynolds et al. 2006). The area used by the adults for foraging and other needs during the nesting season is known as the breeding (or nesting) season home range (or use area).

By comparing nesting habitat to the surrounding landscape, researchers can draw inferences about which habitat features are selected by nesting birds. Greater representation of specific features at or surrounding nests than generally available in the landscape (large trees, for example) implies active selection by the birds for that feature. Conversely, under-representation of a particular attribute or habitat (non-forested sites, for example) implies avoidance of that habitat for nesting.

Most evaluations of nesting habitat have shown that nests are usually located in large trees, and that trees surrounding the nest are larger than average, with higher canopy closure, than the surrounding area. Below we describe nesting habitat and habitat selection at several scales, as reported for Queen Charlotte goshawks.

***Nest Tree* –** Nest trees typically have well-developed branches or multi-forked tops to support a goshawk nest (McClaren 2003). An evaluation of 37 goshawk nest trees in Southeast Alaska revealed that most were in Sitka spruce (54%) and western hemlock (41%) (Flatten et al. 2002), whereas 131 goshawk nests on Vancouver Island were in primarily Douglas-fir (59%) and western hemlock (31%) (McClaren 2003a). Red alder, amabalis fir (*Abies amabalis*), and western redcedar were used in a few cases (McClaren 2000a; 2000b; 2003b). Nest trees are usually among the largest in the stand (often described as "dominant" or "co-dominant"). Lewis et al. (2003) found nest trees in Southeast Alaska to be larger than those around them at the nest site (mean diameter $\pm$ SE: 69$\pm$3.7 cm vs. 47$\pm$3 cm). Ethier (1999) found 16 nest trees on Vancouver Island to be 89 percent larger in diamter than trees in the surrounding 0.04 ha. Nest trees were found at a variety of elevations (Table 2), ranging from 10 m to 814 m elevation, and were fairly evenly distributed among aspects on Vancouver Island (McClaren 2003a).

Table 2. Characteristics of nest trees within and near the range of the Queen Charlotte goshawk (VI = Vancouver, SEAK = Southeast Alaska, OP = Olympic Peninsula, cm = centimeters, m = meters, SE = standard deviation, nd = no data presented).

Location	Sample Size	dbh cm(SE)	Tree Ht m(SE)	Nest Ht m (SE)	Elevation m (SE)	Source
VI	131	71(3)	39(2)	19(0.1)	365(14)	McClaren 2003a
SEAK	37	69(4)	nd	nd	nd	Flatten et al. 2002
OP	14	61(4)	46(2)	22(1)	458(64)	Finn 2000

***Nest Site* –** Nests are typically found in forest patches containing larger trees and higher volume of wood than the surrounding stand (Lewis et al. 2003). For example, 30 nests in Southeast Alaska were in patches of trees averaging 61 m^2/ha basal area, within stands that averaged 49 m^2/ha basal area (Flatten et al. 2002). Ethier (1999) compared 0.04-ha nest sites (n=16) on Vancouver Island to random sites and found a preference for more larger and fewer smaller trees at nest sites.

Nest Area - Iverson et al. (1996) found that 12-ha circular plots centered on 39 nest locations in Southeast Alaska contained more old forest, higher canopy cover, greater representation of multi-storied stands, more hemlock, fewer large openings, and less forest/non-forest edge than random sites of similar size. At the 64-ha scale, nest areas had fewer large openings and less forest/non-forest edge than random sites (Iverson et al. 1996).

Iverson et al. (1996) concluded that goshawks nest in areas that are more homogeneous and heavily forested than the landscape in general. Nests were in areas with a higher degree of canopy closure, and the canopy was more often composed of multiple stories, than were random plots. An updated analysis with an expanded sample of 63 nests from 50 nest areas found that nest areas had significantly more forest, productive forest (i.e., capable of producing at least 1.4 cubic meters of wood fiber per ha per year, or having greater than 47 cubic meters per ha), hemlock, and canopy cover and less non-forested area than random 12-ha plots, and less non-forested habitat and forest/non-forest edge than random 65-ha plots (Lewis 2005).

Vernier and Bunnell (2002) compared 35 12-ha goshawk nest areas on Vancouver Island to habitat available at increasing distances from nests and random locations. They demonstrated that goshawks selected for nest areas with large, contiguous patches of tall, mature and old trees with dense canopies, and avoided younger stands of smaller trees with more open canopies, forest openings, and areas with high densities of roads and streams. There was little or no apparent selection for or against elevation, slope or aspect.

***Nest stand* -** Although northern goshawks across their range occasionally nest in relatively young, even-aged stands, they usually select mature and old forests that contain relatively large trees with high canopy closure (Shuster 1980, Reynolds et al. 1982, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Reynolds 1989, Reynolds et al. 1992, Squires and Reynolds 1997, Daw et al. 1998, Cooper and Chytyk 2000, Cooper and Stevens 2000, Greenwald et al. 2005). This likely reflects the need for a well-developed branch structure to support a nest, surrounded by a dense stand with a closed canopy that provides protection to the female, eggs, and young from predators and inclement weather (Reynolds et al. 1982, Rohner and Doyle 1992, McClaren 2003a). These tendencies have been confirmed for Queen Charlotte goshawks, as research from Alaska and British Columbia has demonstrated that nest trees there are usually located in comparatively high-volume stands with a relatively dense, multi-storied canopy, compared to surrounding forest (Iverson et al.1996, Flatten et al. 2002, Lewis et al. 2003, McClaren 2003a, Doyle 2005). Studies by Daw et al. (2001) and Titus et al. (1997) showed that nests located without a random survey design had similar characteristics to those located randomly.

Researchers have found some nests in maturing second-growth (regenerating, previously harvested) stands (Bosakowski et al. 1999, McClaren 2003a). Most (86%) of the second-growth stands supporting nests on Vancouver Island were 60 to 80 years old, although suitable structure is apparently achieved in a minimum of about 50 years on the most productive sites (McClaren 2003a). In western Washington, a few goshawk nests have been located in 40 to 54-year-old stands on high-productivity sites (Bosakowski et al. 1999), but nest trees in second growth there were considerably larger than average for the stands, averaging 56 cm dbh for 3 nest trees vs. 26 cm average dbh for the nest stands (Bosakowski et al. 1999).

Re-occupancy of historically known nests (n = 30) on the Olympic Peninsula of Northwest Washington was most likely in stands with high overstory depth (canopy $\geq$25 meters, top to bottom), and low shrub cover (<20 percent) (Finn et al. 2002a, Finn et al. 2002b). Nest areas in contiguous forest had higher occupancy rates than those in fragmented forests on Vancouver Island (McClaren 2003a).

Post-fledging Area – Fledglings learn to fly and hunt in the mature and old forest surrounding their nests, while they are still fed and protected by their parents prior to dispersal (Reynold et al. 1992, Kennedy et al. 1994). McClaren et al. (2003b, 2005) determined the size of "post-fledging areas" (use areas of individual fledglings) for 12 radio-tagged fledglings from fledging through dispersal (which averaged 46 days) on Vancouver Island. Individual areas ranged from 15 to 230 ha, and averaged 59 ha. They found clusters of 3 alternate nest trees to have a combined post-fledging area size between 100 and 200 ha. Mahon et al. (2003) reported that post-fledging areas in interior British Columbia averaged only 17 ha, and were entirely within what was otherwise defined as the "nest area." Mahon et al. (2003), however, used a combination of radio-tagged fledglings and audio-detections, which had potential for missing locations farther from the nest. Another potential explanation for the dramatic difference in fledgling use area size is that prey communities differ between interior British Columbia (where prey is more varied, abundant, and available) and the coastal range of the Queen Charlotte goshawk.

Most of the fledglings monitored by McClaren et al. (2005) included the nest tree within their post-fledging area. During their first three weeks, fledglings remained within 200 to 300 m of nests, then, upon completion of primary and tail feather growth, moved further from the nest. They remained within these "activity centers" for the next few weeks, developing flying skills, and then departed their post-fledging areas. McClaren et al. (2005) noted that the movement patterns they documented were consistent with those reported for goshawk fledglings in Sweden and New Mexico.

Titus et al. (2006) delineated hypothetical, circular post-fledging areas with a radius of 1,500 m, approximating the average distance moved prior to dispersal by a sample of radio-tagged juveniles in Southeast Alaska. Their analysis of 136 of these 707-ha post-fledging areas found that, on average, medium- and high-volume old growth covered 39 percent, non-forested and non-commercial forest covered 45 percent, low-volume forest covered 8 percent, and clearcuts covered 4 percent.

Iverson et al. (1996) evaluated post-fledging habitat in Southeast Alaska by comparing habitat characteristics within 240-ha circles around 34 Queen Charlotte goshawk nests to habitat elsewhere within the surrounding 4,000 ha (the approximate average area used by goshawk pairs. They found no differences in the proportions of the seven habitat types in the 240-ha nest areas and random 240-ha circles (due to high variability). However, pairwise comparisons of habitat cover types within 240-ha and 4,000-ha circles centered on the individual nests revealed significant differences. Productive old forest was, on average, 10 percent more of the area near goshawk nests than in the larger use areas, and the proportion of clearcut and nonforest in 240-ha nest plots (27 percent) was less than that in 4,000 ha plots (30 percent). Again, this suggests a nonrandom use of habitat, with goshawks selecting for greater amounts of productive old forests in the 240 ha (post-fledging) area surrounding the nest stand.

Post-fledging Family Area - Reynolds et al. (1992) identified a somewhat more inclusive area surrounding the nest used by hatch-year birds and the adults between fledging and dispersal as critical to juvenile survival. This area varied from 120 to 240 ha, and was believed to correspond to the defended area (territory) of the resident pair. They named this the “post-fledging family area", and recommended that it be managed for hiding cover (for the fledglings) and prey habitat. Kennedy et al. (1994) used five radio-tagged adult females and 15 fledglings to evaluate post-fledging family areas in New Mexico. They found that the average adult female core area approximated the area used by fledglings prior to dispersal. Post-fledging family areas ranged from 125 to 240 ha, which they believed reflected differences in food availability.

Home Range Habitat

North America - Studies of habitat selection by radio-tagged goshawks outside their nest stands have documented disproportionate use of stands with higher canopy closure, larger trees, and greater number of large trees than found in randomly selected stands (reviewed by Greenwald et al. 2005). Most of these studies could not distinguish what the birds were doing at the time of each location (e.g., foraging, roosting, or traveling), although five studies identified foraging locations through use of posture-sensitive switches.

Most studies showed that goshawks avoided open areas and logged, early seral stands, and none showed selection for such features (Greenwald et al. 2005). Selection for stand diversity among the studies was inconsistent, with goshawks using a great variety of stand types. No selection was found for forest edges.

Some studies did not use radio-telemetry, instead relating territory occupancy or reproductive success to habitat features at the home range scale. These studies consistently showed a relationship between closed-canopy forests with large trees and goshawk occupancy. McClaren et al. (2002), however, interpreted “minimal spatial variation in nest productivity,” but “high temporal variability in nest productivity”, as indicating that ephemeral factors such as weather and prey availability have greater impact on reproductive output than habitat characteristics. They cautioned, however, that their method required adults to initiate breeding at a site, so if habitat became unsuitable birds would not nest and would not be included in the analysis.

Mahon and Doyle (2005) attributed high site fidelity and re-occupancy at nest sites with 200-meter unharvested buffers where up to 95 percent of the surrounding 24 ha was harvested in west-central British Columbia to prey communities adapted to open habitats. Conversely, logging was detrimental to goshawks in coastal rainforest habitats, where prey adapted to clearcut and young seral forest habitat are lacking (Doyle and Mahon 2003, Doyle 2006).

***Southeast Alaska* -** Habitat use by goshawks in Southeast Alaska was studied by tracking 67 radio-tagged individuals (35 adults, 29 juveniles, 3 immatures) during 1992-1996 (Titus et al. 1994, Iverson et al. 1996). Although there was much individual variation, goshawks used very high/high-volume and medium-volume old forest (see Table 3 for definitions) more often than predicted by their availability within minimum convex polygons enclosing each bird's use area. Mature sawtimber, scrub forest, and low-volume productive old forest were used in proportion to their availability and significantly less than the two higher volume cover types. Nonforest and clearcut cover types were avoided relative to other cover types and relative to their availability. There was no discernable difference in forest cover selection between males and females, or between breeding and non-breeding seasons.

Male goshawks tended to use elevation classes in proportion to their availability, but females showed selection for lower elevation classes, with females selecting for the 0-150 m elevation class disproportionately to its availability. Female relocations were also closer to the beach than systematic points but male relocations were not (Iverson et al. 1996).

***British Columbia* -** McClaren (2003a) obtained 259 locations from 63 goshawks radio-tagged on Vancouver Island between 1996 and 2001. She found 74 percent of locations in old forests, 20 percent in second-growth forests, and 4 percent in mixed old forest and second growth. Although old forest covers far less than 74 percent of the land on Vancouver Island, no statistical analysis of habitat selection has been completed for these data.

Table 3. Descriptions of forest volume classes and categories used on the Tongass National Forest, Southeast Alaska (USDA Forest Service 1997).

Forest cover type	Description
Productive Forest	Forest capable of producing at least 20 cubic feet of wood fiber per acre per year, or having greater than 8,000 board feet per acre.
Unproductive Forest	A community of at least 10 percent cover by trees that produces < 20 ft^3 per acre per year, or having < 8000 board feet per acre.
Scrub Forest	Synonymous with Unproductive Forest
Non-forested	Less than 10 percent cover by trees
Old Growth Forest	Later stages of forest stand development characterized by patchy, multi-layered canopy; trees of many age classes; large trees that dominate the overstory; large standing dead or decadent trees; and accumulations of large, down, woody material.
Mature Sawtimber	Second growth forest that has reached culmination of mean annual increment (rate of growth has begun to slow). This is approximately 75 to 150 years old in SE Alaska, depending on site productivity. Most stands in this age class are in the stem exclusion phase, although some features of understory reinitiation may begin to occur in the later stages of this age class
Productive Forest Volume Classes:	
Very high volume	Forest averaging 39,000 board feet per acre. The description of this type of forest stand is similar to high-volume productive forests.
High volume	Forest averaging 31,400 board feet per acre. Dominant trees are over 30 meters tall (100 feet), canopy cover is 65-95 percent, and understory production is moderate.
Medium volume	Forest averaging 25,100 board feet per acre, characterized by uneven-aged trees of 20-30 meters (60-100 feet) with numerous gaps in the forest canopy. The open canopy results in an abundant understory but the forest floor is still subject to snow burial.
Low volume	Forest averaging 15,700 board feet per acre, characterized by relatively open forests, tree heights of 20 meters (60 feet) or less and a very brushy understory.

Seasonal Movements

Goshawk pairs typically spend the nesting season within a defined use area around the nest. Migration distance following breeding appears to vary geographically, annually, and demographically. Some populations in the lower 48 states are apparently non-migratory (Drennan and Beier 2003); others move up to a few hundred km seasonally (Squires and Reynolds 1997, Stephens 2001, Smith and Vekasy 2003). Incursions (or "invasions") of large numbers of goshawks have been noted approximately every 10 years when cyclic prey across interior Alaska and Canada is scarce (Palmer 1988, del Hoyo et al. 1994, Doyle and Smith 1994, Squires and Reynolds 1997, Elphick et al 2001). These incursions are sometimes of all adults (Palmer 1988), suggesting poor nesting success during prey-lean years. In the Kluane region of Yukon, Canada, goshawks were year-long residents when hare numbers were high, but migrated (or became "nomadic") during periods of low hare abundance (Doyle and Smith 1994). During non-incursion years, migrant goshawks tend to be primarily immature birds at some sites (Squires and Reynolds 1997). McGowan (1975) found that juveniles in interior Alaska tended to travel farther than adults.

Taverner (1940) and Beebe (1974) characterized the Queen Charlotte goshawk as non-migratory. Studies of radio-tracked goshawks in Southeast Alaska and British Columbia support this characterization. Of 38 instances when a goshawk was monitored from the nesting season into the following winter, 28 (74 percent) remained in Southeast Alaska throughout the winter, 2 were confirmed dead, 6 were not relocated during fall or winter so may have left the region, and the remaining 2 died, lost their radios, or had radios that failed (ADF&G 1996). On Vancouver Island, McClaren (2003a) found 80 percent of 68 radio-tagged goshawks stayed within 30 km of their nests year-round, simply expanding their breeding home ranges during the winter months. A few moved to distinct wintering areas up to 100 km away (McClaren 2003a, 2003b), including two that moved to adjacent coastal mainland British Columbia (McClaren 2004) for the winter. Lewis and Flatten (2004) documented a radio-tagged male in Southeast Alaska that moved >80 km from its nesting area during the non-breeding season, and a radio-tagged female that moved >44 km from its nesting area and returned in early August (during the breeding season).

Following the nesting season, females typically moved farther, leaving the nesting area, while males stayed within and adjacent to the nesting area, in both Southeast Alaska and on Vancouver Island (Flatten et al. 2001b, Lewis and Flatten 2004, McClaren 2004). This differs from observations in Arizona, where females averaged 6.2 km from their nests during winter, and 72 percent of female relocations were within 5 km of the nest. Males were relocated 7.4 km from their nests, on average, and were found within 5 km only 45 percent of the time (Drennan and Beier 2003).

Home Range/Use Area Size

Because goshawks typically expand their home range after the breeding season, or move to an entirely different wintering area, researchers often distinguish among breeding season home ranges (or use areas), winter (or non-breeding season) home ranges, and annual (or year-round) home ranges.

Squires and Reynolds (1997) reported estimates of breeding-season home ranges in North America ranging from 570 to 3,500 ha. Males typically have larger breeding-season home ranges than females, because they hunt for the brooding female who stays at or near the nest through much of the nesting season (Kennedy et al. 1994). Large home ranges are also expected where prey is less available. Comparison of home range sizes among studies, however, is confounded by differences in methods of estimation, so direct comparison is not always appropriate (Iverson et al. 1996, Squires and Reynolds 1997).

Lewis and Flatten (2004) calculated 100 percent minimum convex polygons for 26 adult female and 29 adult male goshawks radio-tagged in Southeast Alaska. They found significantly smaller breeding-season use areas for females (mean = 4,549 ha) than for males (mean = 6,043 ha). This is consistent with the findings of Kennedy et al. (1994) in New Mexico. In an effort to reduce errors associated with outlying data points, Lewis and Flatten (2004) also calculated 95% minimum convex polygons, which resulted in a smaller difference between the sexes (females: 4,153 ha, males: 4,862 ha). These calculations updated previous estimates based on smaller sample sizes reported in Iverson et al. (1996) and Flatten et al. (2001b).

Use areas during the non-breeding season were larger than those used during the nesting season, and female use areas were larger than male use areas during that period. Minimum convex polygons for females averaged 33,839 ha (95 percent minimum convex polygon: 31,784 ha) and for males averaged 19,454 ha (95 percent minimum convex polygon: 16,503ha) (Lewis and Flatten 2004).

Year-round home ranges were 47,563 ha for females (95 percent minimum convex polygon: 42,451 ha) and 15,719 ha for males (95 percent minimum convex polygon: 12,431 ha) (Lewis and Flatten 2004). These dramatic differences between the sexes reflect longer-distance movement of females, which appear to be less tied to individual nesting areas during the non-breeding season, as compared to males, which appear to remain largely resident in their chosen nest area (though often expanding their use area during the winter).

Use areas in Southeast Alaska are considerably larger than those reported for goshawks elsewhere in North America (Squires and Reynolds 1997, Squires and Kennedy 2006). A strong inverse relationship exists between the sizes of home ranges and population densities within many raptor species (Newton 1979), likely reflecting prey availability. Many studies of use area sizes outside Alaska have relied upon ground-based telemetry, rather than tracking from aircraft as in Southeast Alaska. The likelihood of locating long-distance dispersers is expected to be higher using aerial telemetry, so comparing use area sizes in Alaska to home ranges from elsewhere using other methods may be misleading.

Food Habits

An evaluation of goshawk foraging behavior is essential for assessing the overall needs of the species (Reynolds et al. 1992). Foraging behavior can best be understood by evaluating the species's morphology, behavior, hunting style, and diet. Evaluation of the goshawk's status also requires an understanding of their prey's habitat needs and responses to forest management. Below we address the goshawk's foraging strategy and foraging habitat needs, specifics of the goshawk's diet, and habitat needs of the most commonly taken prey. Finally, we evaluate how forest management practices might affect goshawks by altering the abundance and availability of their prey.

Foraging Patterns and Habitat Use

Goshawks are the largest North American accipiter. To meet energy requirements, goshawks generally forage over long distances and capture relatively large-bodied prey (Kenward 1982, Boal and Mannan 1994, Squires and Reynolds 1997). Throughout most of the species' range, goshawks are associated with forests and woodlands. They have broad short wings and a long tail, which enable rapid acceleration and agile maneuverability necessary for catching prey within these settings. Goshawks typically forage using a short-sit, short-flight sequence. Goshawks search for quarry for a short period of time from a perch, then move to another perch, watch, move again, and repeat the process until prey is acquired (Kenward 1982). Most prey items weigh between 300 and 400 grams, but goshawks take prey ranging from about 17 grams to at least 1,500 grams (Kenward et al. 1981, Reynolds and Meslow 1984, Squires and Reynolds 1997).

Foraging habitat may be selected more for prey availability than for prey density. Availability can be affected by vegetative cover (both overstory and understory) (Reynolds et al. 1992, Beier and Drennan 1997, DeStefano and McCloskey 1997, Ethier 1999). Goshawks take advantage of the element of surprise, often using cover to conceal their approach from alert and evasive prey (Beebe 1976, Bergstrom 1985, Backstrom 1991, Squires and Reynolds 1997). Excessively dense vegetation, though, can exclude goshawks by interfering with their flight, and reduce hunting success by providing escape cover for prey (Bechard 1982, Kenward and Widen 1989, Reynolds 1989, Reynolds and Meslow 1984, DeStefano and McCloskey 1997).

Prey availability is defined by both prey numbers and habitat characteristics. Beier and Drennan (1997) found that goshawks in Arizona selected foraging sites based primarily on habitat characteristics. Sites used by foraging goshawks had a higher canopy closure, greater tree density, and higher density of large trees than random "contrast plots." There was strong selection for the densest stands (>80% canopy closure), which were also the rarest within the landscape. Medium-sized birds were less abundant at sites used by goshawks, and densities of other prey did not differ between used and random plots. During winter, goshawks appeared to select sites with higher tree densities and canopy cover, but prey abundance was nearly identical at goshawk kill sites and paired "reference" plots (Drennan and Beier 2003). Thus, in addition to adequate prey populations, suitable cover characteristics appear to be crucial for foraging success.

Older forests and woodlands in the Pacific Northwest and Alaska are generally multi-layered, with different prey species occurring in different layers. Reynolds and Meslow (1984) determined that goshawks used all layers while hunting, but foraged slightly more often in the ground-shrub layer of the forest than in the shrub-canopy, tree canopy, and aerial zones. Understory structural characteristics that promote an abundance and availability of ground and low-shrub dwelling species, together with the availability of appropriate perches above this layer, are likely essential for goshawk foraging success.

Ethier (1999) found red squirrels (*Tamiasciurus hudsonicus*) on Vancouver Island similarly abundant in old growth and second growth, but found goshawks far less common in second growth. He attributed this to reduced access to prey because of the high density of stems in second growth, which would interfere with flight lines and decrease hunting success.

Good (1998) documented goshawks in Wyoming killing prey in, then preferentially revisiting, sites with greater densities of large trees, less shrub cover, smaller openings, and larger patches of forest and conifer forest cover, compared with either random sites or sites that were visited less often.

Although goshawks are generally associated with mature and old forests, they also forage along forest edges (Kenward 1982) and some types of open areas (White et al. 1965, Younk and Bechard 1994). Goshawks use the habitats of their prey, so the regional differences in habitat preferences of goshawks likely reflect variation in prey that goshawks can effectively exploit in different areas. For example, Kenward (1982) found goshawks at forest edges in Great Britain and Sweden. There, goshawks preyed on rabbits and pheasants that inhabited adjacent fields. Goshawks perched along forest edges and hunted the ecotone. In contrast, in the boreal forest in Sweden, goshawks preyed primarily upon red squirrels, which occur in woodlands (Kenward 1982). As a result, goshawks showed no preference for edges, and within the woodland, goshawks selected for mature forest and tended to hunt in larger patches of mature forest (Kenward 1982, Kenward and Widen 1989).

<u>Diet</u>

Goshawks prey on a variety of medium-sized birds and mammals, including grouse, passerines, woodpeckers, hares and rabbits, and squirrels (Palmer 1988, Squires and Reynolds 1997). Prey taken by goshawks across North America include 21 mammal and 45 bird species (Drennan and Beier 2003). Diet varies in relation to density and availability of potential prey species.

Studies in Alaska and British Columbia have identified taxa frequently taken by nesting Queen Charlotte goshawks, but even within this region the relative importance of these taxa varies spatially, seasonally, and annually in response to availability.

Lewis et al. (2004) evaluated breeding-season diet at five goshawk nests in Southeast Alaska in each of two years using video surveillance of prey deliveries, analysis of regurgitated pellets, and examination of prey remains. The three methods produced different results, with videography providing the most complete view of breeding-season diet, revealing the greatest quantity and diversity of prey. Birds were identified in 91 percent of prey remains, 59 percent of pellets, and 78 percent of video-taped prey deliveries. Mammals (primarily red squirrels) formed the balance of identified prey in each case. Pellet analyses overestimated the importance of mammals, while prey remains examinations overestimated birds (Lewis et al. 2004).

Thrushes (primarily varied thrush, *Ixoreus naevius*) were the most commonly observed avian prey, constituting 26 percent of deliveries recorded by videography (Lewis et al. 2004). These were followed by grouse (*Dendragapus* spp.) (20 percent), jays (13 percent), Northwestern crows (*Corvus caurinus*) (7 percent), ptarmigan (*Lagopus* spp.) (6 percent) and other birds (6 percent). Red squirrels accounted for 17 percent of prey deliveries, and other mammals (mice, voles, hares and marmots) accounted for 5 percent.

Titus et al. (1994) evaluated prey remains found near 15 nests and identified ten species or species groups that were important prey of Queen Charlotte goshawks in Southeast Alaska. Five prey species or species groups were most common: Steller's jay (*Cyanocitta stelleri*) remains were found at all 15 nest sites, grouse were at 11 nests, varied thrushes at 9 nests, red squirrels at 7 nests, and woodpeckers (Picidae) were found at 6 nests. Other prey species or species groups included sharp-shinned hawks (*Accipiter striatus*; present at 4 of 15 nests), alcids (Alcidae; 3 nests), yellowlegs (*Tringa* sp. ; 2 nests), ptarmigan (2 nests), and northwestern crow (2 of 15 nests).

Doyle (2005) analyzed pellets and prey remains collected over five years from six nests on the Queen Charlotte Islands. Diet estimated from five nests on Graham Island, (the larger and northernmost of the two “main” islands of the Queen Charlotte group) was dominated by red squirrels, which were present in 80 percent of pellets, constituted 35 percent of prey items in 171 samples, and contributed 61 percent of total prey biomass. Unidentified passerines formed the next most frequently encountered class of prey on Graham Island, with large passerines in 37 percent of pellets and small passerines in 11 percent of pellets. Together these two size classes of otherwise unidentified birds contributed only six percent of prey biomass. Identified passerines (thrushes, jays, robins and crows) together added only another 2.5 percent of biomass consumed. Sooty grouse (*Dendragopus fuliginosis*) (formerly blue grouse, *D. obscurus*) constituted only 2 percent of prey by number, but because of their size they contributed over 17 percent of biomass. Various woodpeckers made up 11 percent of prey by number, but only 3 percent of biomass.

On Lyell Island (a smaller, eastern island in the Queen Charlotte group) the diet at one nest was dominated by birds (70 percent of prey items identified, and 80 percent of biomass), rather than squirrels (14 percent by number and 11 percent of biomass). Nearly 59 percent of total biomass was sooty grouse (18 percent of pellets).

Roberts (1997, cited in Cooper and Stevens 2000) analyzed 44 pellets collected below nest trees on the Queen Charlotte Islands, and found that the breeding-season diet consisted primarily of red squirrels (44 percent by number) and various songbirds (47 percent by number). Ethier (1999) examined 90 pellets from 10 nests on Vancouver Island and found the most common prey were red squirrels (69 percent of pellets), varied thrush (39 percent of pellets), Steller's jays (38 percent) and northern flicker (*Colaptes auratus;* 34 percent). He detected no grouse in the diet. Red squirrels, therefore, appear to be the single most important prey species for the Queen Charlotte goshawk in British Columbia (both Vancouver and the Queen Charlotte Islands) and much of Southeast Alaska.

Prey delivery rates in Southeast Alaska are comparable to those in other goshawk populations despite the relatively large breeding-season home ranges reported for Queen Charlotte goshawks (Table 4). Direct observation of prey deliveries underestimated delivery rates, as demonstrated by the estimates produced by the two techniques for simultaneous periods reported by (Rogers et al. 2005) in Table 4.

Two studies have reported biomass delivery rates (Lewis 2001, Smithers et al. 2005), which potentially offer a more useful comparison of habitat quality. Although prey delivery rates appear lower in Minnesota than in Southeast Alaska, prey averaged larger in Minnesota (275 g per delivery) than in Southeast Alaska (214 g per delivery in northern Southeast Alaska and 173 g per delivery in southern Southeast Alaska), resulting in biomass delivery rates in Minnesota intermediate between those of southern and northern Southeast Alaska (Table 4).

Table 4. Prey and biomass delivery rates reported for goshawks in North America.

Location	prey/hr	grams/hr	Technique	Reference
Southeast AK	0.29		Video	Titus et al. 1999
Northern SE AK	0.30	55.5	Video	Lewis 2001
Southern SE AK	0.23	32.4	Video	Lewis 2001
Minnesota	0.14	36.4	Video	Smithers et al. 2005
East-central Arizona	0.28		Video	Rogers et al. 2005
East-central Arizona	0.16		Direct Observation	Rogers et al. 2005
Northern Arizona	0.25		Direct Observation	Boal and Mannan 1994
Nevada	0.31		Direct Observation	Younk and Bechard 1994

Spatial Variation in Prey

The distribution of prey taxa varies regionally within Southeast Alaska (Iverson et al. 1996, MacDonald and Cook 1999), and British Columbia (Nagorsen 2002, Doyle 2005, Doyle 2006), with relative abundance in the diet largely reflecting local availability (Doyle 2005). For example, red squirrels do not occur on Prince of Wales Island and islands to the west (MacDonald and Cook 1999), but are common in the diet elsewhere within the range of the Queen Charlotte goshawk (Lewis 2001, Doyle 2005). Lewis (2001) documented a significantly lower proportion of mammals delivered to nests in southern Southeast Alaska (including Prince of Wales), where 99 percent of the biomass delivered was avian, as compared to northern Southeast Alaska, where mammals accounted for 26 percent of prey biomass.

Although an endemic northern flying squirrel (*Glaucomys sabrinus griseifrons*) is present on Prince of Wales Island and elsewhere in the goshawk's range (MacDonald and Cook 1999), the species is nocturnal (Burt and Grossenheider 1976), essentially unavailable to goshawks, and has not been detected in diet studies in the region. Flying squirrels are reportedly crepuscular in Oregon, where they are relatively common prey (Richard Reynolds, pers. comm., 2006).

Sooty grouse are present on most islands in Southeast Alaska and coastal British Columbia, but are absent from Prince of Wales Island and nearby islands (Lewis 2001). The Prince of Wales spruce grouse (*Falcipennis canadensis isleibi*) (an endemic subspecies) occurs on Prince of Wales and nearby islands, including Heceta, Kosciusko, Warren and Zarembo, but is absent elsewhere (Dickerman and Gustafson 1996, Russell 1999). Spruce grouse are approximately half the size of sooty grouse (Lewis 2001) and are believed to exist at lower densities than sooty grouse in Southeast Alaska (Gabrielson and Lincoln 1959, Russell 1999) potentially contributing to food stress for goshawks in the Prince of Wales area (which also has no red squirrels). Sooty grouse populations on the Queen Charlotte Islands are believed to be depressed by logging, forage competition from high populations of introduced deer and nest predation by introduced raccoons (Golumbia 2000, Pojar and Banner 1984, Doyle 2004a, Doyle 2005), although these effects appear to be less dramatic on Lyell Island than on Graham Island (Doyle 2005).

Northwestern crows are abundant along most of the marine shorelines, but rare in interior forests. They are preyed upon by goshawks that use marine shoreline (Lewis 2001), but not by birds nesting in the interior of large islands (Chytyk and Dhanwant 1997 cited in Cooper and Stevens 2000, S. Lewis, pers. comm.).

Prey choices are limited within the range of the Queen Charlotte goshawk, where hares are limited to portions of the mainland but are missing from all islands except Vancouver and Douglas islands, where they have been introduced (MacDonald and Cook 1999, Ethier 1999, Doyle 2005, Nagorsen 2002). Eastern cottontails (*Sylvilagus floridanus*) have been recently introduced on Vancouver Island, but are apparently restricted to the southern part of the island (Nagorsen 2002). Ground squirrels (*Spermophilus parryii*) are limited to portions of the mainland (MacDonald and Cook 1999, Nagorsen 2002). Grouse and tree squirrel distribution is discontinuous. By contrast, in the Olympic and Cascade mountains of western Washington (which we consider outside the range of the Queen Charlotte goshawk), primary prey include two species of grouse, band-tailed pigeons (*Columba fasciata*), snowshoe hares (*Lepus americanus*), and both ground and tree squirrels (Watson et al. 1998, Bloxton 2002). Goshawks there relied less on smaller birds which probably offer a lower energetic return for the capture effort expended (Watson et al. 1998).

<u>Seasonal Variation in Prey</u>

Most diet information is from breeding season observation. Winter diet studies have consistently documented seasonal shifts to a small number of non-hibernating mammals (e.g., squirrels, rabbits or hares) or non-migratory birds (e.g., grouse, jays), with individual birds typically specializing on one or two species of prey (Doyle and Smith 1994, Stephens 2001, Drennan and Beier 2003).

Many prey species taken in the breeding season are migratory. In Southeast Alaska, for example, varied thrushes, red-breasted sapsuckers (*Sphyrapicus ruber*) and greater yellowlegs (*Tringa melanoleuca*) are common during summer but absent or rare in winter (Armstrong 1995, Iverson et al. 1996).

Red squirrels and sooty grouse are likely the primary winter prey for most Queen Charlotte goshawks (Doyle 2006), except on and near Prince of Wales Island, where squirrels and sooty grouse are absent. Instead, the smaller and apparently less common spruce grouse is likely a primary winter prey item.

Other potential winter food sources include crows, which remain common along the shorelines in winter (Armstrong 1995), Steller's jays, and ptarmigan. Waterfowl become more abundant in Southeast Alaska during winter (Conant et al. 1988), but goshawks rarely feed on marine birds during the nesting period (Lewis 2003), and may not during winter because of this potential prey's distance from cover, the availability of open water for escape, and the risk of predation by bald eagles (*Halieetus leucocephalus*) near open water (Lewis 2003).

Ground squirrels and chipmunks (Sciuridae) are taken by goshawks outside the range of *A. g. laingi* during the spring, summer and fall (Squires and Reynolds 1997, Drennan 2006), but these species hibernate during winter and are unavailable then. These species are essentially absent from the range of the Queen Charlotte goshawk (MacDonald and Cook 1999, Nagorsen et al. 2002, Burles et al. 2004) except on portions of the mainland.

Hares and rabbits, an important winter goshawk food in many areas (e.g., Doyle and Smith 1994, Stephens 2001, Drennan and Beier 2003, Drennan 2006, Doyle 2006), are present only on Douglas Island, Vancouver Island and in isolated areas of the mainland (MacDonald and Cook 1999, Nagorsen 2002). Domestic rabbits (*Orytolagus cuniculius*) have been introduced to the Queen Charlotte Islands, but they have apparently not become well established or widespread there (Golumbia et al. 2003).

Annual variation in prey

Goshawk density and reproductive effort vary with fluctuations in snowshoe hare populations in Yukon Territory, Canada (Doyle and Smith 1994) and hare and ruffed grouse cycles in Michigan (Postupalsky 1998). Squirrel densities have also been correlated with goshawk nest activity levels and reproductive success on Vancouver Island, the Queen Charlotte Islands, and in Arizona, with higher squirrel densities noted following years with large crops of conifer cones (McClaren 1997, Ethier 1999, Doyle 2003, Salafsky 2004, Salafsky et al. 2005, Doyle 2007). To the extent that other important prey species' populations vary, goshawks may be similarly affected. For example, annual fluctuations in berry production (especially blueberries) could affect grouse reproduction, which might influence goshawk nesting if alternative prey are inadequate.

Effects of Variations in Prey

Spatial variation in prey availability affects the density of goshawk territories (Doyle and Smith 1994, Crocker-Bedford 1998a, McClaren 2003b, Reich et al. 2004). In areas with low abundance and diversity of prey, such as Prince of Wales (which lacks red squirrels, suitable alternative mammalian prey, and sooty grouse) and the Queen Charlotte Islands (where grouse populations are believed to be depressed, and alternative prey species are limited) we expect wider territory spacing (i.e., lower breeding-pair densities) than in areas with greater abundance, diversity, and availability of prey. We also expect less stability in goshawk nest activity (number of pairs attempting to nest) where prey diversity is low, as opportunities to compensate for temporal fluctuations in prey populations by switching to alternate prey are limited.

Temporal variation in prey availability can result in starvation of significant numbers of adult (Doyle 2003, McClaren 2003b) and juvenile (Wiens et al. 2006a) goshawks in local areas. Mortality of both male and female adult goshawks in Southeast Alaska was highest in late winter, when food availability is lowest (Flatten et al. 2002, Titus et al. 2002). Adult females that dispersed from their breeding areas had much higher survival rates than those that stayed over winter. Most females that died during Flatten et al.'s (2002) study were from the Prince of Wales area, which lacks red squirrels, hares and sooty grouse to support goshawks during winter (Titus et al. 2002).

Seasonal and annual variation in prey influences both the proportion of active nest areas and reproductive output (McGowan 1975, Doyle and Smith 1994, Keane 1999, McClaren et al. 2003a, Salafsky 2004, Reynolds et al 2005, Salafsky et al. 2005, Doyle 2007). Body condition of adults early in the breeding season appears to be critical to initiation of nesting, with few birds nesting in times of prey scarcity and many nesting during times of abundance. Winter food availability, therefore, probably limits goshawk reproductive effort in most years.

Nest productivity (fledglings produced per nesting attempt) fluctuates with food availability (Ward and Kennedy 1996, Dewey and Kennedy 2001, Salafsky 2004, Salafsky et al. 2005). Nestling aggression and siblicide (Estes et al. 1999) and skewed sex ratios of nestlings (favoring males) (Ingraldi 2005) have also been linked to temporal declines in food availability.

Prey Habitats

In order to evaluate the possible effects of land management practices upon goshawk prey, Iverson et al. (1996) examined the habitat associations of the ten most important prey species or species groups. Seven are primarily associated with forested habitats: Steller's jay, grouse, varied thrush, red squirrel, woodpeckers, sharp-shinned hawk, and alcids. One other important species, the northwestern crow, occurs mostly in the beach fringe habitat, and in particular, near the fringe of old forest. Most are found in higher densities in old forest than other habitats. Exceptions are Steller's jays (which are most common near edges), ptarmigan (which prefer alpine and subalpine areas), and yellowlegs (which use muskegs, beaches, and estuaries) (Iverson et al. 1996). The following text briefly describes the habitat associations and, when possible, the diet of the ten primary prey species or species groups for the goshawk. Very little is known about some prey species in Southeast Alaska. Studies conducted outside of Southeast Alaska and coastal British Columbia are reported, but how well the conclusions apply to the range of the Queen Charlotte goshawk is unknown.

Steller's jays use conifer forest stands of many ages, although maximum abundance has been reported in old forests (Noble 1977, Manuwal 1991). In Southeast Alaska, Kessler and Kogut (1985) found Steller's jays in young clearcut areas, but they were absent from older seral stages where understory vegetation was shaded out by the overstory. Kessler and Kogut (1985) also found Steller's jays in old forest, especially along streams and muskeg. Kessler (1979) considered old growth, pole, and shrub/sapling stages all moderately important, and clearcuts and young growth least important. DellaSala et al. (1996) found Steller's jays at similar densities in old growth and 20-year-old stands subjected to various treatments (i.e., thinned, "gapped," and unmodified). Iverson et al. (1996) considered the species more common near forest edges.

Two species of grouse occur in Southeast Alaska: Prince of Wales spruce grouse (on Prince of Wales and nearby islands) and sooty grouse (on the mainland and many islands, with the exception of Prince of Wales and nearby islands). Both are closely associated with conifer forests throughout their ranges (Aldrich 1963, Zwickel and Bendell 1972, Hines 1987, Zwickel 1992).

Spruce grouse use mature conifer stands in winter, and open forest habitats for courtship, nesting, and brood-rearing during spring and summer (Johnsgard 1975, Gustafson 1994, Russell 1999). Closed canopy, pole-stage stands with minimal understory development are thought to be of little value (Gustafson 1994). Radiotelemetry studies indicate spruce grouse in Southeast Alaska select bog wetlands (muskegs), old growth forest, and 15-35 year old second-growth spruce forest, and avoided clearcuts (Russell 1999). These observations are supported by Kessler and Kogut (1985), who found spruce grouse in pole stage clearcuts and young sawtimber. Spruce grouse nests on Prince of Wales and Heceta islands were in cedar-hemlock stands with high canopy cover. Brood-rearing females used open-canopy scrub forests more often than other habitat types, and displaying males used poorly drained, mixed-confer sites with open canopy, dense shrubs, and stunted conifers (Russell 1999).

Sooty grouse use forest openings and early successional-stage clearcuts during spring (Fowle 1960, Wetmore et al. 1985, Hines 1987, Manuwal and Huff 1987, Doyle 2004a). Doyle (2004a) found highest densities of sooty grouse near young clearcuts (<15 years old) adjacent to mature and old forest, and in areas with the greatest amounts of uncut forest. Use of older harvested areas was low, and use of low-productivity forest was lower than use of higher-productivity forest. Doerr et al. (1984) documented almost exclusive use of old growth by calling males in Southeast Alaska, and little use of nearby 1- to 23-year old clearcuts. Of the male grouse located within a clearcut, none were within 80 m of a forest edge, and the average distance from forested edges was 260 m. During the breeding season, males used perches in live trees for calling sites. Sooty grouse typically winter in mature or old conifer stands (Johnsgard 1975, Hines 1987) and little use is made of mid-successional stages (21 to 100 years old) (Hines 1987).

Varied thrushes reach peak numbers in moist, old forest, especially where shrub and herb understories are well developed (Noble 1977, Kessler 1979, Carey et al. 1991, Manuwal 1991). DellaSala et al. (1996) found no significant difference in varied thrush density between old forest and 20-year-old stands, but all other researchers found them significantly more common in old forest. For example, Wetmore et al. (1985) documented varied thrush densities in unlogged areas to be 3 to 30 times greater than in logged areas, with lowest densities in clearcuts. Kessler (1979) considered the species absent in clearcuts, scarce in 11-year-old stands, and most abundant in old forest. Manuwal (1991) found maximum densities in old forest, but relatively common in other age classes. Savard et al. (2000) documented higher densities in old forest than in either clearcuts or 40- to 60-year-old second growth on Vancouver Island, the Queen Charlotte Islands, and the Mainland South Coast near Vancouver. Varied thrushes forage primarily on ground and lower shrub layers of the forest.

The red-breasted sapsucker is common in Southeast Alaska; hairy (*Picoides villosus*), downy (*Picoides pubescens*), and three-toed woodpeckers (*Picoides tridactylus*) and northern flickers (*Colaptes auratus*) are uncommon, and the black-backed woodpecker (*Picoides arcticus*) is considered rare (Isleib et al. 1993). All but the downy woodpecker require mature or old forests for feeding and nesting, and their numbers are significantly higher in old forest than in earlier successional stages. Downy woodpeckers use smaller trees and often breed in orchards and urban areas (Kessler 1979; Sidle 1985; Manuwal and Huff 1987; Schoen et al. 1988; Carey 1989; Carey et al. 1991; DellaSala et al. 1996, Savard et al. 2000).

Red squirrel habitat in Southeast Alaska includes adequate conifer seeds for food, large nest trees, canopies with interlocking crowns, and large trees, snags, and fallen logs for food caches (Suring 1988, Smith et al. 2003). Spruce seeds are the primary food (Wolff and Zasada 1975). Population declines have been reported following clearcutting (Wolff and Zasada 1975, Medin 1986). Young stands are used, but are considered low-value habitat because of smaller and inconsistent cone crops and inadequate nest sites. Cone crops may be adequate by 100 years (Ruth and Bernsten 1955), but nest trees and food cache sites are generally available only after stands reach approximately 250 years. Sullivan and Moses (1986) found survival and productivity rates significantly higher in mature and older stands than in young stands. Ransome and Sullivan (2003) compared demographics of Douglas squirrels (*Tamiasciurus douglasii*) (a species similar to, but smaller than, the red squirrel) in old growth and mature second growth on the southern coast of British Columbia. They found no difference in movement, density, mass, survival, or percentage of population breeding in the two age-classes of forest, although recruitment was higher in the mature (70- to 80-year-old) second growth. Red squirrels abandon their territories following clearcut logging, and conversion of mature forests to younger stands is expected to result in short-term population reductions. Long-term population effects depend on the amount and distribution (temporal and spatial) of timber harvest (Smith et al. 2003).

Sharp-shinned hawks, like goshawks, are closely associated with forests and woodlands. Because of the sharp-shinned hawk's speed and maneuverability, it is unlikely that goshawks capture many adults; juveniles and fledglings are more vulnerable. Little is known of them from the range of the Queen Charlotte goshawk.

A variety of alcids occur in the marine waters of Southeast Alaska and British Columbia. The most common, especially along inside waters, is the marbled murrelet (*Brachyramphus marmoratus*), which forages in marine waters and nests almost exclusively in old forests (DeGange 1996). Although the species is abundant in Southeast Alaska, few nests have been found, most within the canopy but a few on the ground in old forests (DeGange 1996), demonstrating habitat overlap with goshawks. Murrelets, however, are uncommon in the diet of the Queen Charlotte goshawk in Alaska (Lewis 2001). Pigeon guillemots (*Cepphus columba*) have been taken by goshawks in Southeast Alaska. They nest along rocky shorelines and forage in near-shore waters, primarily using habitats rarely hunted by goshawks (Lewis 2003). Another alcid, the ancient murrelet (*Synthliboramphus antiquus*), nests on forested islands in burrows and is present in some areas, especially the Queen Charlotte Islands. The species may be available to goshawks, but most of its activity within the forest (entering and leaving nest burrows) is nocturnal, and the species has not been detected in diet studies to date (Ethier 1999, Lewis 2001, Doyle 2005).

A few goshawk prey species are found in lower abundance in old forests than in other habitat types. The northwestern crow uses primarily beach fringe areas throughout Southeast Alaska, especially those where old-growth forest borders beaches (Madge and Burn 1994, Iverson et al. 1996). Two species of ptarmigan are considered common or fairly common in Southeast Alaska. The willow ptarmigan (*Lagopus lagopus*) uses a variety of habitats, including shrubby alpine areas, willow and alder thickets, and riparian areas. The rock ptarmigan (*Lagopus mutus*) uses rocky upland habitats. Both species tend to summer at high elevations and winter along major stream and river drainages (Weeden and Ellison 1968, Johnsgard 1975, Isleib et al. 1993). Yellowlegs are neotropical migrants that nest and forage in muskegs in Southeast Alaska (Armstrong 1995).

Our review indicates that goshawk prey species use essentially all of the habitats and seral stages present in coastal British Columbia and Southeast Alaska, but that mature to old forest is preferred by most prey. Compared with other regions, prey adapted to open habitats is notably missing.

Demographic Characteristics

Populations can be described in terms of size (number of individuals), structure (age and sex distribution), breeding status (percentage of breeders by age class), fecundity, survival, mortality, growth rates, or other measures. Some of these statistics have been estimated for the Queen Charlotte goshawk; others have not.

Population Estimation

Estimating the size of a goshawk population is difficult for a number of reasons; no method of direct census is available. The secretive birds are spread thinly across habitat with abundant hiding cover; they are generally silent and evasive except when defending a nest and even there they are frequently missed (Patla et al. 1996, Flatten et al. 2001b, McClaren et al. 2003a, Boyce et al. 2005). Instead, indirect methods have been used to estimate the size of breeding populations. No method of estimating the size of the non-breeding population is currently available.

***Nesting Density* –** Where habitat is relatively homogeneous, goshawk pairs appear to distribute themselves relatively evenly across the landscape (Squires and Reynolds 1997, Reynolds and Joy 1998, 2006, McClaren 2003a, Reich et al. 2004, Doyle 2005, Doyle and Holt 2005, Reynolds et al. 2005, Reynolds and Joy 2006). The distance between adjacent nesting pairs appears to vary inversely with prey availability (McClaren 2003a, Reich et al. 2004), especially during winter (Doyle and Smith 1994, Doyle 2005) and is probably maintained by aggressive, territorial defense (Squires and Reynolds 1997, Reich et al. 2004). The area around the nest that is defended against other goshawks is known as a *territory*. The size of this area is unknown, but the entire area between adjacent active nests (nests in which eggs are laid) may not be defended. The territory is believed to be centered on the active nest, and therefore shifts as alternate nests are used in different years. For purposes of discussing nesting density, we refer to the distance between adjacent active nests (or recently active nests during years when a known pair does not nest) used by different goshawk pairs, and not the distance between alternate nests of a single pair. Where alternate nests are known, the geographic center of a pair's recently active nests ("territory centroid") is implied (Reynolds and Joy 2006).

Nesting densities (number of territories in a given area, inferred by average distance between adjacent territory centers or counts of known nests in a thoroughly searched area) have been evaluated in several areas across North America. Kennedy (1997) summarized mean nearest-neighbor distances of 3.0 to 5.8 km between nest areas on study sites in Oregon, California, and Washington. On the Kaibab Plateau of Arizona, territory centroids were spaced approximately 3.9 km apart (Reynolds and Joy 2006). Nest areas in west-central mainland British Columbia have been documented 4 to 7 km apart (Doyle and Mahon 2001, Mahon and Doyle 2001).

Nesting density appears to be consistently lower in the range of the Queen Charlotte goshawk. For example, McClaren (2003a) found nest areas on Vancouver Island spaced at approximately 7 km in intensively searched areas. Nest areas on the Queen Charlotte Islands have been found 9 to 15 km apart (Doyle 2005), averaging 11.3 km (Doyle and Holt 2005).

These study areas were searched systematically to enable calculation of inter-nest area distances, but variations in search intensity, observer bias, habitat density and other factors may limit comparability of results (Reynolds et al. 2005). Intensive searches for adjacent nest areas that would allow comparison of nesting densities have not been accomplished in Southeast Alaska.

***Habitat Capability* -** Breeding populations of goshawks have been estimated on Arizona’s Kaibab Plateau through extrapolation of observed territory spacing across suitable habitat (Reynolds and Joy 1998, 2006; Reich et al. 2004; Reynolds et al. 2005). Similar extrapolation of observed spacing of known nests has been modeled by various authors for coastal British Columbia (Table 5). Such estimates measure the capacity or *habitat capability* of an area, rather than population size, because they provide an estimate of how many pairs could fit into existing habitat if it were saturated. These estimates rely on discrimination of suitable habitat, which may be stratified to reflect greater capability in some areas than others. Here we follow convention from literature on this topic and refer to the area surrounding one pair’s nest area(s), up to approximately halfway between adjacent pairs’ nest area(s) as a territory, recognizing that the entire “territory” as used in this context, may not be actively defended.

Doyle (2005) used thresholds of 41 percent and 61 percent mature and old forest within 10,000-ha “predicted territories” to define potential habitat capability on the Queen Charlotte Islands. These thresholds reflected observed minimum mature/old forest composition in 10,000-ha circular plots centered on known (n=10) and successful (n=4) nests on the Queen Charlotte Island. Doyle (2005) estimated that there may have been between 54 to 58 suitable goshawk territories across the Queen Charlotte Islands prior to initiation of timber harvest. Currently, only 25 of the potential territories mapped by Doyle (2005) contain over 41 percent mature/old forest, and only 10 contain over 61 percent, suggesting that existing habitat may support only 10 to 25 viable territories. Doyle and Holt (2005) used extrapolations of observed nest area spacing (11.3 km) (instead of 10,000-ha circles) and similar definitions of suitable habitat to estimate current habitat capability of 24 to 43 potential nest areas on the Queen Charlotte Islands.

Table 5. Estimated number of potential territories and breeding pairs of Queen Charlotte goshawks on British Columbia coastal islands.

Island Group	Nest Area Spacing (mean km)	# of Territories (Habitat capability)	Avg. Territory Occupancy Rates (%)	Estim. # of Territorial Pairs
Queen Charlotte Is.[1]	11.3	24-43	43[5]	10-18[5]
Queen Charlotte Is.[2]	?	10-25	57*	4-13**
Queen Charlotte Is.[3]	7	47-53		
Queen Charlotte Is.[4]	?	50		
Vancouver Island[4]	6.9	300	55[5]	165[5]
Vancouver Island[3]	7	103-126		

Sources: [1] Doyle and Holt 2005, [2]Doyle 2005, [3] Marquis et al. 2005, [4]Cooper and Chytyk 2000, [5] McClaren 2006a,
* % of territories active in previous 3 years
** Estim. number of territories active in previous 3 years

Marquis et al. (2005) used observed nest area spacing of 7 km from Vancouver Island and the coastal mainland to place 126 theoretical territories on Vancouver Island and 53 on the Queen Charlotte Islands. Only 103 of the hypothetical territories on Vancouver Island contained over 25 percent "good" and "best" habitat, suggesting habitat capability of 103 to 126 territories. Analogous calculations for the Queen Charlotte Islands yielded habitat capability of 47 to 53 potential territories.

Not all habitat capability estimates use observed nest spacing. Cooper and Chytyk (2000) used simple proportions of the areas surveyed and unsurveyed for goshawk nests on Vancouver Island, and adjusted the result to reflect perceived higher quality of the surveyed areas, estimating that Vancouver Island may support approximately 300 pairs. Cooper and Chytyk (2000) used similar methods to estimate that the Queen Charlotte Islands may support 50 pairs.

Approximations of average home range size have also been used to estimate habitat capability. A model developed by the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, and the U.S. Forest Service in 2000 for goshawks in Southeast Alaska using hypothetical hexagonal home ranges ("cells") estimated that the Tongass National Forest could potentially support about 747 goshawk pairs at saturation. Cells covered 4,900 ha each in areas with red squirrels and 7,300 ha in areas without squirrels, approximating the average use area size (minimum convex polygons) of radio-tagged adult male goshawks (n=24). Cells with less than 20 percent productive old forest (the approximate minimum observed among radio-tagged goshawks), above 762 m (2,500 ft) elevation, or centered over saltwater were excluded (Schempf and Woods 2000).

An earlier habitat capability model for Queen Charlotte goshawks based on estimated home range sizes initially estimated that habitat in Southeast Alaska might support 810 breeding pairs, and coastal British Columbia (including the coastal mainland) 1,750 pairs (Crocker-Bedford 1990b). Subsequent refinements of the model for Southeast Alaska to reflect updated information on size of home ranges, habitat preferences, and disproportionate harvest of highest-volume stands reduced the estimate to 100 to 200 pairs in Southeast Alaska (Crocker-Bedford 1994). No new estimate was made for British Columbia, beyond the suggestion that habitat capability there was substantially less than 1,700 pairs.

***Nest Area Occupancy and Activity* –** Not all territories are occupied or active in any given year, and some are apparently unoccupied or inactive most years (Detrich and Woodbridge 1994, Squires and Reynolds 1997, Reynolds et al. 2005, Reynolds and Joy 2006, Squires and Kennedy 2006, Salafsky and Reynolds 2005). Estimates of habitat capability, therefore, exceed actual breeding populations. Some authors have adjusted habitat capability estimates with territory occupancy or nest activity rates to estimate the number of breeding pairs.

Territory occupancy, defined as presence of one or more adults in the vicinity of the nest stand during the breeding season, ranged from 66 to 79 percent across several study areas throughout the western United States (Desimone and DeStefano 2005). Doyle (2005) found territory occupancy at 6 of 10 known nest areas in the Queen Charlotte Islands in 2005 and at 5 of 8 nest areas in 2004 (60 to 63 percent occupancy). McClaren (2003a) found 54 percent occupancy of 44 nest areas on Vancouver Island between 1994 and 2002 (n=163), ranging from a low of 40 percent in 1995 to 100 percent in 1996. Occupancy was higher in contiguous forest than in fragmented forest. Flatten et al. (2001b) found 45 percent occupancy, overall, between 1991 and 1999 in Southeast Alaska.

Nest activity, or *nesting attempts,* (defined by the presence of eggs, nestlings or adults on a nest) appear to be more variable than territory occupancy, as individual goshawk pairs tend to remain in their nesting area but may not nest every year (Reynolds et al. 1994, 2005, McClaren 1998, 2000b; McClaren et al. 2002).

Goshawks are typically secretive and not always detected when they are present in a nesting area (Flatten et al. 2001). At other times they aggressively defend their nest site against human intruders. This can bias occupancy and activity estimates unless care is taken to conduct surveys thoroughly (Boyce et al. 2005, Salafsky et al. 2005) and uniformly (McClaren et al. 2002). Repeated visits can help identify occupied territories that would otherwise be considered unoccupied. Boyce et al. (2005) tested various methods and recommended three or four visits (depending on survey technique) to a nest area before considering it unoccupied. Comparisons of occupancy and activity rates among studies, therefore, are likely to be unreliable unless survey efforts are equal.

Flatten et al. (2001b) found active nests in 25 percent (annual range 19 to 36 percent) of territories known from a previous year during surveys done in Southeast Alaska from 1991 to 1999. This compares to a range of 18 to 58 percent annual nest activity for 98 to

103 nest areas on the Kaibab Plateau of Arizona between 2000 and 2002 (Salafsky et al. 2005).

Detection of territory occupancy and nest activity in Southeast Alaska was enhanced when a sample of adult goshawks was radio-tagged, allowing confirmation of occupancy or activity where call surveys failed to detect goshawks (Flatten et al. 2001b). Broadcast call surveys of known nest areas between 1991 and 1999 (n = 198) confirmed nest activity in 16 percent of territories, on average (annual range 9 to 25 percent) and occupancy only (no active nest located) at 35 percent. Searches of nesting areas with telemetry receivers where goshawks had previously been radio-tagged (n = 40), however, found active nesting in 77 percent of the territories (annual range 40 to 100%). These searches do not represent a random sample of territories, as only active breeders were radio-tagged, so it is unlikely that 77 percent of all potential territories were active, but Flatten et al. (2001b) did conclude that a significant proportion of goshawks and active nests were probably not detected during searches using only broadcast calling.

The "Canadian Northern Goshawk (*A. g. laingi*) Recovery Team" (Canadian Recovery Team) estimated the breeding pair population on Vancouver Island by adjusting the number of potential nest areas predicted by Cooper and Chytyk (2000) using observed territory occupancy rates to conclude that Vancouver Island might support about 165 pairs (McClaren 2006a). Adjustment of Marquis et al.'s (2005) estimate of 103 to126 potential territories suggests there may be about 57 to 70 occupied territories on Vancouver Island. The Canadian Recovery Team used observed territory occupancy rates from the Queen Charlotte Islands to calculate that 10 to 18 of Doyle and Holt's (2005) 24 to 43 potential territories might be occupied by goshawk pairs. Doyle (2005) used nest activity rates (rather than occupancy rates) to conclude that only 4 to 13 territories might currently support breeding on the Queen Charlotte Islands (Table 5).

The Southeast Alaska interagency team that estimated habitat capability for the Tongass National Forest at 747 potential territories concluded that territory occupancy and nest activity rates were too uncertain to allow accurate estimation of the breeding pair population (Schempf and Woods 2000). If occupancy rates in Southeast Alaska are similar to those measured by Flatten et al. (2001b), though, the region probably has several hundred occupied territories, with a few hundred pairs breeding during most years.

In summary, although population estimates are of low precision and vary considerably, various methods have produced estimates on the order of about 70 to 180 pairs in Canada, and a few hundred to several hundred pairs in Alaska.

Detection Rates **-** Evaluation of nesting densities (discussed above under "Nesting Densities") and home range sizes (discussed above under "Home Range/Use Area Size") suggest that Queen Charlotte goshawk populations may exist at lower densities than goshawks studied elsewhere. Other indications of comparatively low-density populations include detection rates on standardized surveys.

Patla et al. (1996) tested efficacy of tape-broadcast surveys for locating goshawk nests in southeast Alaska by broadcasting near known goshawk nests, replicating studies conducted in Arizona and New Mexico (Kennedy and Stahlecker 1993). Response rates were comparable to those recorded in the southwestern United States. Watson et al. (1999) also found detection probabilities using broadcast calling at known nest sites in coastal rainforests (in Washington State) similar to those reported from the southwestern United States. Detection rates on Vancouver Island within known, active nesting areas, however, were lower than reported by Kennedy and Stahlecker (1993) (McClaren et al. 2003a).

Schempf et al. (1996) reported 0.56 detections per 100 stations, using standardized broadcast call surveys as described by Joy et al. (1994) while surveying 717 stations in wilderness and roadless areas of Southeast Alaska in 1995. This was significantly lower than Joy et al.'s (1994) 1.0 to 2.0 detections per 100 stations in Arizona.

Ethier (1999) systematically surveyed forested areas on Vancouver Island from 1994 to 1996 at 2,584 call stations, eliminating nesting areas from his survey area to reduce bias from repeated sampling in known nest areas. He had 0.93 detections per 100 call stations, with highest response rates in old-growth forest and lowest response in second growth. Detections in fragmented forest were intermediate.

McClaren (2003a) reported that broadcast surveys on Vancouver Island at 3,789 stations between 1991 and 2002 resulted in 52 goshawk detections (1.4 detections per 100 stations). Much of this sampling (especially after 1999) was done within known nest areas to determine occupancy and locate alternate nests, however, so it is not directly comparable to Schempf et al.'s (1996) or Ethier's (1999) efforts, which systematically sampled habitat independent of known nests.

U.S. Forest Service biologists in Southeast Alaska conducted broadcast call surveys and valley watches at 6,276 sites across the Tongass National Forest in proposed timber harvest units (to locate nests that would require protection under Forest Plan standards and guidelines) and at known nest areas (to determine nest site activity) between 1992 and 2005. They reported 234 detections (3. 7 detections per 100 stations) (USDA Forest Service 2006b). These surveys, like McClaren's (2003) surveys, are not directly comparable to Schempf et al.'s (1996) or Ethier's (1999) efforts, because they were in known nest areas or were concentrated in high-volume stands, increasing the probability of detecting goshawks. Furthermore, they did not follow strict sampling protocols (sample stations were variably spaced, etc.). Guidance for monitoring goshawks at bio-regional scales was recently produced by the Forest Service Washington Office (Woodbridge and Hargis 2006), but a program consistent with this guidance has not been implemented in Alaska.

<u>Population Trends</u>

Changes in goshawk population status could potentially be documented through evaluation of count data from migration monitoring stations; trend data from existing, broad-scale avian monitoring programs; productivity measures and other demographic data that allow estimation of population growth rates; changes in historical geographic distribution (range contraction or expansion); encounter rates from standardized detection surveys; trends in density of breeding pairs; or trends in availability of preferred habitat (Andersen et al. 2004). Each of these data sources has limitations, and none offer a clear picture of goshawk population trends in the western United States (Anderson et al. 2004) or in coastal British Columbia/Southeast Alaska.

Kennedy (1997) reviewed available literature on goshawk populations in the western United States and concluded that existing data on range contraction, population density, fecundity, survival, and rates of population change were all insufficient to determine population trends. Smallwood (1998) pointed out that the statistics Kennedy (1997) evaluated were unreliable or imprecise at the continent-wide scale she addressed. Crocker-Bedford (1998b) asserted that demographic statistics alone are unlikely to provide sufficient information on population status for goshawks because of limitations of sample sizes and confounding variables such as prey availability, weather and the degree of population isolation. Smallwood (1998) encouraged range-wide evaluation of habitat fragmentation and migratory counts as methods for detecting trends in goshawk populations. Crocker-Bedford (1998b) pointed out that documentation of a population decline is not among the five factors to be considered when making a decision on whether a species should be listed under the *Endangered Species Act*. Instead, he recommended a habitat-based review that considers deforestation and maturation rates of impacted forests, with evaluation of goshawk habitat requirements at three levels: breeding pairs, local populations, and regional metapopulations. DeStefano (1998) recommended that decisions on the status of goshawks be based on availability of old (and presumably mature second growth) forest along with data on demography and distribution. Kennedy (1998) believed that habitat monitoring should augment demographic studies, and suggested that models to predict relationships between habitat and population trends could be developed once habitat needs are better understood and adequate demographic data are available. Migration counts were suggested as a potential tool for monitoring trends in regional goshawk populations in some areas (Kennedy 2003). The Queen Charlotte goshawk is not migratory (Iverson et al. 1996, McClaren 2003a, Flatten et al. 2001b), so this method is not feasible for the subspecies.

Productivity of Queen Charlotte goshawks has been studied on Vancouver Island (McClaren 2003a), the Queen Charlotte Islands (Doyle 2005) and in Southeast Alaska (Titus et al. 1999, Flatten et al. 2001b). Survival estimates have been reported for Southeast Alaska (Flatten et al. 2001b, Titus et al. 2002), yet data remain inadequate to confidently assess rate of population change (McClaren 2003b, McClaren 2004).

Doyle (2005) estimated the number of “territories capable of supporting breeding” on the Queen Charlotte Islands, based on the observed percentages of mature and old forest within occupied and active territories, and concluded that there may have been between 54 to 58 territories in 1800, but that logging has reduced that number to as few as 10 to 25 suitable territories, with only 4 to 13 actually supporting breeding. Similar modeling with somewhat different parameters (Doyle and Holt 2005) predicted that suitable goshawk territories will continue to decline until about 2055, then recover slightly as second- growth stands mature prior to harvest, supporting between 17 and 38 suitable territories. Doyle (2005) cautioned, though, that “at the present rate of productivity, insufficient young are possibly being produced to allow the population to be maintained.”

Crocker-Bedford (1990b) modeled goshawk habitat capability as a function of breeding pair density in various habitats across Southeast Alaska. He concluded that goshawk habitat capability on the Tongass National Forest declined by over 26 percent between 1954 (when industrial-scale clearcutting began) and 1988. Higher rates of timber harvest on non-National Forest lands in Southeast Alaska, plus region-wide timber harvest prior to 1954, contributed to an estimated overall decline in habitat capability of 30 percent across Southeast Alaska. Habitat capability was estimated to have declined by 49 percent in coastal British Columbia (Crocker-Bedford 1990b). Crocker-Bedford’s (1990b) model relied on his estimations of breeding pair densities (which have not been measured in Southeast Alaska), and how he believed such densities would vary with percentage of productive old growth forest on the landscape at a watershed scale. (Actual relationships between percentage of forest and goshawk populations have not been quantitatively measured within the range of the Queen Charlotte goshawk.) Habitat capability on the Tongass National Forest was estimated to have declined by 26 percent even though only 10 percent of the old-growth forest was logged because logging was concentrated in areas that were originally the least fragmented (Crocker-Bedford 1990b). These estimates have not been verified by field work, and must be considered an untested hypothesis.

Although information remains incomplete, several reviewers have concluded that widespread habitat loss throughout the subspecies range suggests that the population is declining (Crocker-Bedford 1994, Cooper and Chytyk 2000, Cooper and Stevens 2000, Gotthardt et al. 2005).

<u>Nest Productivity</u>

Productivity in birds is typically defined as the number of fledglings (or advanced nestlings) per occupied nest, occupied territory, or territorial pair (i.e., birds observed in the vicinity of a nest or similar evidence of occupancy) (e.g., Postupalsky 1974, Steenhof 1987, Kennedy 1997, Salafsky et al. 2005). Many goshawk studies, however, report the number of fledglings (or advanced nestlings) per active nest or nesting attempt (i.e., nests in which eggs were laid) (e.g., Iverson et al. 1996, Squires and Reynolds 1997, Reynolds and Joy 1998, Reynolds and Joy 2006, McClaren 2003a), or per successful nest (i.e., nests which produced at least one fledgling) (e.g., Squires and Reynolds 1997, Reynolds and Joy 1998, Reynolds and Joy 2006). Because territory vacancy can be difficult to determine and likely has been inconsistently estimated, we use fledglings per active nest (which is commonly reported in goshawk literature) for comparison among studies.

A great majority (87 percent) of Queen Charlotte goshawk nesting attempts known from the Queen Charlotte Islands, Vancouver Island, and Southeast Alaska (n = 293) have produced fledglings (Table 6). Productivity has averaged 1.6 young per active nest in British Columbia, and 2.0 per nest in Alaska (Table 6). These statistics are within the range of published productivity and nest success figures for various goshawk populations of North America (Table 6).

Most Queen Charlotte goshawk nests, like many of the nests in other studies, have been found in the latter stages of breeding, presumably biasing nest success estimates because of undetected failures. To eliminate this bias, some researchers (e.g., Reynolds and Joy 1998, Flatten et al. 2001) calculated nest success and productivity using only the subset of nests known prior to the period reported (i.e., individual nests were not included in calculations of nest success and productivity for the year they were discovered).

Ninety-one percent of 11 nests in Southeast Alaska located in March and April (during nest-building or early incubation stages) were successful, producing an average of 1.9 fledglings per nest (Iverson et al. 1996). This compares to 94 percent success (and 2.1 fledglings per nest) overall for the same period (1991 to 1996), suggesting that bias in productivity calculations from including nests found later in the nesting season is rather slight but perhaps real.

Large annual fluctuations in goshawk breeding populations are documented in both Europe and North America (Newton 1979, DeStefano et al. 1994a, Doyle and Smith 1994, Squires and Reynolds 1997, Finn et al. 1998, Postupalsky 1998, Reynolds and Joy 1998, McClaren et al. 2002, 2003, 2004; Doyle 2003, Fairhurt and Bechard 2005), and are likely caused by prey fluctuations and/or weather, which affect overwinter survival and condition of adults.

McClaren et al. (2002) reported significant annual fluctuations in nest productivity on Vancouver Island, but only minimal variation among nest areas within years. This pattern was also shown for study sites in New Mexico and Utah (McClaren et al. 2002), suggesting that area-wide, temporal variation in prey and/or weather had greater effect on productivity than territory quality.

If goshawks do not attempt breeding unless environmental conditions allow a reasonable probability of success, the comparison of most interest among populations, perhaps best reflecting long-term reproductive viability, may not be mean brood size or nest success, but the proportion of the population that attempts to breed (i.e., breeding propensity) (Reynolds et al. 2005).

Table 6. Mean fledglings per active nest and percent nest success in North American goshawk studies. Location abbreviations: C = central, E = eastern, EC = east-central, N = northern, S = southern, SE = southeastern.

Years	Location	Nesting Attempts	Fledglings per attempt	% Nest Success	Source
1991-99	Alaska (SE)	113	2.0	93	Flatten et al. 2001
1994-02	Vancouver Island	141	1.6	81	McClaren 2003
1995-04	Queen Charlotte Is.	39	1.6	94	Doyle 2005
1971-73	Alaska(C)	33	2.0	----	McGowan 1975
1987	Arizona (N)	12	2.1	100	Crocker-Bedford 1990
1987	Arizona (N)	2	0.5	50	Crocker-Bedford 1990
1991-96	Arizona (N)	273	1.6	83	Reynolds and Joy 1998
1992-02	Arizona (N)	435	1.7	78	Reynolds et al. 2005
1990-92	Arizona (N)	22	1.9	91	Boal and Mannan 1994
1993-98	Arizona (EC)	109	1.3	70	Ingraldi 2005
1993-94	Arizona (SE)	14	1.5	79	Snyder 1995
1981-83	California	181	1.7	91	Bloom et al. 1986
1984-92	California	84	1.9	87	Woodbridge and Detrich 1994
1987-90	California	23	1.4	78	Austin 1993
1992-95	Idaho/Wyoming	39	1.8	50	Patla 2005
1998-02	Idaho/Wyoming	20	1.8	20	Patla 2005
984-88	New Mexico	16	0.9	44	Kennedy 1989
1991-92	Nevada	36	2.2	-----	Younk and Bechard 1994
1992-02	Nevada (N)	212	2.3	91	Fairhurst and Bechard 2005
1984-95	New Mexico	80	1.3	-----	McClaren et al. 2002
1977-90	New York/NJ	36	1.4	80	Speiser 1992
1998-01	Minnesota	43	1.9	38-83	Boal et al. 2005
1969-74	Oregon	48	1.7	90	Reynolds and Wight 1978
1992-93	Oregon	50	1.3	-----	DeStefano et al. 1994a
1992	Oregon	12	1.2	83	Bull and Hohmann 1994
1994	Oregon/Washington	81	1.6	90	McGrath et al. 2003
1972-76	South Dakota	17	1.4	76	Bartelt 1977
1991-99	Utah	118	1.3	-----	McClaren et al. 2002
1968-92	Wisconsin	184	1.6	73	Erdman et al. 1998
1989-92	Yukon	19	2.3	73.6	Doyle and Smith 1994

Survival

Adult goshawk survival rates have been studied in several locations in North America (Table 7). Adult female survival has typically averaged higher where sample sizes allow for separation by gender, but variance associated with these estimates results in overlapping confidence intervals for the genders.

Table 7. Survival rates (and standard errors) for adult goshawks in North America.

Location	Adult Females	Adult Males	All Adults Combined	N	Study Duration (Yrs)	Source
SE Alaska			0.72(0.16)	39	4	Iverson et al. 1996
SE Alaska	0.74(0.06)	0.59(0.10)		32F/31M	8	Flatten et al 2002
Arizona	0.87(0.05)	0.69(0.06)	0.82(0.05)	99F/94M	6	Reynolds and Joy 2006
Arizona	0.75(0.02)	0.75(0.02)		294	9	Reynolds et al. 2004
California	0.69(0.09)	0.61(0.05)	0.66(95)	40F/55M	2	DeStefano et al. 1994b
New Mexico			0.86(0.09)	45	11	Kennedy 1997

Most adult mortality in Southeast Alaska and on Vancouver Island occurs in late winter (Titus et al. 2002, McClaren 2003a), when prey densities are lowest and snow or other factors may limit prey availability. Dead birds recovered were emaciated or in areas with limited prey, and food stress or starvation was suspected (Titus et al. 2002, McClaren 2003a).

Survival was significantly higher for females dispersing outside their breeding season range after the nesting season (0.96, SE = 0.03) than for females who stayed on their breeding season ranges throughout the year (“resident females”) (0.57, SE = 0.12) (Flatten et al. 2002). Five of eight resident females that died were in prey-poor areas of southern Southeast Alaska with no red squirrels or sooty grouse, which are believed to be important winter prey elsewhere within the range of the Queen Charlotte goshawk (Titus et al. 2002).

Adult male survival in Southeast Alaska (0.59) is among the lowest reported for the species. This may be partially explained by use of tailmount transmitters, which were used on some males, but no females. Reynolds et al. (2004) demonstrated reduced annual survival of goshawks tagged with tailmount vs. backpack transmitters in Arizona (0.29 vs. 0.75).

Squires and Kennedy (2006) reviewed juvenile survivorship rates for North America and Europe and found annualized survivorship between 0.16 and 1.0, with the lowest reported from Southeast Alaska. Supplemental feeding trials demonstrated that survival of juveniles is sometimes enhanced when additional food is available, indicating that prey availability may limit survival in some areas during some years (Ward and Kennedy 1996, Dewey and Kennedy 2001, Wiens et al. 2006a).

Wiens et al. (2006a) measured survival of 89 juveniles in Arizona during fledgling dependency (the time between fledging and dispersal from the nest area, when young birds are fed and protected by the adults) and following dispersal (when the young leave the nest area and become independent). They found significant variation in survival among years (1998 to 2001), but limited variance among or within broods during any given year. During fledgling dependency, survival was lowest during the first week out of the nest and increased as the young birds approached dispersal age. Survival declined upon initiation of dispersal, but again increased with time. Survival during both periods was highest in years with greater prey abundance, ranging from 0.82 to 1.0 during fledgling dependency and from 0.48 to 0.87 following dispersal. Fledglings succumbed to predation and starvation throughout their first year.

Broberg (1997a) estimated annual juvenile survival of Queen Charlotte goshawks in Southeast Alaska at 44.5 percent, based on a percentage of reported radio-tracking recoveries between 1992 and 1994. This estimate assumed mortalities for those birds not relocated after January, potentially biasing the estimate as some may have been alive but outside the area monitored, or with failed transmitters.

Natal Dispersal

Fledglings typically learn to fly and hunt within a few hundred meters of their nest (see ***Post-fledging Area***, above) then leave the nest area and do not return. Ultimately, some establish breeding territories of their own. This process is known as *natal dispersal*. Such dispersal is critical to population dynamics and genetic structure of metapopulations, which often include source and sink areas (Greenwood 1980, Arcese 1989, Greenwood and Harvey 1989, Wiens 1996, Paradis et al. 1998). Radio-marked juvenile goshawks often disperse beyond their natal populations in the southwestern United States, a factor believed to be important to maintaining regional metapopulations (Fairhurst and Bechard 2003, Wiens et al. 2006b).

Fledglings in Southeast Alaska have shown a mean maximum movement of 63 km (range 11 to 163 km) from their nest sites. Following initial nomadic movements away from their nest sites, juveniles often established use areas in late fall and winter where they were consistently relocated until radio tags either failed or were shed, or mortality occurred. These cannot be considered natal dispersal distances because no juveniles were followed through a subsequent breeding season. They do demonstrate considerable mobility, however, including crossings of substantial water gaps (Titus et al. 1994, Iverson et al. 1996).

Kennedy and Ward (2003) used food supplementation to demonstrate that food availability affects juvenile movements, with supplemented birds wandering from the natal area sooner, but returning and remaining in the natal area through the fall, while control birds dispersed. Thus, dispersal movements may reflect relative availability of prey in non-supplemented populations.

Breeding Dispersal

In most cases, breeding goshawks re-occupy and (when conditions allow), re-nest in the same territory they used the previous year. This is known as breeding philopatry, site fidelity, or territory fidelity. While goshawks typically exhibit territory fidelity, they often (though not always) use an alternate nest within their territory in subsequent years. Advantages of territory fidelity include familiarity with food and cover within the territory, and defensive advantage in territorial aggression (Greenwood and Harvey 1982). Movement of a breeding adult from one nest territory to another in subsequent years is known as *breeding dispersal* (Greenwood and Harvey 1989). Such moves often follow reproductive failures, and are more common among young birds than old ones (Newton and Marquiss 1982, Greenwood and Harvey 1982). Food shortages have been implicated in breeding dispersal by sparrowhawks (*Accipiter nisus*), a smaller, forest-dwelling accipiter of Europe, and are suggested as the ultimate cause of both reproductive failure and breeding dispersal (Newton and Marquiss 1982).

Reynolds and Joy (2006) documented high territory fidelity (97 percent for males, 94 percent for females) and mate fidelity (99 percent for males, 97 percent for females) among goshawks on Arizona's Kaibab Plateau. In contrast, relatively low territory fidelity (56 percent) was documented among 18 female goshawks monitored at least 2 years in Southeast Alaska. No males changed territories (n=11) during the seven-year study. Female breeding dispersal season was believed to be related to food stress, as over-winter survival was high for females that dispersed (0.96), but low for those who did not (0.57), and 5 of the eight that dispersed were in prey-poor areas that lack red squirrels and sooty grouse (Flatten et al. 2001, Flatten et al. 2002, Titus et al. 2002, Titus et al. 2006).

In Arizona, where territory fidelity was 97 to 99 percent, territory occupancy was estimated at 95 percent during years with high nest activity (Reynolds and Joy 2006). Reliable territory occupancy estimates are not available for Southeast Alaska, but the comparatively high rate of breeding dispersal in Southeast Alaska suggests that vacant territories are readily available and (like low nest density, large home range size and low survey detection rates) suggests comparatively low overall population density among Queen Charlotte goshawks.

Females that dispersed paired with new mates in their new territories as, presumably, did the males that stayed in the territories those females left. Thus, mate fidelity largely matched territory fidelity in Southeast Alaska (Flatten et al. 2001).

Researchers expect Queen Charlotte goshawks (juveniles and adults) to move among islands and the mainland of Southeast Alaska, between Southeast Alaska and mainland British Columbia, and among Vancouver Island, the British Columbia mainland and the Olympic Peninsula (Robus 2006, McClaren 2006a). Talbot et al. (2005) found evidence that birds on the Queen Charlotte Islands, however, are genetically separated from other populations, with little contemporary gene flow into those islands from the neighboring mainland or island populations.

Life-table Calculations

Table 8 presents required productivity (young per active pair) for population stability under a variety of assumptions believed reasonable for Queen Charlotte goshawks. Comprehensive data are lacking for juvenile survival, age of first breeding, and percent adults breeding. There is some information on Queen Charlotte goshawk productivity (1.6 to 2.0 young per active pair (see Table 6)) and on adult survival (0.72 annually (Iverson et al. 1996), 0.59 for males and 0.74 for females (Flatten et al. 2002)). In other goshawk populations, adult survival estimates have tended to be higher (see Table 7). Table 8 considers the effects of two adult survival rates, 0.72 and 0.80, to evaluate the sensitivity of the model to this statistic. Juvenile survival estimates for other goshawk populations have generally been between 0.35 and 0.50 (Newton 1979, Kennedy 2003), so Table 8 considers these values. Finally, goshawks in many populations rarely breed at 1 year of age, but do breed at 2 years where territories are available (e.g., Reynolds et al. 1994, Younk and Bechard 1994, Wiens and Reynolds 2005), so the table presents the effects of age at first breeding of two and three years. Percent of traditional territories with active pairs in various studies and years has varied from less than 25% to more than 75% (Reynolds and Joy 1998), although Flatten et al. (2001b) documented a range of only 19 to 36 percent activity in previously known nest areas in Southeast Alaska between 1991 and 1999. Table 8 presents several values for percent of adults breeding.

Adult survival, juvenile survival, age of first breeding, and percent of adults breeding all influence required levels of productivity. A modest change in adult survival (0.72 to 0.80) appears to be especially effective in influencing results. This pattern is typical for long-lived species, which need to produce only a small number of young over their lifetime to maintain their populations.

Since productivity within the range of the subspecies has averaged 2.0 or fewer fledglings per active nest (Table 6), a high percentage of birds must breed when relatively young, given the observed survival rates. Should actual mean adult survival be roughly 0.8, many of the parameter combinations examined demand productivity no greater than documented for the wild population, especially if age of first breeding averages closer to 2 than to 3 and more than 50% of adults normally breed. With lower adult survival, as measured in Southeast Alaska, proportion of adults breeding and productivity would have to be higher than observed in most scenarios.

These calculations assume no immigration, which is probably not the case for much of the range of the Queen Charlotte goshawk. Preliminary genetic investigations suggest that there is little or no contemporary gene flow into the Queen Charlotte Islands (Talbot et al. 2005), but birds from elsewhere probably do enter the goshawk populations on Vancouver Island and in Southeast Alaska (Talbot 2006).

Table 8. Required productivity for stable populations of monogamous birds based on various demographic assumptions (sex ratio assumed 1:1, populations assumed free of emigration or immigration).

Demographic assumptions				Required young per active pair per year
Adult Survival = 0.72				
	Juvenile Survival = 0.35			
		First breeding age 2		
			25% adults breed	9.0
			50% adults breed	4.5
			75% adults breed	3.0
			100% adults breed	2.2
		First breeding age 3		
			25% adults breed	12.5
			50% adults breed	6.3
			75% adults breed	4.2
			100% adults breed	3.1
	Juvenile Survival = 0.50			
		First breeding age 2		
			25% adults breed	6.2
			50% adults breed	3.1
			75% adults breed	2.1
			100% adults breed	1.6
		First breeding age 3		
			25% adults breed	8.6
			50% adults breed	4.3
			75% adults breed	2.9
			100% adults breed	2.2
Adult Survival = 0.80				
	Juvenile Survival = 0.35			
		First breeding age 2		
			25% adults breed	4.8
			50% adults breed	2.9
			75% adults breed	1.9
			100% adults breed	1.4
		First breeding age 3		
			25% adults breed	7.3
			50% adults breed	3.6
			75% adults breed	2.4
			100% adults breed	1.8
	Juvenile Survival = 0.50			
		First breeding age 2		
			25% adults breed	4.0
			50% adults breed	2.0
			75% adults breed	1.4
			100% adults breed	1.0
		First breeding age 3		
			25% adults breed	4.1
			50% adults breed	2.6
			75% adults breed	1.7
			100% adults breed	1.3

Population Viability Analysis

Population viability analyses are mathematical modeling procedures used to study demographic prospects of small populations. Population viability analyses can provide valuable insights into vulnerability of wild populations and the factors most important in producing population changes. Nevertheless, population viability analyses have been criticized because of (1) inadequate demographic data in most cases, (2) difficulty in validation of model outcomes, and (3) strong effects of various alternative modeling assumptions on those outcomes (Boyce 1992, Ralls and Taylor 1997, Beissinger and Westphal 1998, Groom and Pascual 1998, Reed et al. 1998). Lacking relevant demographic data, population viability analyses have commonly been constructed using estimates of demographic parameters and have yielded results of largely unknown accuracy qualifying only as hypotheses of unknown validity. Such results, therefore, might best be considered evidence, but not facts.

Beissinger and Westphal (1998) tabulated the data requirements for various population viability analyses. Even the technique demanding the least amount of data, deterministic single-population modeling, has information requirements exceeding available demographic knowledge for the Queen Charlotte goshawk. Because of these data limitations, results of any PVA for the subspecies must be recognized as only a set of hypothetical scenarios.
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Broberg (1997a) modeled population viability for Queen Charlotte goshawks based on assumptions of various population demographics including initial population sizes of 243 and 417 individuals. Population survival beyond 100 and 200 years was sensitive to juvenile survival (modeled at 35 to 50 percent), with probability of extinction increasing dramatically when juvenile mortality exceeded 45 percent. Population growth rate was stable, implying stochastic effects would be the most likely cause of extinctions. Additional analyses of stable versus declining habitat carrying capacity (Broberg 1997b) suggested that population viability was similar for most scenarios whether habitat capability remained stable through the modeling period or if it declined at 0.5 percent per year.

Genetic Considerations

Extinction is commonly considered a demographic process (Beissinger and Westphal 1998), but genetic deterioration can also contribute to extinction in some populations (Mills and Smouse 1994). Genetic drift and inbreeding effects can lower the adaptive norms of small populations, in part through increased expression of lethal genes and loss of genetic diversity. As yet, no studies of genetic threats to the Queen Charlotte goshawk have been conducted, and it is unknown if the subspecies is experiencing genetic stress.

The Queen Charlotte goshawk (*A. g. laingi*) is potentially separated from *A. g. atricapillus* by the Coast Range mountains, a barrier of high, glaciated peaks along the mainland with habitat unsuitable for occupancy by goshawks. Dispersing goshawks may occasionally travel across the ice fields or through the few major river valleys that transect the mountains.

The potential for gene flow from *atricapillus* goshawks is much greater at the southern end of *laingi* range, where Vancouver Island lies in close proximity to the more continuous forested habitat of northern Washington and southern mainland British Columbia. Jewett et al. (1965) and Beebe (1974) suggested that a zone of intergrades exists on Vancouver Island. Indeed, genetic analyses by Talbot (2006) suggest that goshawks on Vancouver Island are genetically closer to *atricapillus* than the goshawks on the Queen Charlotte Islands or in Southeast Alaska. Examinations of goshawks from Southeast Alaska by Webster (1988), Titus et al. (1994), and Iverson et al. (1996) also suggest a zone of intergrades between *atricapillus* and *laingi* goshawks there, in terms of coloration and size, with a cline of increasingly larger birds to the north.

Preliminary work by Gust et al. (2003) suggests that goshawks in Southeast Alaska and coastal British Columbia may represent a metapopulation (a group of subpopulations characterized by local extinctions and recolonizations). Metapopulations are more vulnerable to loss of genetic diversity and overall extinction than other population structures because their effective population size is smaller than other structures of similar size. Vulnerability is largely a function of gene flow and extinction rates among subpopulations (Frankham et al. 2002).

Immigration is crucial in countering genetic deterioration (Frankham et al. 2002), but little direct information is available on the extent of immigration of *atricapillus* goshawks into the range of *laingi* and the extent of mixing among sub-populations within *laingi* range. Talbot et al. (2005), however, found genetic evidence of little or no contemporary gene flow into the goshawk population on the Queen Charlotte Islands, suggesting that the small population there may be at risk from genetic isolation.

Observation of intergrades in Southeast Alaska and on Vancouver Island, and genetic evidence of *atricapillus* heritage among goshawks on Vancouver Island suggest that genetic risks in those areas may be related more to genetic dilution and hybridization, rather than from isolation and loss of genetic diversity.

PART II -- EFFECTS OF FOREST MANAGEMENT ON GOSHAWKS

Local and Regional Scale Influences

Timber harvest affects goshawks at local and regional scales by impacting nest sites, prey abundance, or prey availability. Local effects of timber harvest can be addressed in the demographic terms of individual survival and productivity, whereas if sufficient individuals are affected, population level effects will occur. The following section addresses potential effects of timber harvest at both scales. Because few data are available on *laingi* population responses to timber harvest, this discussion includes information about goshawks in other locations.

Nest Habitat

Goshawks nest in large patches of mature to old trees with relatively closed canopies, although exceptions have been noted in some areas (reviewed by Squires and Reynolds 1997 and Daw et al. 1998). Nests tend to be located in the least fragmented areas of individual home ranges (Bloxton et al. 2003), and nest areas in large patches of old or mature forest are used more consistently than those in small patches (Woodbridge and Detrich 1994). Mature and old forest surrounding the nest is believed to be important to fledglings learning flight and hunting skills (Schnell 1958, Kennedy 1989, Reynolds et al. 1982). Logging within and near nest stands has been implicated in nest site abandonment, although effects of such logging on productivity have varied (Crocker-Bedford 1990a, Penteriani and Faivre 2001, Doyle and Mahon 2003, Mahon and Doyle 2005). Goshawks require trees with adequate structure (limbs or multiple tops) to hold their nests. Logging could conceivably remove all such trees (in adequate size patches) from the central portion of a nesting territory where nests are located to maintain territorial spacing (Reynolds et al. 2005), thereby limiting goshawks locally. Individual trees with adequate structure to support nests are likely to persist or regenerate in most cases, but these remnant trees must be surrounded by patches of mature or old forest large enough to include clusters of alternate nests and provide post-fledging habitat. Lack of such consideration is likely to result in gaps in nesting distribution, and reduction or loss of breeding populations in logged areas.

Effects on Prey

Studies across North America show logging can affect avian abundance, species richness, bird community composition, and nesting success (Sallabanks et al. 2001). On the Queen Charlotte Islands, Savand et al. (2000) found breeding bird density and diversity higher in old forest than in 40- to 80-year-old second growth forest. Species evenness was similar among forest age classes. On Vancouver Island, bird density, diversity, and evenness were higher in old forest than in 40- to 80-year old second growth, but species richness was similar (Savand et al. 2000). Species that were consistently more abundant in old forest included the brown creeper (*Certhia americana*), chestnut-backed chickadee (*Parus rufescens*), hairy woodpecker, marbled murrelet, Pacific-slope flycatcher (*Empidonax difficilis*), red-breasted nuthatch (*Sitta canadensis*), varied thrush, Vaux's swift (*Chaetura vauxi*), and winter wren (*Troglodytes troglodytes*). Three of these (thrush, woodpecker and murrelet) are important goshawk prey species. Bird communities in clearcuts were highly variable, but consistently favored dark-eyed juncos (*Junco hyemalis*), fox sparrows (*Passerella iliaca*), orange-crowned warblers (*Vermivora celata*), and song sparrows (*Melospiza melodia*) (Savand et al. 2000), all small birds that contribute little to the goshawk diet.

Six of the ten primary prey species (or species groups) reviewed above are associated with old forest (grouse, varied thrush, red squirrel, woodpeckers, sharp-shinned hawk, and alcids) and are expected to be adversely affected by timber harvest (Iverson et al. 1996). Three species (northwestern crow, yellowlegs, and ptarmigan) are not expected to be affected by timber harvest (Iverson et al. 1996). Steller's jay is associated with mature and old forest, but may be more common along forest edges than in contiguous old forest (Sieving and Willson 1998), so forestry practices that create edges could benefit Steller's jays in some situations.

Although some prey species are adversely affected by logging, others may benefit. As forest succession progresses, the abundance and availability of prey is likely to change. For example, spruce grouse on Prince of Wales Island avoided clearcuts, but used 15- to 35-year-old second growth (Russell 1999). Older second growth was largely unavailable in Russell's study area, so its value to spruce grouse is unknown.

Goshawks may be able to forage in second-growth stands as they approach maturity. Stands containing trees that begin cone production within the rotation cycle may provide habitat for red squirrels, if crowns interlock to allow the squirrels to travel from tree to tree in the canopy, and if remnant trees from the previous stand provide other structural requirements, such as locations for food caches and nests (Ransome and Sullivan 1997). Doyle (2004b) documented increased evidence of red squirrels in 40- to 59-year old stands on the Queen Charlotte Islands, especially on high-productivity, spruce-dominated sites, as compared to younger second growth and lower-productivity sites without spruce. (No second-growth stands over 60 years old were sampled). These time frames are likely to be longer on lower-productivity sites, sites without spruce (e.g., only hemlock and/or cedar, which have smaller cones), and where climate is colder (e.g., north through Southeast Alaska). Silvicultural treatment, such as thinning to accelerate growth of individual trees, also affects the age at which stands become useful to squirrels and goshawks.

The importance of cone production to red squirrels, and of red squirrels to goshawks, is highlighted by observations from Vancouver Island and the Queen Charlotte Islands, where goshawk reproductive performance varied with red squirrel numbers and cone crops (Ethier 1999, Doyle 2003, 2007).

The effects of logging on goshawk prey communities depend in part on the condition of the surrounding area. Widen (1997) reviewed the effects of forest management on goshawks in Fennoscandia, and concluded that fragmentation of mature forest patches reduced hunting opportunities where remaining patches were surrounded by second-growth forests. Forest/farmland edges in Scotland, however, appeared to provide preferred hunting habitat, as these edges were used by pheasants (*Phasianus colchicus*) and hares (*Lepus europaeus*) (Kenward 1982).

The rainforests of Southeast Alaska and insular British Columbia generally lack suitable-sized prey adapted to large openings and edges. Doyle and Mahon (2003) compared effects of clearcut logging on prey availability in west-central British Columbia versus the island rainforest landscape of the Queen Charlotte Islands. They concluded that clearcut harvesting of the island rainforest may result in loss of foraging opportunities, due to the lack of prey species adapted to open clearcut or young seral forest there, whereas goshawk productivity appeared to be unaffected or possibly improved by such harvesting in west-central British Columbia, where prey diversity and abundance was enhanced (Mahon and Doyle 2005, Doyle 2006). Suitable-sized prey adapted to the open conditions produced by logging (e.g., hares and ground squirrels) were present in the west-central British Columbia study area, but are absent from most of the coastal rainforests.

American robins (*Turdus migratorius*) are common in clearcuts, yet they are infrequently preyed upon by goshawks in British Columbia and Southeast Alaska. American robins contributed only 3 percent of prey deliveries in Southeast Alaska, while the similar-sized varied thrush, which is found primarily in mature and old-growth forest, contributed 10 percent of deliveries (Lewis 2001). Although robins are more abundant in harvested areas than in nearby old forest, Lewis (2001, p. 113) did not find the species more abundant in the diet where timber harvest was heaviest. Alternatively, Ethier (1999) used cast pellets (which overestimate bird contribution to the diet (Lewis et al. 2004)) to determine that robins were 13 percent of the diet at nests in second-growth forests on Vancouver Islands, but only 2 percent at nests in old growth forest.

Structural Effects of Forest Management on Foraging

Prey availability is a function of both prey abundance and prey vulnerability. Forest management can affect both.

Goshawks hunt by alternating short flights with a period of watching from a perch. Once prey is spotted, an attack is launched from the perch (Squires and Reynolds 1997). This method of hunting relies on cover to conceal the predator’s approach, perches from which to observe and attack, adequate visibility for spotting prey, and adequate space between trees to allow for flying between perches and attacking prey (Reynolds et al. 1992).

Logging removes both cover and perches. Goshawks will hunt forest edges if prey occur there, but the centers of large openings are of little value to a raptor that launches attacks from perches rather than from the air, as many other hawks do. Smaller openings, which maximize edge and minimize the area outside a goshawk’s strike zone, are believed to have lower impacts on goshawk foraging than larger clearcuts (Reynolds et al. 1992).

Selective harvests, which leave some proportion of the trees standing in the harvest unit, are likely to have less impact on goshawk foraging than clearcuts, provided that the remaining trees have branches adequate to support goshawk perching (Detrich and Woodbridge 1994). Guidelines for management of goshawk habitat on National Forests in the Southwestern U.S. call for retention of clumps of mature trees with interlocking crowns to support red squirrels and other mature-forest prey, interspersed by a mixture of age classes and stem densities (Reynolds et al. 1992, Long and Smith 2000).

Forest canopy removal stimulates new growth, and within a few years most harvest units in the temperate rainforest are stocked with a dense layer of herbs, shrubs, and tree seedlings. Such habitats may hold prey, but goshawks show no preference for such areas

(Iverson et al. 1996, Greenwald et al. 2005), probably because visibility is limited and access to prey is hindered by dense undergrowth.

The shrub/forb understory layer is eliminated as conifer trees outgrow the shrubs, shading them under a dense, interwoven canopy. In Southeast Alaska this occurs in about 25 to 35 years on productive forest sites (Alaback 1982). These young forests contain very high densities of relatively small trees. Russell (1999) documented relatively high use of such stands by spruce grouse on Prince of Wales Island in Southeast Alaska, but high stem densities likely exclude goshawks, because the stands are too dense for the goshawks to efficiently fly through. As with earlier seral stages, prey using these stands are likely not available to goshawks. Various studies have shown that goshawks generally avoid these “early seral” stands (Iverson et al. 1996, Crocker-Bedford 1998b, Greenwald et al. 2005).

With age, some trees out-compete their neighbors, and stem densities decline. Doyle (2004b) measured stem densities in second-growth stands on the Queen Charlotte Islands, and concluded that goshawks could access prey (primarily red squirrels) in stands as young as 40 to 59 years old on the most productive, spruce-dominated sites. This approximates the age of some nest stands on Vancouver Island (McClaren 2003a) further suggesting that on the best sites in the southern portion of the temperate rainforest, Queen Charlotte goshawks can exploit stands that are approximately 50 years old. This will take longer on colder or less productive sites (Doyle 2004b), including most or all of Southeast Alaska.

Trees typically reach economic maturity (when annual growth rates begin to slow, or culmination of Mean Annual Increment) well before they reach maximum size and development (Daniel et al. 1979). Silvicultural practices within the range of the Queen Charlotte goshawk are based largely on 80- to 120-year rotation lengths, with the shortest rotations in the southern portion of the range on high-productivity sites, and longer rotations in the northern portion of the range, and on higher-elevation and lower-productivity sites (USDA Forest Service 1997). Minimum harvestable age is estimated at 50 years for the most productive Douglas-fir sites on Vancouver Island, although harvest ages of 70 to 100 years are typical of most coastal western hemlock sites on Vancouver (BCMF 2004b, p. 83-84) and the Queen Charlotte Islands (BCMF 2000, p. 125). Trees of this age are considered “mature sawtimber.” Little such forest currently exists in Southeast Alaska, as large-scale industrial logging began in the 1950s and did not peak until several decades later (US Forest Service 1997). Both Vancouver Island and the Queen Charlotte Islands currently support substantial stands of mature sawtimber. Large areas of younger second growth in Southeast Alaska will reach that stage over the next several decades (discussed in detail in Part III, below). Such stands typically have very sparse understories, because light interception is high.

Shade-tolerant shrubs and forbs begin to recolonize the forest floor as trees reach approximately 140 to 160 years (Alaback 1982). Some of the dominant trees begin to die, creating small openings. These developments provide food and cover for a variety of birds and small mammals, some of which are suitable prey for goshawks (e.g., sooty grouse, woodpeckers, Steller’s jays, varied thrush).

Old forest develops as younger trees mature in the gaps created by the loss of the older, dominant trees, creating a multi-layered canopy in approximately 300 to 500 years (Alaback 1982, Alaback 1990). The diverse understory and significant accumulation of downed logs tends to be patchy, offering a combination of cover for prey and hunting opportunities for goshawks. Under current management regimes, it is unlikely that old forest characteristics will develop on lands managed for timber production in either Southeast Alaska or coastal British Columbia because second-growth stands become economically viable just as they become structurally suitable for goshawk nesting and foraging.

In summary, quantity and quality of habitat for goshawk foraging diminishes where productive old forest is converted to early seral stages. This decrease is partly attributable to a reduction in prey abundance in younger forests, and from an immediate reduction in concealment cover and hunting perches, followed by a period of dense second growth with little or no understory. Small-scale timber harvest that emulates natural disturbances might have only localized and negligible adverse effects on goshawks and their prey, but large-scale clearcuts are likely to adversely affect goshawk foraging opportunities and success.

The size of goshawk home ranges is likely determined by the need to include adequate foraging area (Kenward 1982). If habitat alteration reduces availability or abundance of prey in some habitats, and eliminates part of the landscape as habitat in which prey occurs and goshawks can hunt, it is likely that goshawks will have to expand their home ranges to include adequate foraging area. Physiologically, foraging is a trade-off between the energy expended to acquire food and energy derived from its acquisition. The energetic demands of foraging increase with distance traveled. The thresholds for individual survival and for supplying food to nestlings and a brooding mate in this energy balance are unknown, but habitat alteration that decreases foraging efficiency will push individuals and broods toward that threshold.

Longer travel distances during foraging increase energy demands on adults, increasing the probability that adults may abandon nests. Iverson et al. (1996) documented three adult females in Southeast Alaska abandoning their nest sites and young during the fledgling-dependency period. In these cases, the females permanently abandoned their territories, occupying separate non-breeding season use areas and establishing new breeding season use areas the following year. In all three cases, the males continued provisioning the young, but it is unknown if the survival or fitness of the young was affected. Similar behavior has been noted in female Cooper's hawks (*Accipiter cooperii*) (Kelly and Kennedy 1993) and sparrowhawks (Newton and Marquiss 1982) in poor physical condition. If habitat alterations contribute to impaired physical condition of adult goshawks, and their poor condition stimulates them to abandon their nests, mates, and broods, habitat alteration could affect survival or fitness of both adults and young.

There is also potential to increase the proportion of the breeding population that foregoes breeding while searching for a new territory, mate, and prey.

Fledglings learn flight and hunting skills in the area immediately surrounding their nests (see "Post-fledging Area" section, above). Logging that reduces prey availability or structural integrity of the habitat for foraging in the area surrounding the nest stand is likely to increase mortality among fledglings during this vulnerable period.

Competition and Predation

Timber harvest that converts old forests to early seral stages facilitates increased density of potential competitors or predators such as red-tailed hawks (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*), both of which exist in Southeast Alaska and tend to use more open habitats than goshawks (Armstrong 1995, La Sorte et al. 2004). Great horned owls occasionally prey on goshawks, especially juveniles (Weins et al 2006a), and predation could increase if owl density increases following logging or if logging removes cover near nest sites that help protect nestlings from predators (Reynolds et al. 1982, Moore and Henny 1983, Boal and Mannan 1994).

Increased foraging distance during nesting could adversely affect reproductive success by increasing the time adults spend away from nests, decreasing their ability to protect young from adverse weather and predators. Newton (1986) found that when prey supplies were low, female sparrowhawks foraged further from nests and the incidence of nest failure due to predation and adverse weather increased. In areas where the landscape is broken into islands, such as within much of the range of Queen Charlotte goshawk, goshawk home ranges may include several adjacent islands (e.g., several home ranges on north Prince of Wales Island). If traveling distances during foraging are increased in these areas due to habitat alteration, adults returning to nests with prey will presumably have to make more open water crossings, increasing their vulnerability to predation and kleptoparasitism by bald eagles (Lewis 2003).

Population Level Response

Habitat alteration and fragmentation can affect goshawk survival and productivity at the population level if it decreases foraging habitat quality across the landscape. Dense understories resulting from large-scale conversion of old forests by fire and timber harvest limit goshawk populations in the Coast Ranges of Oregon by restricting access to the diverse and abundant prey communities that exist there (Reynolds and Meslow 1984, DeStafano and McCloskey 1997).

Newton (1979) summarized studies of many raptor species demonstrating that raptor populations are limited by either food or nest sites, whichever is in limited supply. He noted changes in food supply commensurate with changes in the density of raptors. Marked changes in sparrowhawk population size occurred when 20 percent of the suitable woodland habitat was harvested, with population decline disproportionate to the decrease in woodland habitat area. Declines continued despite an abundance of unoccupied nesting sites, although many of these were not in optimal habitat (Newton 1986), suggesting that prey availability posed the limitation rather than nest sites.

Several investigators have concluded that food availability, as controlled in part by habitat structure, is more likely than nest sites to limit goshawk populations (Doyle and Smith 1994, Ward and Kennedy 1994, Younk and Bechard 1994, Reynolds and Joy 1998, Reynolds et al. 2006).

Conservation Assessment for the Northern Goshawk in Southeast Alaska

A 1996 assessment of goshawks in Southeast Alaska (Iverson et al. 1996) synthesized research conducted in Alaska, with relevant information from elsewhere within the species' range. The assessment included a series of conclusions about the ecology of goshawks ("General Conclusions") and how timber harvest could or will affect goshawks and their prey ("Management Considerations"). Each of these conclusions is described below, with page number/paragraph number citations indicating where relevant information for each conclusion is discussed in the assessment.

General Conclusions

Goshawks in Southeast Alaska nest in areas that differ from the surrounding landscape. Despite considerable variation, the amount of productive old forest surrounding nests (240-ha scale) contain an average of 9 to 11 percent more productive old forest than in the surrounding 4,000-ha circles. Nests have not been found in clearcuts or early seral forests. Therefore, a reduction in the amount of productive old forest reduces goshawk nesting habitat (68/4, 62/6).

Radio-tracked goshawks were relocated in productive old forest 67 percent of the time. Clearcutting reduces the amount of this preferred habitat type (63/1+2).

Relocations of goshawks in scrub forest often occurred in patches of old forest too small to be detected in the GIS-based method of habitat analysis. Therefore, the value of scrub forest to goshawks may depend on the presence of productive old forest inclusions, and the proportion of relocations identified as occurring in productive old forest likely underestimates the proportion of time goshawks spent there (63/1+2).

The use of scrub forest, and variability in its availability among goshawk use areas, likely accounts for much of the variability in the amount of productive old forest within goshawk use areas. The negative impact to goshawks of converting old forest to early seral stage stands will be less in areas where extensive, high quality scrub forest with old forest inclusions can provide compensatory foraging habitat (72/3).

The size and habitat composition of goshawk use areas varied widely, but the minimum proportion of productive old-growth forest within breeding season use areas was 23 and 28 percent for males and females, respectively. It is unknown how goshawks would be affected by reducing the proportion within the landscape below these levels. However, Goodman (1987) proposed that vulnerability to extinction from chance environmental events substantially increases when habitat quality is reduced to near-minimum conditions (64/3).

Goshawks occupy the top trophic level in the forest community, and are thus susceptible to disruptions in lower trophic levels. Reductions in prey populations will likely reduce the probability of persistence of goshawks (65/3).

Habitat quality for 8 of 10 important goshawk prey species or species groups is reduced by harvest of productive old-growth forest. These species are most abundant and available to goshawks in productive old forest. Although goshawks in Southeast Alaska forage in a variety of habitat types, reductions in the abundance and availability of important prey taxa will cause a reduction in the abundance, productivity, and survival of goshawks (68/5).

Goshawks in Alaska have large home ranges, with males and females having median breeding season use areas of 4,400 and 3,600 ha, respectively. Studies in Europe (Kenward 1982) indicate that the size of home ranges is largely determined by the need for adequate foraging area. Birds monitored in more modified habitat on northern Prince of Wales Island used larger areas than birds elsewhere in Southeast Alaska, attributable to both habitat modification and naturally lower prey species diversity found there (63/4, 68/6).

The large size of goshawk use areas in Southeast Alaska is relevant to conservation for two reasons. First, individuals with large home ranges may be energetically stressed, have lower productivity, and may be less resilient to additional stress. If so, the Southeast Alaska population may be more sensitive to reduction in habitat quality than populations with smaller home ranges. Second, management efforts intended to conserve goshawk habitat must conserve large areas in order to be adequate (65/3).

Goshawks are long-lived, have low productivity, and occur at low densities. In Southeast Alaska they appear to be nonmigratory. Demographic sensitivity analysis of species with these life history traits shows that adult survival rates greatly affect population growth ("growth" is used here to include both positive and negative changes in population size). Therefore, habitat changes that affect adult survival rates might adversely affect the probability of persistence of the population. Survival rates could be negatively affected, particularly during periods of stress, by forest management if prey density or availability is reduced (65/1).

It is unknown if goshawk populations in Southeast Alaska are declining. However, if the amount and quality of habitat available to goshawks limits their population size, trends in population size can be inferred from trends in habitat. Goshawks require old forest, although the relationship between goshawk numbers and amount of productive old forest is likely nonlinear. It remains unknown what effect reducing the amount of productive old forest to any given level will have, but abundance of goshawks will probably decline if the amount of old forest declines below some critical level (66/3).

It is likely that productive old forest already harvested contained goshawks and their prey at densities comparable to those found in unharvested areas, so goshawk abundance has likely been reduced by the previous intensive timber harvest. The magnitude of this decline and the implications at the population level remain unknown (66/4).

<u>Management Considerations</u>

Iverson et al. (1996) estimated the relative habitat quality of seral stages and of forest stands exposed to timber harvest at a variety of temporal and spatial scales. Stands in the stem initiation phase (0 to 25 years after harvest) provide no nesting habitat and, at best, minimal foraging habitat, the quality of which depends on site-specific conditions. During the stem exclusion phase (30 to 150 years), the forest is too dense for foraging, and provides little nesting habitat until late in this stage. In understory reinitiation (150 years plus), foraging habitat gradually begins to improve. Nesting is not likely until the latter part of this period when trees become larger. Old forests (> 250 years) provide the best habitat for both foraging and nesting.

Silvicultural practices that emulate the processes that create the natural forest structure and community will have less impact upon goshawk populations than large-scale, even-age management. Uneven-aged silviculture that removes single trees or groups of trees was considered best for goshawks because it would retain some older trees for nesting and maintain relatively high value foraging habitat in a variety of areas across the landscape and habitat for a diverse suite of prey.

Iverson et al. (1996) evaluated landscape-scale habitat quality produced by 200- and 300-year rotations. Under a 200-year rotation, about 5 percent of the available forest is cut every decade. At any time, roughly half the forest would be aged 0-100 years (stem initiation and stem exclusion stages), and half the forest would be 100-200 years. During the latter half of this older age class the understory would begin to develop. Although Iverson et al. (1996) considered a forest under a 200-year rotation to be of higher value to goshawks than one under a 100-year rotation (where there would be no stands older than 100 years), they concluded that it was unlikely that goshawks could persist in forest devoid of an old-growth component.

Under a 300-year rotation, about 3.3 percent of the forest would be cut per decade, and any time after a complete rotation approximately one-third of the forest would be 0-100 years old, one-third would be 100-200 years old, and one-third would be 200-300 years old. Thus, approximately two-thirds of the forest would be mature sawtimber and old forest. Iverson et al. (1996) used two lines of reasoning to conclude that goshawks would have a high likelihood of persistence in such a landscape.

First, about 70 percent of goshawk radio relocations were in mature and old forest, which is nearly consistent with the landscape that would result from a 300-year rotation.

Second, the mean proportion of productive old forest within breeding season use areas (100 percent minimum convex polygons) was 48 percent, with a standard deviation of 15. They assumed that the proportion of old forest within use areas equated to the proportion of that habitat type needed within the landscape to have a high probability of sustaining goshawks. Thus, managing for a forest containing 48 percent productive old-growth would provide for only roughly one-half of the population (half of the birds had more productive old growth than average). One standard deviation above the mean (63 percent old-growth forest) would provide for most of the population, and thus would have a much greater likelihood of sustaining a viable population of goshawks across the landscape. Iverson et al. (1996) noted that this level was consistent with 68 percent of radio-relocations occurring in old-growth forest.

PART III - CONDITION OF THE FOREST IN SOUTHEAST ALASKA AND BRITISH COLUMBIA

The current and projected future conditions of the forest in Southeast Alaska and British Columbia are presented below. In Southeast Alaska, this largely means the Tongass National Forest (77 percent of the landscape), although the National Park Service manages approximately 13 percent, the State of Alaska 5 percent, Native Alaskan corporations 3 percent, and other land owners (municipal, private and other agencies) 3 percent (Appendix A, Table A-8). Management by these landholders varies dramatically, as discussed below.

In British Columbia, most of the forest is managed by the Provincial government. Private land covers 29 percent of Vancouver Island, but only about 1 percent of the Queen Charlotte Islands (Appendix A, Table A-6). Much of the private land is held by logging companies and is vulnerable to timber harvest, and most of the remainder of private land is subject to timber harvest, agriculture, or other development. As in Alaska, therefore, the future of goshawk habitat in British Columbia is largely dependent on management of public lands.

Tongass National Forest Lands, Alaska

The Tongass National Forest covers 6.76 million ha, 6.3 million ha of which is within the range of the Queen Charlotte goshawk as we define it. About 60 percent is forested (with >10 percent tree cover), and the remainder is wetland, alpine areas, rock, and ice. Of the forested land, 57 percent (2.2 million ha, or 30 percent of the total Tongass) is *productive forest* (see Table 3 for definitions). The remaining 43 percent of the forested land is *unproductive forest* (Table 9), which includes scrub forest, muskeg, and cottonwoods (USDA Forest Service 1997, p. 3-248).

About 11 percent of the productive forest has been cut to date, and an additional 9 percent is scheduled for harvest (Table 9).

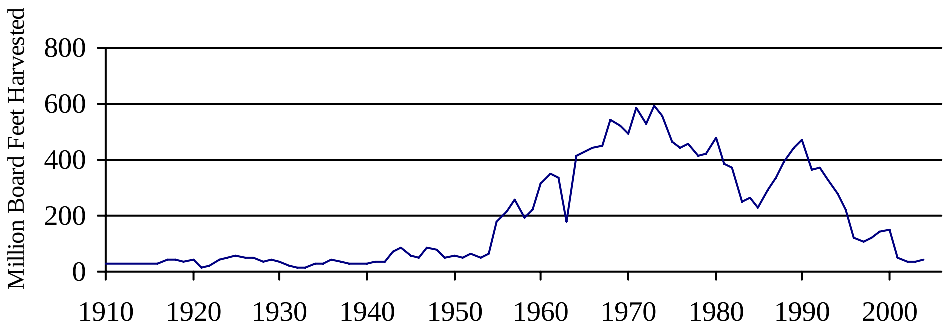
Table 9. Forest area for the Tongass National Forest, excluding the Yakutat Ranger District (which is outside the range of the Queen Charlotte goshawk). Sources: USDA Forest Service 1997, p. 3-248; Goldstein 2006; Rose 2006b; Nested subsets of left-justified data sum to totals immediately above in each column.

Attribute	Hectares	% of Prod. Forest	% of Prod. Old Growth
Total Land Area	6,290,000		
Productive Forest	2,214,000	100	
Productive Old Forest	1,981,000	89	
Second growth <100 yr old	219,000	11	
Second growth >100 yr old	7,000	0	
Non-productive Forest	1,670,211		
Non-forested	2,405,790		
Productive Old Forest	1,981,000	89	100
Non-development designations	1,399,000	63	71
Congressionally designated	801,000	36	40
USFS designated	598,000	27	30
Development designations	582,000	26	29
Scheduled for harvest	195,000	9	10
Inoperable/unsuitable	208,000	9	10
Retention/buffers	179,000	8	9

Commercial logging was initiated in Southeast Alaska in the late 1800s, and an estimated 18,000 ha of productive old forest were harvested prior to 1954 (Iverson et al. 1996, p. 7). In 1954, a major pulp mill was completed in Ketchikan and industrial-scale logging was initiated in 1955. Timber harvest increased from 41 million board feet per year from 1909 to 1952 to 380 million board feet per year from 1955 to 1995 (USDA Forest Service 1997, Table 3-73), then declined to 89 million board feet per year between 1996 to 2004 (USDA Forest Service 2006) (Figure 2). Recent declines are due to several factors, including changes in market conditions (Brackley et al. 2006), more restrictive standards and guidelines in the 1997 Tongass Land and Resources Management Plan ("Forest Plan" or "Plan") (USDA Forest Service 1997), and litigation (USDA Forest Service 2006). This history of timber harvest is relevant to goshawks because it has created large blocks of second growth near (now closed) pulp mills in Ketchikan and Sitka and an operating sawmill in Wrangell.

Projections of future harvest are uncertain. In 1997, the Forest Service projected that 192,000 ha of productive old forest would be harvested between 1997 and 2095 with full implementation of the alternative selected for the 1997 Forest Plan (Iverson 1997). Market forces changed and demand for timber from the Tongass National Forest has declined significantly, prompting a revision of previous estimates (Brackley et al. 2006). The most recent projections estimate demand for the period 2005 through 2025 to range from 48 to 370 million board feet per year. The higher demand levels would occur only if new manufacturing facilities (e.g., fiberboard or ethanol plants) are constructed to utilize low-grade logs unsuitable for high-quality lumber (Brackley et al. 2006).

Figure 2. Volume of Timber harvest on the Tongass National Forest, 1910-2004 (Sources: USDA Forest Service 1997, USDA Forest Service 2006).



The current Forest Plan allows for harvest of up to 267 million board feet per year (USDA Forest Service 1997). Given 100-year rotations as described in the plan, the amounts of harvested and unharvested lands were projected to stabilize as harvest shifted entirely to second growth around 2055, 100 years after industrial-scale logging began (Table 10). Because demand for timber has been less than expected when the plan was developed and harvests have been lower than projected, the shift from a harvest dominated by old (previously unharvested) forest to a harvest of primarily or exclusively second growth will likely be delayed.

Table 10. Past and projected amounts of old and mature forest on the Tongass National Forest (Data sources:, [a]USDA Forest Service 1997, Table 3-3; [b]Iverson et al. 1996, p. 7; [c]Rose 2006a, [d]USFWS 1997a; [e]Iverson 1997; all other values calculated from these data). Differences in projection methods for 2055 and 2095 explain 2055 POF harvest exceeding 2095 POG harvest.

Year	POF[1] Present (ha)	POF Harvested to Date[3] (ha)	POF Harvested to Date[3] Percent	Mature Sawtimber[2] (ha)
1909	2,231,000	0	0	0
1954	2,213,000	18,000[b]	1	0
1996	2,049,000[a]	164,000[b]	7	18,000[b]
2005	2,019077	176,000[c]	8	18,000[b]
2055	1,867,000[d]	364,000	16	148,000[d]
2095	1,875,000	356,000[e]	16	158,000[d]

[1]POF = productive old forest
[2]Mature sawtimber defined as 75-150 years old
[3]Compared to 1909 baseline

Rate of Harvest

Iverson et al. (1996) concluded that an ecological rotation of 300 years (i.e., approximately 1/3 of the forest in second-growth between 0 and 100 years old, 1/3 between 100 and 200 years old, and 1/3 older than 200 years, when considering all harvested and unharvested forest lands) would likely sustain goshawks. They evaluated projected harvest rates and identified areas that would exceed such a harvest rate by 2055 with full implementation of the existing (1979) Forest Plan (USDA Forest Service 1979). At the Forest-wide scale, harvest was within the 300-year rotation in both 1995 and 2055. Analysis at this scale, however, could mask effects of intensive harvests that could create gaps in goshawk distribution across the forest. The analysis was therefore repeated for biogeographic provinces. They identified one province (North Central Prince of Wales Island), of 20 on the Forest within the range of the goshawk, with more than 13 percent harvested by 1995 (the threshold for the amount that could be harvested by year 40 of a 300-year rotation). By 2055 (after 100 years of industrial-scale logging), half of the biogeographic provinces would exceed 33 percent of the forest harvested. Provinces at risk by 2055 were scattered across the Forest.

On a finer scale, the Tongass is subdivided into 140 management areas (139 within the range of the Queen Charlotte goshawk) that range in size from thousands to hundreds of thousands of hectares. Harvest rates exceeded a 300-year rotation in 27 (19 percent) of 139 management areas in 1995. These were spread across the Forest. By 2055, 73 of the management areas (52 percent) were projected to exceed that objective.

Distribution of Old and Mature Forest

The impact on goshawks of cutting a given proportion of the old forest (as evaluated by Iverson et al. 1996) will vary depending on the amount of the landscape that was forested to begin with. For instance, cutting 50 percent of the forest in an area completely covered with productive old forest will result in a landscape that is still 50 percent old-growth forest, and probably could still support goshawks. In an area that is only 50 percent productive old-growth forest prior to harvest, removal of 50 percent of the forest will result in a landscape consisting of only 25 percent old-growth forest, which may not be adequate (Doyle 2005).

Conversely, lightly harvested areas may appear secure, offering a buffer for more heavily harvested areas. In reality, many areas with little timber harvest (e.g., much of the eastern mainland, and southern Baranof Island) had little forest to begin with, and probably can support very few goshawks.

USFWS (1997a) focused on areas of high quality habitat in their analysis of historical, current, and projected future distribution of old and mature forest habitat. By identifying regions within the Tongass that originally contained substantial amounts of preferred habitat, and comparing those to areas already logged or projected to be logged, they identified areas of conservation concern.

The Forest Service has subdivided management areas (which were evaluated by Iverson et al. (1996)) into Value Comparison Units that are typically 4,000-8,000 ha, most following watershed boundaries (USDA Forest Service 1997). Some Value Comparison Units with little or no forest are much larger. There are 877 Value Comparison Units within the range of the Queen Charlotte goshawk (as defined by USFWS 1997a, which excluded lands north and west of Lynn Canal and Icy Strait) on the Tongass National Forest. Their smaller size provides better resolution in determining geographic patterns and changes over time.

Most Value Comparison Units had between 30 to 70 percent cover by productive old forest in 1995; 27 percent had less productive old forest and 19 percent had more. Goshawk use areas, as defined by 100 percent minimum convex polygons of radio-locations, were more narrowly focused: most use areas had between 30 and 60 percent old growth; only 8 percent had less than 30 percent old forest, and 17 percent had more than 60 percent old forest (USFWS 1997a).

Goshawks select for old-growth forest, spending time in this cover type disproportionately to its availability, with 68 percent of locations in productive old forest. Only 2 goshawks (3 percent) spent less than 30 percent of their time in productive old forest, and only 17 percent spent less than half their time there (Iverson et al. 1996). Thus, landscapes containing a higher proportion of old forest appear to be higher quality habitat for goshawks.

Habitat quality was defined by the percentage of selected habitat (old and mature forest) in the Value Comparison Units. High quality habitat was defined by mature and old forest within one standard deviation above the mean percent of old forest in goshawk use areas (i.e., 48 to 63 percent old and mature forest). Lower quality Value Comparison Units were defined as those within one standard deviation below the mean observed in goshawk use areas (i.e., 33 to 48 percent). Value Comparison Units with greater than 63 percent mature and old forest were considered highest quality, and those with less than 33 percent were considered lowest quality (USFWS 1997a).

These categories are relative; a quantitative comparison of their value is not appropriate but they can be used to compare habitat quality *among* areas in a general sense. Goshawks use nonproductive (scrub) forest in proportion to its availability (Iverson et al. (1996), so scrub forest may also be important in determining habitat quality.

The analysis illustrates the geographic distribution of productive old forest, so that areas dominated by old forest and areas where old forest is scarce can be recognized. However, the primary value of this method is to illustrate the change in habitat quality *within* areas over time as old forest is converted to early seral forest.

Mature forest, a development stage with less structural complexity than old forest, is likely to remain a very small percentage of the landscape where timber is managed on 100-year rotations (Table 10). This age class is included with old forest in the definition of habitat quality, though, because goshawks have shown positive selection for it.

In 1954, prior to industrial-scale logging, much of the eastern mainland and northern island areas within the Tongass were in the lowest quality habitat category, while much of the southern and central Tongass were in higher quality categories. Most timber harvesting has been in areas with the highest volume forests, reducing portions of the best quality habitat to lower quality habitat, as defined by the percentage of old and mature forest in each Value Comparison Unit (Figure 3). This trend is expected to continue as harvesting shifts from northern Prince of Wales Island and eastern Chicagof islands (Figure 3) to southern Prince of Wales and the middle islands, especially Kupreanof and Kuiu islands (Figure 4).

Figure 3. High-quality habitat impacted since 1954 and remaining in 1995. Unshaded areas were (and remain) low or lowest quality habitat (<48 percent old forest in VCUs).

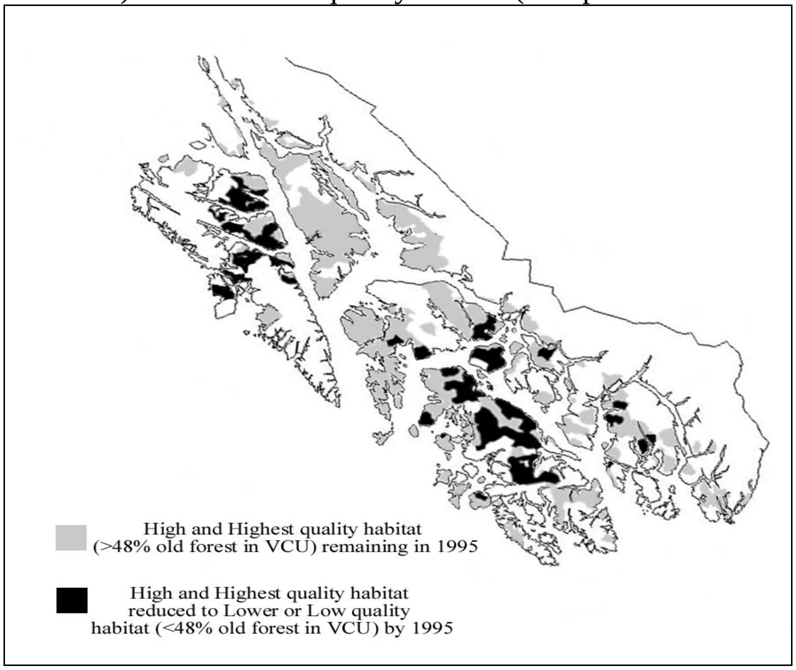
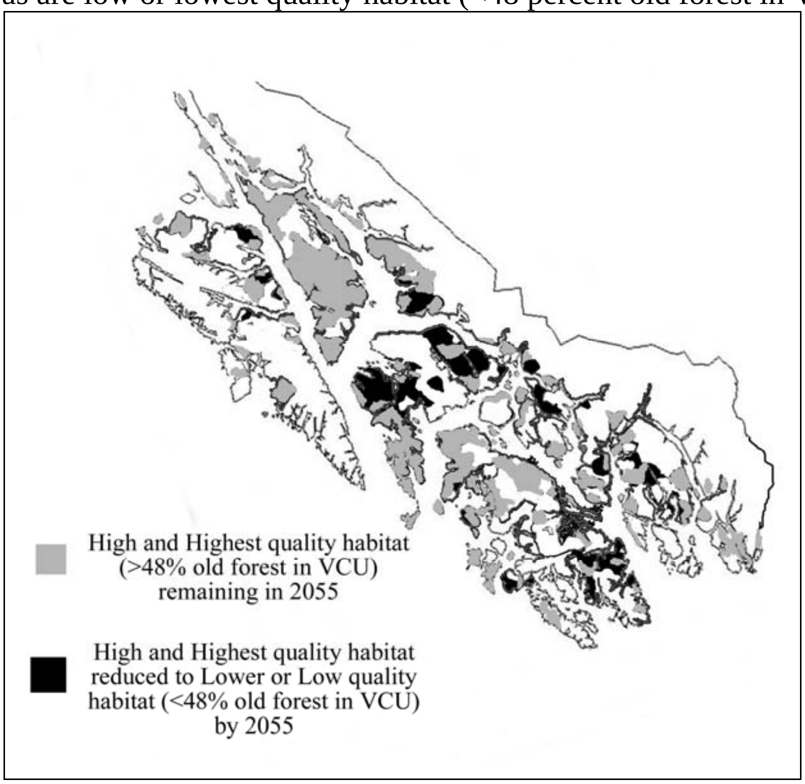


Figure 4. High-quality habitat projected to decline in quality between 1995 and 2055. Unshaded areas are low or lowest quality habitat (<48 percent old forest in VCUs).



Declines in habitat quality are projected to continue through 2055, but stabilize and possibly recover slightly by 2095 as second-growth forests mature (Table 11). Habitat quantity and quality should stabilize forest-wide by that time, although spatial arrangement is expected to shift as stands mature and are harvested.

Table 11. Number (and percent) of Value Comparison Units south of Icy Strait and east of Lynn Canal on the Tongass National Forest in habitat categories defined by their percentage of mature (75 to 150 yr-old) and old (>150 yr-old) forest

Mature and Old Forest in VCU (%)	Habitat Quality	Number of VCUs[1] (%)			
		1954	1995	2055	2095
>63	Highest	191 (22)	120 (14)	103 (12)	111 (13)
48-63	High	225 (26)	227 (26)	191 (22)	227 (26)
33-48	Low	200 (23)	253 (29)	257 (29)	245 (34)
< 33	Lowest	264 (30)	280 (32)	329 (37)	297 (34)

1- Includes only those Value Comparison Units within the range of the Queen Charlotte goshawk as reported by Iverson et al. (1996)

These projections illustrate a general shift toward lower quality goshawk habitat over time as a result of timber harvest. The prevalence of "Low Quality" habitat (33-48 percent old-growth forest) increases from 23 to 34 percent over the interval modeled. Value Comparison Units with "highest" quality habitat decrease from 22 to 13 percent, and combined "highest" and "high" value habitat Value Comparison Units decrease from 48 to 39 percent. Value Comparison Units in "low" and "lowest" categories increase from 53 to 68 percent. These decreases suggest that habitat quality has declined on the Tongass, and is expected to continue to do so. Projections available in 1997 suggested that this decline would continue for about 50 years before stabilizing. Since harvest rates over the last 10 years have been lower than projected, it is likely that the projected decline will be slower and more protracted unless new manufacturing capacity stimulates renewed demand for timber (Brackley et al. 2006).

Standards and Guidelines

The 1997 Tongass Land Management Plan managed risk to goshawks and other species through a conservation strategy that protects approximately 1.4 million ha of productive old forest (63 percent of the productive old forest remaining on the Tongass) in “Old Growth Reserves” and other non-development land designations. Retention of stands to protect non-timber resources, such as buffers along beaches, estuaries and streams within the otherwise harvestable “matrix” is projected to protect about 179,000 ha (8 percent of the productive old forest). Additional protection measures were included specifically for goshawks.

Nest-site protection includes preservation of at least 40 ha (100 acres) of productive old forest around confirmed and probable nests and minimization of human disturbances at active nests during the breeding season. Surveys are required to locate nesting goshawks during project planning. Foraging habitat provisions require maintenance of important features of stand structure within timber sale units in 26 VCUs on Prince of Wales Island where more than 33 percent of the productive old forest has been harvested since 1954. Important features are described as greater than 30 percent canopy closure throughout the harvest unit, and at least 8 large trees and 3 large decadent trees per acre (USDA Forest Service 1997, p. 4-90 to 4-91 and Appendix N).

Forest Plan Modifications

The 1997 Forest Plan is being reviewed under three separate programs: the Forest Plan Maintenance Program, the Conservation Strategy Review, and the Forest Plan Adjustment. Each review could result in potentially significant modifications to the plan. The Forest Service has incorporated some elements from all three reviews into one environmental impact statement (USDA Forest Service 2007). A decision document modifying the plan is expected in July, 2007.

A court ruling in the Queen Charlotte goshawk case requires the Fish and Wildlife Service to base a listing decision on land management plans in place at the time of the decision. Information on potential modifications to the current Forest Plan are presented not as a basis for the decision, but to fully disclose the level of uncertainty inherent in our projections of future Forest management in Alaska.

Below is a brief description of each review and its potential to affect goshawk conservation.

***Forest Plan Maintenance Program* –** Forest Service policy and regulations require each national forest to review their Forest Plan every 5 years. Following an internal review in 2004, the Forest Supervisor concluded that the plan did not need to be revised (Cole 2004). Remaining concerns prompted the Forest Service to initiate the Forest Plan Maintenance Program (described at http://www.tongass-fpmaintprog.net/index.php). The program organizes concerns identified by either the Forest Service or the public, evaluates the priority and level of action required to address the issue (ranging from minor modifications of procedures to amendment of the Forest Plan), and tracks progress on each issue. Four of the 53 concerns directly address standards and guidelines designed to protect goshawks. These are stated as:

1) Marten and goshawk standards and guidelines may not be applied consistently across the Forest (Concern number 04-03).

2) Effects of marten and goshawk standards and guidelines may not have been addressed adequately in calculating the Allowable Sale Quantity (Concern number 04-08).

3) Marten and goshawk habitat structural requirements in the standards and guidelines may not be consistent with current science (Concern number 04-09).

4) Goshawk standards and guidelines which provide for nest protection during project planning may not be applicable once a project is under permit or contract (Concern number 04-41).

Other concerns address cost, operability, and silvicultural consequences of non-clearcut timber harvest prescriptions (which are required by the goshawk standards and guidelines in some areas), retention of stream buffers, adjustments of Old Growth Reserves, and other issues that could negatively affect conservation of goshawk habitat. Evaluations are in progress or pending assignment on each of these concerns. The Forest Service may address some of these concerns when it updates the Forest Plan through the Forest Plan Adjustment (see below).

Conservation Strategy Review – The 1997 Forest Plan (USDA Forest Service 1997) established a conservation strategy featuring "coarse-filter" elements intended to provide for many species at a landscape scale, and "fine-filter" elements for those species with additional or more specific needs. Coarse filter elements include a system of large, medium and small Old Growth Reserves and other non-development land designations such as Wilderness, Remote Recreation, Wild River, Municipal Watershed, etc. The strategy also includes specific standards and guidelines for management of "matrix" lands (i.e., outside reserves or other protected status and available for timber harvest or other management activities). Some, such as no-harvest buffers along fish-bearing streams and along marine shorelines, are coarse-filter elements. Others, such as the standards and guidelines described above for goshawks, are fine-filter elements that apply to matrix lands.

The 1997 Forest Plan Record of Decision committed the Forest Service to conduct an interagency review of the conservation strategy. That review was completed in 2006. A description of the process is available at (http://tongass-constratreview.net/). Specifics of the reserve system and details of many of the standards and guidelines were reviewed for consistency with current science and concerns associated with their implementation. No decisions concerning modification of the conservation strategy have been announced, but several alternatives are currently being considered, in conjunction with the ongoing Forest Plan Adjustment.

Forest Plan Adjustment - The Forest Service is currently evaluating several new Forest Plan alternatives (http://tongass-fpadjust.net/) described in a draft environmental impact statement (USDA Forest Service 2007). The new alternatives are required by a ruling from the 9th Circuit Court of Appeals which found that market demand for timber from the Forest had been overestimated and incorrectly used in developing alternatives for the 1997 Forest Plan. The environmental analysis for the 1997 plan also failed to consider the cumulative effects of logging of high-volume old growth on adjacent, non-federal lands (NRDC vs. US Forest Service, 421 F.3d 797, August 5, 2005). Three of the alternatives would maintain allowable timber harvests and habitat protection near current levels; two would substantially decrease harvest levels and increase habitat conservation; and two would substantially increase harvest levels and risk to goshawk populations (USDA Forest Service, 2007). A decision changing the plan is expected in August, 2007.

Non-National Forest Lands, Alaska

About 56 percent of the 2 million ha of non-National Forest lands in Southeast Alaska within the range of the Queen Charlotte goshawk is managed by the National Park Service (Appendix A Table A-8, Albert and Schoen 2006). Glacier Bay National Park, at the northern edge of the subspecies' range, accounts for about 80 percent of the National Park lands, and 10 percent of the total area, in Southeast Alaska. Most of this National Park is not forested, and very little of the forest that does exist in the recently deglaciated portion of the landscape is productive (Table A-7). Nevertheless, a goshawk nest was reported near Gustavus, at the edge of Glacier Bay National Park, by Titus et al. (1999). Smaller Park Service units near Skagway and Sitka cover about 219,000 ha (3 percent of the range of the goshawk in Southeast Alaska). These parks have a higher proportion of productive forest, essentially all of which is protected.

With approximately 396,000 ha, the State of Alaska is the third-largest landholder in Southeast Alaska, with about 5 percent of the land area (Albert and Schoen 2006). The largest single management unit (116,000 ha) is the Haines State Forest in northern Southeast Alaska. About 4,000 ha of productive forest on the State Forest have been converted to second-growth, with another 11,000 ha available for harvest. About 13,000 ha are protected in reserves, inoperable lands and stream buffers (Appendix A Table A-9). The Department of Natural Resources expects to harvest about 140 ha per year, on average, over a 120-year management rotation on the 17,000 ha available for commercial timber harvest (ADNR 2002). Other State lands are managed for community development and commercial forestry, with about 70 ha available annually for harvest (Foley 1997). Due to the comparatively small area, harvest of State lands will have minimal impact on goshawk populations in Southeast Alaska, except perhaps on the Haines State Forest, where harvest of about half of the productive forest may limit the populations locally.

Alaska Native Corporations own approximately 234,000 ha (3 percent) of Southeast Alaska, most of which is managed as commercial forest (Appendix A Table A-9). About 119,000 ha has been harvested to date, with another 42,000 ha likely to be harvested over the next 10 to 20 years (Appendix A Table A-9). One third of the timber harvest that has occurred to date in Southeast Alaska has come from the 3 percent of the land base owned by the Native Corporations. Corporation lands contain a much higher percentage of productive forest and a higher percentage of harvested forest (64 percent) than lands managed by any other major owner. (Region-wide, Southeast Alaska is only 32 percent productive forest, with 13 percent harvested across all ownerships; see Table A-9). Corporation lands on Prince of Wales and surrounding islands, where goshawk prey is limited, may never have supported high densities of goshawks, but probably at least as many as similar lands on nearby Forest Service land. Native Corporation lands are located throughout Southeast Alaska, and goshawks were probably found on most or all of them. Intensive clearcutting on large areas of corporation land has converted many watersheds to very low quality habitat, or non-habitat, for goshawks. Loss of this habitat has likely contributed to at least local declines in goshawk populations.

Municipal, private and other ownerships not discussed above cover about 3 percent of Southeast Alaska. About 96 percent of the 165,000 ha of productive forest on these ownerships remains unharvested (Appendix A, Table A-9). Much this land is not protected from logging, and some is vulnerable. We do not expect disproportionate harvest of these lands in the future, however.

The U.S. Fish and Wildlife Service manages approximately 1,200 ha on three small island groups in Southeast Alaska as part of the Alaska Maritime National Wildlife Refuge. Although these islands are forested, they are too small and isolated to contribute significantly to goshawk conservation.

British Columbia

Approximately 80 percent of the 4.4 million hectares that make up Vancouver and the Queen Charlotte Islands are covered by forest (Tables 12 and 13). About 75 percent of the forested land is public, held as "Crown" lands by the Province of British Columbia (Appendix A, Table A-6). Provincial and Federal parks and reserves protect 15 percent of the land area, and 8 to 12 percent of the productive forest on the islands, depending on how "productive forest" is defined (Tables 12 and 13). Timber harvest on the remainder of the Crown lands is regulated by the *Forest and Range Practices Act*, which was passed in 2002 and replaced the Forest Practices Code of 1995. Regulations implementing the current *Act* took effect January 31, 2004.

Data on timber availability, past harvests, and projected future harvest are compiled by the Province's chief forester, who sets an Allowable Annual Cut for each area (BCMF 2004a). Forest conditions reported by the Ministry of Forests and Range, current to 2001 for Vancouver Island and 1991 for the Queen Charlotte Islands, are shown in Table 12 More recent data on status of the forest in British Columbia have been compiled by Leversee (2006) from 2004 satellite imagery (Table 13). Data from the two sources are similar for total area, total protected area, and areas of total forest and second growth, but differ markedly in how they distinguish productive from non-productive forest. This is due to differences in definitions: Leversee (2006) used site index (height in meters of an average 100-year-old tree) of 12.5 or greater to distinguish productive forest. Ministry of Forests defined "Productive Forest Land" as simply "capable of producing a merchantable stand within a defined period of time." The Ministry defined "non-productive forest" as all lands outside the productive forest that met the United Nations (FAO 2004) definition of "Forest" (i.e., land capable of supporting trees >5 m tall at maturity and canopy cover >10 percent) (Niemann 2006). The Ministry also identified "Other Wooded Land" (areas with either shorter or more scattered trees) which was not included in "Forest Land."

The Ministry's definition of Productive Forest Land is far more inclusive than Leversee's (2006), as the Ministry's definition includes about 79 percent of the total area of the two island groups, and 95 percent of the forested area. Leversee's (2006) definition includes 64 percent of the total area and 71 percent of the forested area. (In Southeast Alaska, Albert and Schoen (2006) estimate that productive forest (as defined by U.S. Forest Service timber volume mapping and extrapolations beyond Forest Service lands) covers 30 percent of the total area and 51 percent of the forested area).

Table 12. Status of forested lands (ha(%)) on the Queen Charlotte Islands and Vancouver Island, British Columbia, provided by the Province of British Columbia's Ministry of Forests and Range. Percentages of total protected, non-forested, total forest, non-productive forest, and productive forest, are of total area. Percentages of protected productive forest, harvestable productive forest, productive old growth, and second growth are of productive forest. "Protected" means parks and similar legal designations. Sources: Queen Charlotte Islands: [a]Eng 1997, [b]Lawrance 1997; Vancouver Island: [c]Niemann, 2006. See text for definitions of productive and non-productive forest.

Attribute	Queen Charlotte Islands	Vancouver Island[c]	Total for Islands
Total area	983,727[a]	3,453,430	4,437,157
Total protected	223,190(23) [a]	456,713(13)	681,713(15)
Protected productive forest	154,233(20)[b]	254,191(9)	408,424(12)
Non-protected productive forest	600,422(80)[b]	2,506,289(91)	3,106,711(88)
Non-forested	183,173(19)[a]	571,362(17)	754,535(17)
Total forest	800,554(81)[a]	2,882,068(83)	3,682,622(83)
Non-productive forest	45,899(5)[*]	121,588(4)	167,487(4)
Productive forest	754,655(77)[b]	2,760,480(80)	3,515,135(79)
Productive old growth	565,991(75)[**]	1,368,672(50)	1,934,663(55)
Total second growth	185,377(25)[a]	1,391,810(50)	1,577,187(49)
Young (< 80 yrs)	na	1,247,077(45)	na
Mature (80-140 yrs)	na	144,733(5)	na

[*] "Total forest[a]" minus "Productive forest[b]"
[**] "Productive forest[b]" minus "Total second growth[a]"

Table 13. Forest statistics (ha(%)) for Queen Charlotte and Vancouver Islands, British Columbia, from Leversee (2006) based on 2004 satellite imagery. Percentages of total protected, non-forested, total forest, non-productive forest, and productive forest, are of total area. Percentages of protected productive forest, harvestable productive forest, second growth, and productive old growth are of productive forest. "Productive forest" = site index $\geq$ 12.5, "Non-productive" = site index <12.5.

Attribute	Queen Charlotte Islands	Vancouver Island	Total for Islands
Total area	1,004,976	3,276,071	4,281,047
Total Protected	227,067(23)	426,498(13)	653,565(15)
Protected productive forest	59,587(13)	164,985(7)	224,572(8)
Non-protected productive forest	387,569(87)	2,118,404(93)	2,505,973(92)
Non-forested	210,027(21)	235,376(7)	445,403(10)
Total forest	794,949(79)	3,031,729(93)	3,826,678(89)
Non-productive forest	347,793(36)	748,340(23)	1,096,133(26)
Productive forest	447,156 (44)	2,283,389(70)	2,730,545(64)
Productive old forest	262,894(59)	626,172(27)	889,066(33)
Total second growth	184,261(41)	1,657,217(73)	1,841,478 (67)
Young (< 80 yr)	156,516(35)	1,295,507(57)	1,452,023(53)
Mature (80-140 yr)	27,747(6)	361,710(16)	389,457(14)

Protected Areas

In 1993, the Province of British Columbia announced a Protected Area Strategy with the objective of preserving 12 percent of the province for ecological, recreational, and cultural values. Numerous protected areas were designated in subsequent years, and by 2000, the 12 percent goal had been met on a Province-wide scale (Scudder 2003).

Recent land use planning efforts that have included a broad range of stakeholders have completed a Land Use Plan for Vancouver Island (BCMAL 2000). A similar effort is underway for the Queen Charlotte Islands, where the stakeholder group has recently produced a recommendations report for a land use plan (Process Management Team 2006). These comprehensive zoning and land use documents are intended to form the foundation of the Province's approach for establishing ecological and cultural reserves that address risks to biodiversity and ecological sustainability.

The Vancouver Island Summary Land Use Plan (BC 2000) increased protected areas on the Island from 10 to 13 percent, although only 8 to 12 percent of the productive forest on the island is protected (Tables 12 and 13) A provincial order will formally recognize the new protected areas following completion of final mapping.

There are two large and several smaller areas on the Queen Charlotte Islands with legislated protection covering about 225,000 hectares, or 23 percent of the islands (Figure 4) and 13 to 20 percent of the productive forest (Tables 12 and 13). There are 14 Haida Protected Areas totaling 200,500 hectares that have been identified as essential for preserving cultural and natural values of the native Haida people, but these areas have not been protected under Provincial or Federal legislation. The stakeholder group's report recommends an additional 204,140 ha (including 162,170 ha of forest) be protected in 21 areas on the Queen Charlotte Islands (Process Management Team 2006).

Timber Harvest

Under Provincial laws dating to the late 1800s, logging companies in British Columbia have been granted "tenures," which grant specific rights to harvest resources from public lands (BCMFR 2006). Tenures have taken many forms, but existing timber tenures on Vancouver Island and the Queen Charlotte Islands are primarily area-based "Tree Farm Licenses", which are managed by private companies to meet objectives set by the Provincial government, and various volume-based "Forest Licenses" issued for harvest of Crown timber within Timber Sale Areas managed by the Ministry of Forests and Range. Timber Supply Areas, Tree Farm Licenses and protected lands are shown in Figure 5.

Private lands cover approximately 29 percent of Vancouver Island, but only about 1 percent of the Queen Charlotte Islands (Appendix A, Table A-6). Private land is largely owned by private timber companies, and approximately 70 percent has been harvested (Table A-6). There is little government regulation of private-land timber harvest.

Timber harvests have been concentrated on the higher-productivity lands at lower elevations, especially along the east side and the north and south ends of Vancouver Island (Figure 5) and the central portion of the Queen Charlotte Islands (Figure 7).

Some Crown land outside protected parks is not available for timber harvest. Approximately 20 percent is not forested and 5 to 36 percent (depending on definition) is non-productive forest (Tables 12 and 13). Productive forest stands in the otherwise harvestable matrix may remain unharvested because they are either inoperable or they are retained to protect other resource values. *Inoperable* stands are those with limitations from terrain features such as steep slopes, unstable soils, low site productivity, and inaccessibility or economic factors such as non-merchantable species. Approximately 45 percent of the available forest land on the Queen Charlotte Islands is classified as inoperable (much of it due to low site productivity, which would probably not be considered "productive forest" under the definition used by the Forest Service in Alaska). On Vancouver Island, 18 percent of the available forest land is considered inoperable (App. A, Table A-6a). Changing technology and economics will affect operability, so considerable uncertainty surrounds long-term designation of areas as inoperable.

Figure 5. Timber Supply Areas (TSAs), Tree Farm Licenses (TFLs) and protected lands on Vancouver and the Queen Charlotte Islands (island masses not to scale) (Source: [http://www. for. gov. bc. ca](http://www.for.gov.bc.ca)).

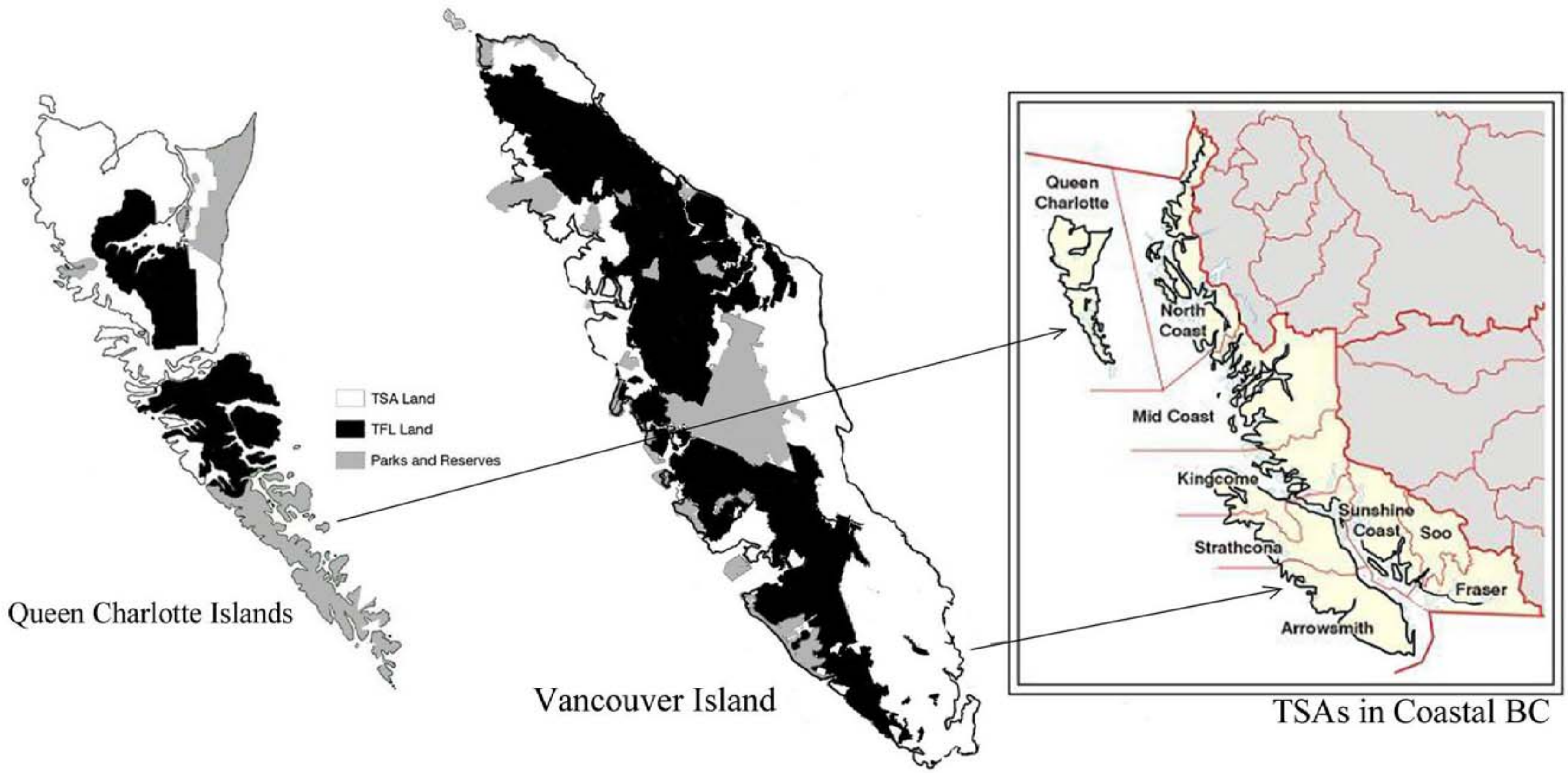


Figure 6. Distribution of old and second-growth forest, and non-forested lands on Vancouver Island, British Columbia. Source: Leversee 2006.

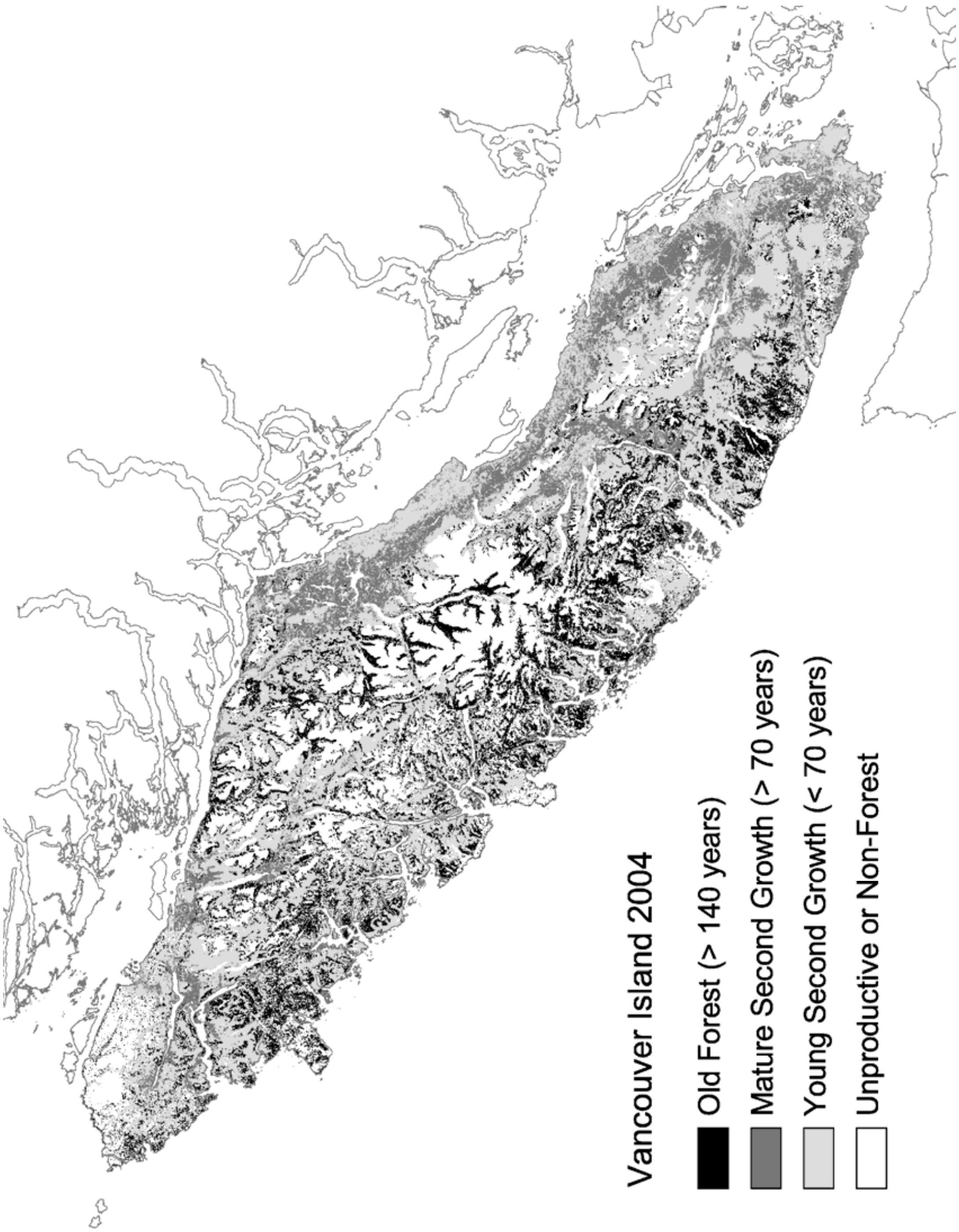


Figure 7. Distribution of old and second-growth forest, and non-forested lands on the Queen Charlotte Islands, British Columbia. Source: Leversee 2006.

Some stands, or portions of stands, that would otherwise be suitable and available for timber harvest, are retained to protect various non-timber values such as fish and wildlife habitat, archeological or cultural sites or recreation features. Examples of such "*retention*" areas within the otherwise harvestable matrix include old-growth management areas, deer winter ranges, riparian reserves, wildlife habitat areas, and archeological sites. Retention areas of otherwise suitable trees protect 12 percent of the productive forest outside protected reserves on the islands (15 percent on the Queen Charlottes and 11 percent on Vancouver Island) (Appendix A, Table A-6a).

The value of retained areas as goshawk nesting and foraging habitat likely varies considerably depending on patch size and forest structure. Riparian buffers, for example, are typically linear and would provide little or no interior forest conditions that appear to provide the best goshawk habitat. Low-productivity sites likely have few suitable nest trees surrounded by adequate foraging habitat to support fledglings learning to hunt. Other designations, such as Ungulate Winter Ranges, are often too small, by themselves, to provide suitable post fledging areas (McClaren 2004).

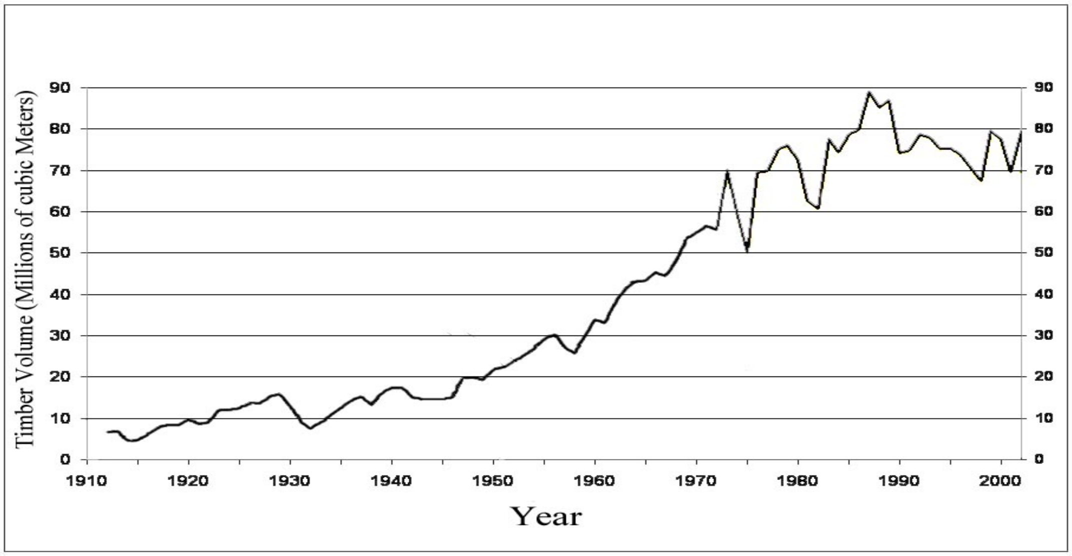
Several differences between the Queen Charlotte Islands and Vancouver Island are evident. On the Queen Charlotte Islands, which contain about 20 percent of the productive forest on the two island groups, most (73 percent) of the productive forest remains unharvested, and over half (64 percent) is expected to be protected from harvest, either in parks (9 percent) or the otherwise logged matrix (55 percent) (Appendix A, Table A-9). In contrast, on Vancouver Island, which contains about 80 percent of the productive forest land on the two island groups, nearly half (49 percent) has already been harvested, with another 16 percent likely to be cut (Table A-9). The percentage of productive forest protected in parks is similar (9 percent), but a much lower percentage of the forest in the logged matrix will remain uncut on either inoperable land (16 percent) in retention areas (10 percent) (Table A-9).

<u>Harvest Rates</u>

Timber harvest began in British Columbia in the 1800s, with relatively steady growth between 1910 and peak harvests in the late 1980s (Figure 8). As in Alaska, changing values and economic conditions have resulted in allocation of some forested lands to uses other than timber harvest. In spite of a reduced land base open to logging, however, harvests in British Columbia have not declined in recent years as dramatically as they have in Alaska (compare Figures 2 and 8).

On a landscape basis, the harvest rate on Vancouver Island has exceeded an ecological rotation of 300 years - a rate that Iverson et al. (1996) believed offered a high likelihood of sustaining goshawks in Southeast Alaska. With nearly half of the productive forest harvested on Vancouver Island over the last 100 years (Table A-9), well over a third is currently between 0 to 100 years old. The rate in the Queen Charlotte Islands appears to be closer to the desired ratio of one third less than 100 years old, since 28 percent has been cut to date. Still, either would likely be considered at risk, using the criteria of Iverson et al. (1996).

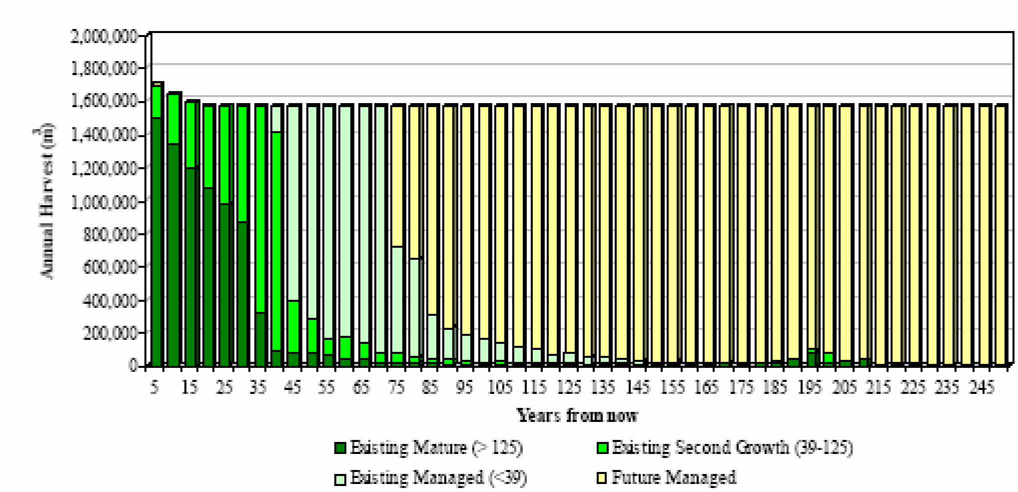
Figure 8. Province-wide timber harvests in British Columbia, 1912 to 2003 (Source: BCMF 2004).



Timber harvests will include progressively less old (previously unharvested) forest into the foreseeable future, as the remaining, available old forest is liquidated and maturing second growth becomes more prevalent in the harvest. Individual forest tenures will shift to almost entirely second growth in 2 to 12 decades, averaging about 5 decades (Table A-1). This represents continued reduction in goshawk habitat for up to 120 years, with most of that loss occurring over the next few decades as old forests continue to make up a (declining) majority of the harvests. As objectives for old-forest retention are met and exceeded in about 200 years, relatively modest amounts of old forest may again be harvested from some tenures. This pattern is illustrated in Figure 9, which is taken from the Timber Supply Analysis Report from Tree Farm License 44 on Vancouver Island, which is typical for the tenures throughout the range of the Queen Charlotte goshawk in British Columbia.

Differences between currently authorized Allowable Annual Cut and the Long Term Harvesting Level are termed "falldown," and reflect the rates that current harvest (to the extent that it matches the Allowable Annual Cut) exceeds sustainability (Marchak et al. 1999). To adjust for falldown, the British Columbia Ministry of Forests (2004c) estimated that timber supply will decline by 6.8 million cubic meters per year, Province-wide, between 2000 and 2050. Harvests on the Queen Charlotte Islands and Vancouver Island are projected to decline by 1.87 million cubic meters per year during that period (Appendix A, Table A-10). This reflects changes in land status that have reduced the area available for timber harvest and a slower rate of harvest to allow previously harvested second growth to attain economic maturity.

Figure 9. Timber supply sources for Tree Farm License 44, Alberni East and West on Vancouver Island (TFICL 2002).



Land Use Regulation

Under the *Forest and Range Practices Act*, which took force in 2004, logging companies that hold forest tenures (such as Tree Farm Licenses and Forest Licenses) must produce Forest Stewardship Plans that describe how each tenure will be managed to meet various objectives established by land use plans, specific regulations, and Ministerial designations. This is a significant departure from the previous management system in which government prescribed to a much greater degree how logging was to be done in order to meet Provincial objectives. Logging within Timber Supply areas (which are administered by the BC Forest Service, rather than by individual logging companies) must also comply with the various objectives that apply to any given area.

Land and Resource Management Planning - Land Use Plans are broad-scale zoning documents produced by stakeholder groups that define management direction for individual land use designations within relatively large planning areas. Vancouver Island's land use plan was completed in 2000 (BCMAL 2000) and the Queen Charlotte Islands' plan is nearing completion (Process Management Team 2006). The plans describe objectives for each of several resources such as visual, recreation, tourism, wildlife, fish, cultural heritage, water, timber, and aquaculture for each designation. Objectives for wildlife and biodiversity management have the greatest potential to conserve goshawk habitat, and are described below for each land use designation in the Vancouver Island land use plan (BCMAL 2000).

"Protected" designations, which cover 439,000 ha (13 percent) in the Vancouver Island plan area, allow no timber harvest and are intended primarily to protect natural and cultural values. This is the primary "coarse-filter" strategy intended to protect biodiversity and sensitive species such as goshawks. Other designations, such as "Agriculture," "Settlement," or "Private" (which total 806,000 ha, or 24 percent of

Vancouver Island) make little or no official allowance for protection of wildlife habitat. Between these extremes is a range of “Resource Management Zones” (RMZs) with varying levels of protection for goshawks and their habitat.

“Enhanced Forestry” RMZs cover approximately 808,000 ha (24 percent) of Vancouver Island, and emphasize intensive forest management to increase timber production. Larger harvest units are authorized, but adverse impacts to watersheds are to be minimized. Legislated environmental stewardship provisions and existing Wildlife Habitat Areas and Ungulate Winter Ranges must be maintained (some cutting may be authorized in such areas), but wildlife habitat is a secondary consideration and must be addressed in ways that minimize impacts to timber supply. The “General” management regime for wildlife and either “General” or “Basic” (a lower level of protection) regime for biodiversity management apply in Enhanced Forestry RMZs, depending on location.

“General” RMZs (1,028,000 ha, 31 percent of Vancouver Island) are managed for a variety of resources, including “standard timber harvesting and production in accordance with the principles of integrated resource management.” Wildlife and Biodiversity management regimes stress consistency with existing legislation and policies. Retention of old forests for biodiversity is limited primarily to inoperable lands and other areas withdrawn from the timber harvesting land base.

“Special Management” RMZs (268,138 ha, 8 percent) stress various non-timber resources such as wildlife or fish habitat, scenic values, biodiversity, or recreation, depending on the location. Timber harvest is allowed, but constrained by “special” objectives that limit the size of openings and encourage creation of mature-forest structure. Strategies such as longer rotations and greater retention are suggested (not required) to accomplish the desired objectives, though these strategies have apparently not been implemented.

Forest Planning and Practices Regulation – Provincial objectives for several resources are specified in the *Forest Planning and Practices Regulation* (BCMFR 2004). Forest tenure holders must address each of these objectives in their Forest Stewardship Plans. Objectives with potential to help conserve goshawk habitat include:

> Species at risk, regionally important wildlife, and specified ungulates:
>
> > Without unduly reducing the supply of timber from British Columbia's forests, conserve sufficient wildlife habitat in terms of amount of area, distribution of areas and attributes of those areas, for the survival of species at risk, regionally important wildlife, and specified ungulates.
>
> Wildlife and biodiversity at the landscape level:
>
> > Without unduly reducing the supply of timber from British Columbia's forests and to the extent practicable, design areas on which timber harvesting is to be carried out that resemble, both spatially and temporally, the patterns of natural disturbance that occur within the landscape.

Wildlife and biodiversity at the stand level:
> Without unduly reducing the supply of timber from British Columbia's forests, retain wildlife trees.

Water, fish, wildlife and biodiversity within riparian areas:
> Without unduly reducing the supply of timber from British Columbia's forests, conserve, at the landscape level, the water quality, fish habitat, wildlife habitat and biodiversity associated with riparian areas.

Methods for addressing each of these objectives are discussed below.

<u>Species at Risk and Other Identified Wildlife</u>

In 1999, British Columbia's Ministry of Environment, Land and Parks (recently renamed Ministry of Environment) released an *Identified Wildlife Management Strategy* as a way to reduce the impacts of forest and range activities on designated species at risk and other regionally important species requiring special management consideration (BCMWLAP 2004). The Strategy, which was updated in 2004 and integrated with the new *Forest Planning and Practices Regulation*, includes designation of Wildlife Habitat Areas and development of General Wildlife Measures that apply in those Wildlife Habitat Areas (unless an exemption is issued). Authority to designate each of these elements is granted to the Minister of Environment by the *Government Actions Regulation* (BC Reg. 582/2004). The Strategy includes non-binding recommendations for broader-scale land use planning, especially for wide-ranging species like the goshawk. Impacts to short-term harvest levels from implementation of the Strategy in each Forest District may not exceed 1 percent of the timber harvesting landbase estimated by Timber Supply Reviews (BCMWLAP 2004). The *Identified Wildlife Management Strategy* is intended as a single-species ("fine-filter") complement to the broader, coarse-filter provisions of the province's forest and range practices legislation, and strategic land-use planning.

The list of Identified Wildlife currently includes 85 elements (species, subspecies and populations). The Ministry of Environment has determined that these elements "may be affected by forest or range management on Crown land and require protection in addition to that provided by other mechanisms" (Barisoff 2004). This category, known officially as "Species at Risk," includes the Queen Charlotte goshawk. In the future, other "regionally important wildlife" may be added to the list of Identified Wildlife (BCMWLAP 2004). Goshawk nests not designated within Wildlife Habitat Areas under the 1% cap are currently proposed to be identified as a "Wildlife Habitat Feature" under the Forest and Range Practices Act. Once included on the list of Wildlife Habitat Features, forest activities may not damage nests or render them ineffective. Damage and rendering ineffective have not been defined. Wildlife Habitat Areas for goshawks are intended to maintain breeding habitat at known goshawk nests to ensure that breeding pairs may successfully raise young to dispersal (McClaren 2004). Design criteria for goshawk Wildlife Habitat Areas include approximately 200 ha in the vicinity of the nest, with consideration of up to 2200 ha of foraging area in the surrounding landscape (in adjacent protected and inoperable areas, or in the Wildlife Habitat Area if necessary).

General Wildlife Measures that are required within goshawk Wildlife Habitat Areas include restrictions on timber harvest, commercial thinning, and road construction within the “core” (post-fledging) area, and a requirement to develop a management plan for harvesting and road construction within the “management zone.”

As of February, 2006, there were 28 Wildlife Habitat Areas designated for the Queen Charlotte goshawk (25 on Vancouver Island, 2 on the Queen Charlotte Islands, and 1 on the northern mainland coast). Much of the area within these Wildlife Habitat Areas is on unsuitable or otherwise protected land, so impacts to the Timber Harvesting Land Base are estimated at 4,592 hectares (BCME 2006a).

Part of the Identified Wildlife Management Strategy is the stated policy that Wildlife Habitat Areas and other protected designations for all designated species at risk and other “regionally important wildlife” must not reduce the short-term timber supply on each Forest District by more than one percent (BCMWLAP 2004). This policy is not legally binding, but rather is considered guidance that should be followed unless circumstances require otherwise, as documented in written rationale. At this time there are approved Wildlife Habitat Areas in the Vancouver Island Region for goshawks, marbled murrelets, coastal tailed frog (*Ascaphus truei*), and Douglas-fir/Garry oak/oniongrass (*Pseudotsuga menziesii/Quercus garryana/Melica subulata*) communities. In the Queen Charlotte Forest District, there are also approved Wildlife Habitat Areas for ancient murrelets, Cassin’s auklets (*Ptychoramphus aleuticus*), and marbled murrelets (BCME 2006a). As a result, very little additional goshawk nesting habitat can be protected with this legislation unless exceptions are made to violate the one percent policy.

The *Forest Planning and Practices Regulation* objectives for species at risk, regionally important wildlife, and specified ungulates require the Ministry of Environment to notify tenure holders of any determinations concerning the areas deemed “sufficient” for the survival of those species. Notifications currently in effect (BCME 2006b) for Queen Charlotte goshawks include one for each of the three Forest Districts on Vancouver Island (none have been indicated on the Queen Charlotte Islands). Land area required for survival of the species in Forest Districts on Vancouver Island ostensibly totals 2,259 ha (Table 14), excluding approved Wildlife Habitat Areas. The notices refer to the “Accounts and Measures for Managing Identified Wildlife” (McClaren 2004) for specifications on distribution and composition of the habitat required.

Table 14. Amount of habitat "required for the survival" of Queen Charlotte goshawks on Vancouver Island (exclusive of approved Wildlife Habitat Areas) as specified by Forest District in Notices produced by British Columbia government under the *Forest Planning and Practices Regulation* (BCME 2006b).

Island Forest District	Total Amount (ha)	Amount in mature timber harvesting land base (ha)
Vancouver		
South Island FD	239	79
North Island FD	277	128
Campbell River FD	1,743	764
Total	2,259	971

Wildlife and Biodiversity Objectives

The now-obsolete *Forest Practices Code* outlined strategies for managing forests at subregional, landscape, and stand scales. Measures to preserve biodiversity were described in the Biodiversity Guidebook (BCMF 1995). The Guidebook prescribed a mixture of seral stages across the landscape, with progressively greater proportions of mature and old forest in landscape units assigned to lower, intermediate, and high biodiversity emphasis. With implementation of the *Forest and Range Practices Act* in 2004, the Guidebook is no longer used as a basis for biodiversity standards, although it remains available as a reference for those tenure holders who wish to develop alternative standards and results, rather than relying on default standards.

The current *Forest Planning and Practices Regulation* specifies default standards to meet landscape-level and stand-level objectives for "wildlife and biodiversity." Landscape-level objectives are met in the Coast Forest Region by limiting the net area of each cutblock (harvest unit) that must be reforested to 40 ha or less, except in Enhanced Forestry zones, where cutblocks may be larger (ABCFP 2005, p. 7-27).

Default standards for the stand-level wildlife and biodiversity objective of "retaining wildlife trees" state that the objective is met if at least 3.5 percent of the area of each cutblock, and at least 7 percent of all cutblocks harvested annually, is retained. Inoperable terrain, unstable soils, riparian buffers and wildlife tree patches within the cutblock may be used to meet the default standard. Alternatively, tenure owners may address the objective differently in their Forest Stewardship Plan if they wish, by specifying a result or strategy they prefer to be accountable for (ABCFP 2005, p. 7-23). Operators are encouraged (but not required) to retain trees around features that offer wildlife habitat benefits, such as bear dens, bat hibernacula, raptor nests, and large snags (ABCFP 2005, p. 7-25).

Operators must also identify strategies and results that retain adequate tree coverage in riparian areas to maintain stream bank or stream channel integrity (ABCFP 2005, p. 7-13). Default standards describe riparian reserve zones (where road construction, gravel extraction, and timber harvest are forbidden) and riparian management zones (where a percentage of tree basal area must be retained). Specific widths of default riparian reserve and management zones, and percentages of basal area that must be retained, vary with the classification of the water body. Operators who wish to develop alternative strategies and results to address the riparian objective (conserve, at the landscape level, the water quality, fish habitat, wildlife habitat and biodiversity associated with those riparian areas) may do so in their Forest Stewardship Plans. Several have recently done so. Alternative strategies and results must be consistent with government's stated objectives for other *Forest and Range Practices Act* values.

***Old Growth Retention Objectives* -** In 2004, the British Columbia Ministry of Sustainable Resource Management established "Provincial Non-Spatial Old Growth Objectives" that must also be addressed in Forest Stewardship Plans (Abbott 2004). The order established "Landscape Units" and old growth forest retention objectives for each of those units. Individual Landscape Units are assigned to low, intermediate, or high biodiversity emphasis, with lower percentages of old growth retention identified for lower-emphasis units. The exact amount of old growth that must be retained depends on the forest type (biogeoclimatic zone) and the "natural disturbance regime" identified for each biogeoclimatic zone variant. Within the Coastal Western Hemlock zone, old-growth retention objectives range from nine to 13 percent, in the Mountain Hemlock zone, objectives range from 19 to 28 percent, and in the Coastal Douglas-fir zone, nine to 13 percent. The objectives are termed "non-spatial" because they describe amounts but not specific areas to be retained, unlike other orders that establish protection of specified areas. In order to meet the non-spatial old growth objectives, tenure-holders and Timber Supply Area managers can rely on existing protected areas such as Wildlife Habitat Areas, riparian reserves, inoperable lands, and other designations that result in retention of old-growth stands.

Summary of Range-wide Habitat Conditions

Timber harvest has converted 13 percent of Southeast Alaska's productive forest to second growth. Logging has been more extensive in British Columbia, where 28 percent of the productive forest on the Queen Charlotte Islands and 49 percent on Vancouver Island has been harvested (Figure 10).

Conservation strategies have been implemented for the goshawk on both Southeast Alaska's Tongass National Forest and British Columbia's Crown lands. Together, these two classifications cover 75 percent of the forest across the range of the Queen Charlotte goshawk. Strategies for both classes of land rely on a "coarse-filter" system of protected areas, supplemented by "fine-filter" elements designed to conserve specific habitat features used by the species.

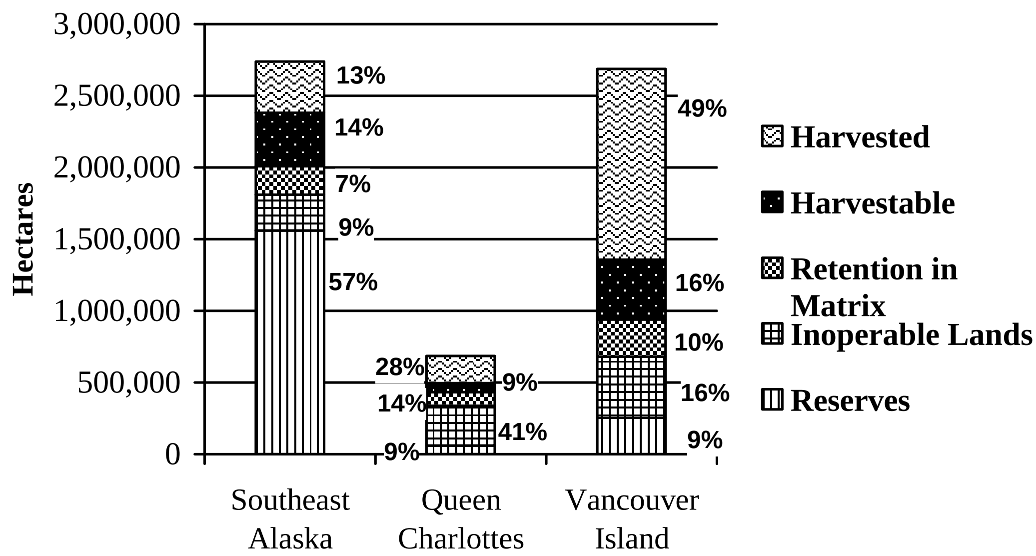
Protected lands in Southeast Alaska include Congressionally designated National Monuments, Wilderness areas, and roadless land designations as well as Forest Plan land use designations that protect additional areas. Altogether, non-development designations cover 5.4 million ha (78 percent) of the 7.0-million ha Tongass National Forest (USDA Forest Service 1997, ROD Table 1 and p. 7), and include approximately 1.4 million ha (63 percent) of the 2.2 million ha of productive forest (Table 9). Approximately 55 percent of the 2.6 million ha of productive forest is protected across all ownerships in Southeast Alaska. Federal and provincial parks protect 225,000 to 408,000 ha (8 to 12 percent) of the productive forest (depending on how productive forest is defined) on the islands of British Columbia (Tables 12 and 13).

Standards and guidelines, which define limits to operability and retention requirements, are projected to maintain approximately 69 percent of the remaining productive old growth forest within areas of commercial timber harvest on the Tongass National Forest (USDA Forest Service 1997, ROD p. 7). In British Columbia, operability limitations and retention requirements are expected to result in maintenance of 1.2 million ha (45 percent) of the 2.7 million ha of productive forests on Crown lands outside designated parks. Retention areas and inoperable lands tend to be in small, fragmented patches and/or lower productivity forests, so these areas should be considered only moderate-quality habitat, on average.

Conservation measures designed specifically for goshawks on the Tongass National Forest include buffers of 40.5 ha (100 acres) of productive old growth around confirmed and probable nests (occupied or not) where timber harvest is not allowed, new road construction is allowed only if no other reasonable road-building alternative exists, and continuous disturbance during the nesting period is not permitted. Surveys for nesting goshawks are required during project evaluations, and retention of 30 percent canopy closure is required in heavily harvested areas on Prince of Wales Island in the southern Tongass.

In British Columbia, birds, their eggs, and occupied nests are protected under the *Wildlife Act* (RSBC 1996, Section 34). Goshawk nests and surrounding habitat can be protected under the Identified Wildlife Management Strategy where the Ministry of Environment designates Wildlife Habitat Areas. Guidelines recommend that Areas designated for goshawks include approximately 200 ha of suitable nesting habitat around the nest to provide for a post-fledging area and alternative nest sites, but the size is variable and may include up to 2200 ha depending on terrain and distribution of habitat and other protected areas. Roads may not be constructed, nor timber harvested or thinned, within the core (post-fledging) area. A management plan is required to harvest timber or construct roads within the management zone outside the core area (McClaren 2004).

Figure 10. Area of productive forest available for harvest, and in protected status across the range of the Queen Charlotte goshawk (Sources: see Appendix A, Table A-9).



Projections of future logging rates are characterized by significant uncertainty, but timber harvest is expected to increase in Southeast Alaska, with the rate of increase largely dependent on the level of new milling or manufacturing capability that develops (Brackley et al. 2006). Timber supply is expected to decline somewhat across Vancouver Island and the Queen Charlotte Islands, as harvest rates are adjusted to a smaller timber-harvesting land base resulting from recent and anticipated future designation of reserves and other management changes (Appendix A, Table A-16). Conversion of old forest to second growth is expected to continue throughout the range of the Queen Charlotte goshawk for 50 to 100 years.

Logging is projected to affect 27 percent of the productive forest across all ownerships in Southeast Alaska. On the Queen Charlotte Islands, 37 percent is available for harvest, and on Vancouver Island, 65 percent is expected to be cut (Figure 10; Appendix A, Table A-9). Most of the current and future goshawk habitat is in the various reserves of Southeast Alaska and inoperable areas and second growth of Vancouver Island (Figure 10). The Queen Charlotte Islands, whose goshawk populations demonstrate the strongest expression of *laingi* characteristics, contain less suitable habitat and a substantial portion of that is either vulnerable to harvest, limited in its value to goshawks by its location within the matrix, or on currently inoperable ground that may be harvested in the future.

Habitat Value

Forest habitat is distributed non-uniformly across the range of the Queen Charlotte goshawk. Productive forest is interspersed with low-productivity scrub forest, wetlands, alpine areas, developed lands and saltwater channels. Prior to logging, Southeast Alaska had 2.2 million ha of productive old forest in the range of the Queen Charlotte goshawk; British Columbia islands had 2.7 to 3.5 million ha of this preferred habitat. Non-productive ("scrub") forest covered about 1.4 million ha in Southeast Alaska and 168,000 to 1.1 million ha (depending on definition of "non-productive") on the British Columbia islands (Tables 9, 12, and 13).

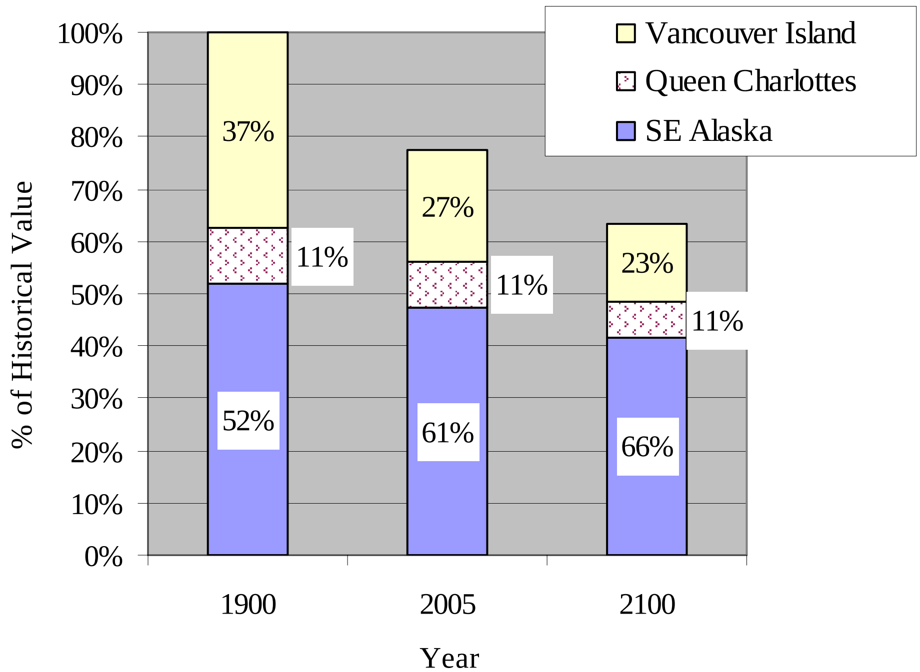
Goshawks preferentially select productive forest for nesting and foraging, and use non-productive forest, presumably for foraging, in proportion to its availability (Iverson et al. 1996). Therefore, we infer that productive forest is higher quality habitat than non-productive forest. If we consider non-productive forest to offer approximately 75 percent of the *habitat value* of productive old growth, we can characterize Southeast Alaska as historically holding about 52 percent of range-wide goshawk habitat, Vancouver Island 37 percent, and the Queen Charlottes about 11 percent, using Ministry of Forests and Range definitions of productive and non-productive forest for British Columbia (Figure 11). These percentages are similar using Leversee's (2006) site index of 12.5 to distinguish between productive and non-productive forest (Southeast Alaska = 52%, Queen Charlotte Islands = 10%, Vancouver Island = 38%).

Timber harvest over the last 50 to 100 years has increased fragmentation of productive forest habitat and reduced the amount of high-quality habitat across the region, although this effect is concentrated in several localized areas. Logging began earlier and has continued more intensively in British Columbia than in Alaska. As a result, a greater proportion of the productive forest has been harvested in the British Columbia portion of the Queen Charlotte goshawk's range (49 to 67 percent) (Tables 12 and 13) than in Alaska (8 to 11 percent on National Forest lands (Tables 9 and 10) plus 4 to 7 percent on native corporation lands).

Clearcut logging provides poor quality habitat following harvest, and moderate-quality habitat for a few decades near the end of each rotation. Fragments of productive forest left along streams and in other relatively small retention areas may provide some foraging habitat, but lack interior forest conditions and are unlikely to provide nesting habitat. Lands currently considered inoperable remain at some risk of harvest, if technological advances and market demands allow for harvest of these lands in the future.

Because second-growth stands provide suitable habitat for only the final 10 to 20 percent of each rotation, we estimate that they provide, on average, about 15 percent of the habitat value of productive old growth. Retention areas are estimated to provide 50 percent of the habitat value of unfragmented productive old growth, and currently inoperable lands are estimated to provide habitat value equal to other productive old growth. Using these discount factors, we estimate that habitat quality has declined by 23 percent range-wide (Appendix A, Table A-13), and that Southeast Alaska currently holds approximately 61 percent, Queen Charlotte Islands 11 percent, and Vancouver Island 27 percent of the existing habitat value (Figure 11).

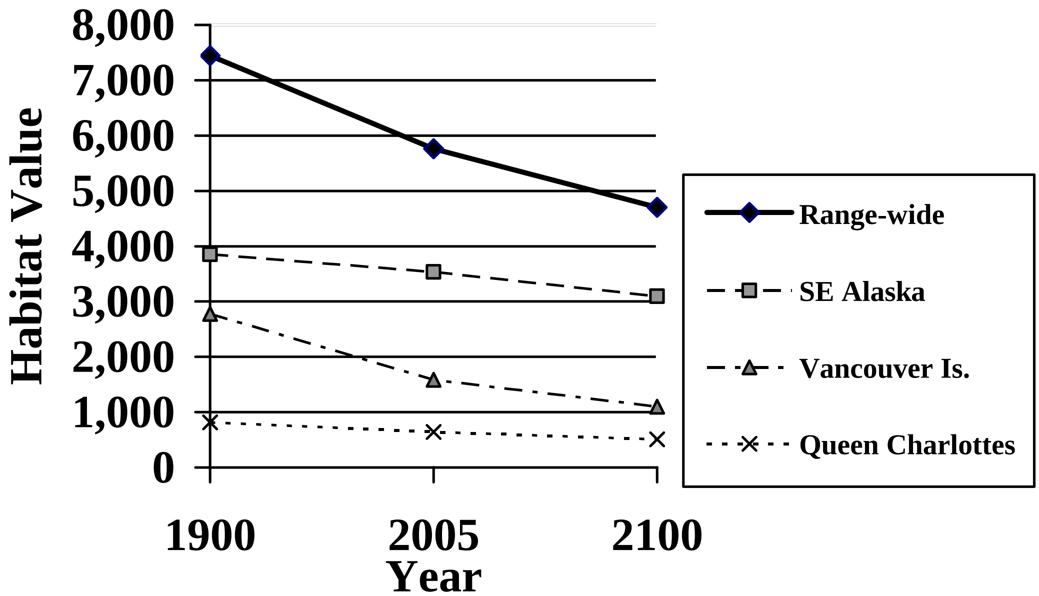
Figure 11. Distribution of historical (1900), remaining (2005) and projected (2100) habitat value using discount factors for non-productive, fragmented, and harvested stands (Appendix A, Tables A-10 to A-13).



Timber harvest is expected on an additional 374,000 ha in Southeast Alaska and on 480,000 ha in British Columbia (Appendix A, Table A-9). Because some currently "inoperable" lands may be harvested in the future, if technology and markets permit, we estimate that these lands have only 85 percent of the habitat value of unfragmented, productive old growth in the future. Application of these discount factors indicate that remaining habitat value will decline by an additional 12 percent in Alaska and 28 percent in British Columbia (20 percent on the Queen Charlotte Islands, 31 percent on Vancouver Island) as all harvestable old growth is converted to second growth (Appendix A, Table A-15). We expect nearly all of this decline to occur in approximately 50 years in British Columbia (Appendix A, Table A-1) and in 50 to 100 years in Alaska (see Table 10 and associated text). At that time, Alaska will have 66 percent of the remaining habitat value, the Queen Charlottes will have 11 percent, and Vancouver will have 23 percent (Figure 11). Trends are shown in Figure 12.

This method of modeling habitat change is sensitive to relative values of various habitats, which are based on interpretation of habitat selection studies. The discount factors and relative habitat values cannot be related directly to goshawk populations, and the results of this exercise should be considered an untested hypothesis.

Figure 12. Trends in habitat value across the range of the Queen Charlotte goshawk, estimated by application of discount factors reflecting hectare-equivalencies relative to productive old- growth forest (Appendix A, Table A-10).



PART IV—THREATS AND VULNERABILITY

Vulnerability Factors

Section 4 of the *Endangered Species Act* requires an analysis of five factors that could cause a species to become endangered or threatened. Each is discussed below.

Habitat Loss

The first listing factor is "the present or threatened destruction, modification, or curtailment of its habitat or range" (ESA Sec. 4(a)(1)(A)). This is the greatest threat to continued viability of the Queen Charlotte goshawk population. Iverson et al. (1996) demonstrated that goshawks in Southeast Alaska avoid forest that has been clearcut within recent decades, probably because of a dearth of both accessible prey and nest sites. Elsewhere in the goshawk's range, small mammals such as ground squirrels, chipmunks, rabbits and hares, and birds such as pheasants (all adapted to open areas or forest edges) provide foraging opportunities for goshawks following timber harvest. These species are naturally lacking from much of the range of the Queen Charlotte goshawk. Thus, it is highly likely that goshawk populations have been negatively affected by conversion of productive old forest to early seral-stage vegetation.

The extent to which goshawk populations have declined is unknown. If population declines have been proportional to conversion of old forest to early seral stages, the goshawk population of Southeast Alaska may have declined by about 15 percent, while those of British Columbia may have declined by about 45 percent.

On Vancouver Island, where half of the productive forest has been converted to second growth (including most of the highest-productivity forest), McClaren (2003) documented successful nesting by goshawks in (mature) second growth, with nest productivity similar among contiguous old growth, contiguous second growth, and fragmented forests. In Southeast Alaska, goshawks on Douglas Island nest successfully in mature (100-year-old) second-growth stands.

Goshawks initiate nesting only when weather and prey availability are favorable, so nest success per attempt is typically high (Table 5). In fluctuating or otherwise marginal habitats, nest-area occupancy and activity rates are more sensitive, but more difficult to measure, indicators of habitat quality (see Nest Productivity discussion, above). On Vancouver Island, Ethier (1999) and McClaren (2003) documented significantly lower occupancy rates in fragmented landscapes than in contiguous old-forest or second-growth landscapes. Flatten et al. (2001) also documented higher nest activity rates in mature, contiguous second growth in northern Southeast Alaska than in the more fragmented forests of southern Southeast Alaska. This relationship may partly reflect lack of key prey (squirrels and sooty grouse) in parts of southern Southeast Alaska, but region-wide there is a lack of prey associated with open habitat, rendering fragmented forests less productive for goshawks. As second growth approaches maturity and becomes more contiguous, forest-dwelling prey and suitable hunting habitat both increase.

Many goshawk researchers believe that the primary limiting factor is adequate densities of accessible prey (e.g., Widen 1997, Reynolds et al. 2006), and that given sufficient prey availability (including huntable forest structure) goshawks select the most suitable, unoccupied nesting area available nearby. In some such cases, relatively young stands are used with good success, if adequate-sized trees are available to support a nest (Widen 1997, Bosakowski et al. 1999, McClaren 2003). Even in these circumstances, however, mature forest structure seems to be important. Although goshawks may prefer old forest stands for nesting, they are apparently not necessary for successful nesting. Consistent preference for old forest implies advantages for nesting goshawks (Greenwald et al. 2005). The advantages represented by these stands for nest sites may be less important than a good food supply in the nesting range, judging from the willingness of the species to accept nesting stands of younger (but mature) trees on occasion. Similarly, if goshawks are exposed to increasingly fragmented and younger forests, younger stands may be used if changes are gradual.

Prey populations must exist in habitat that is practical for goshawks to hunt if they are to use an area successfully. Prey in cover that is too dense for goshawks to penetrate has no value for goshawks, regardless of how many prey may occupy such habitats. Conversely, while goshawks hunt primarily in mature forests, where good prey populations and good hunting conditions exist, they also succeed in some areas of very open non-forest foraging habitat where prey are abundant and vulnerable to goshawks attacking from the edges of forest cover or other perches (see Younk and Bechard 1994). Across much of the northern goshawk's range, therefore, it is very difficult to characterize favorable foraging habitat simply as one sort of habitat structure or another. Goshawks cannot hunt habitats with vegetation too dense for them to penetrate safely, but beyond this, the diversity of habitats that can be hunted successfully depends on the particular prey species present, the habitats they occupy, the specific anti-predator adaptations of the prey, and levels of interference that may exist from other predators hunting the same habitats. It is simplistic to attempt a single categorization of favorable goshawk habitat when many strikingly different habitats may be favorable, depending on the particular prey availability situations characterizing the habitats.

Within the range of the Queen Charlotte goshawk, clearcut and early seral stage habitats apparently form poor foraging habitats (Iverson et al. 1996, Doyle 2006). This is likely due to an absence of lagomorphs, ground squirrels, and edge-adapted birds of appropriate size that might otherwise use open habitats. Dense sapling stands soon form in cutover areas and prevent penetration by goshawks regardless of prey populations therein (Iverson et al. 1996). Cutover habitats will probably not sustain Queen Charlotte goshawks until forests approach maturity, when they are typically scheduled for harvest. Forest management must, therefore, emphasize continued existence of mature and old forest to ensure preservation of the subspecies.

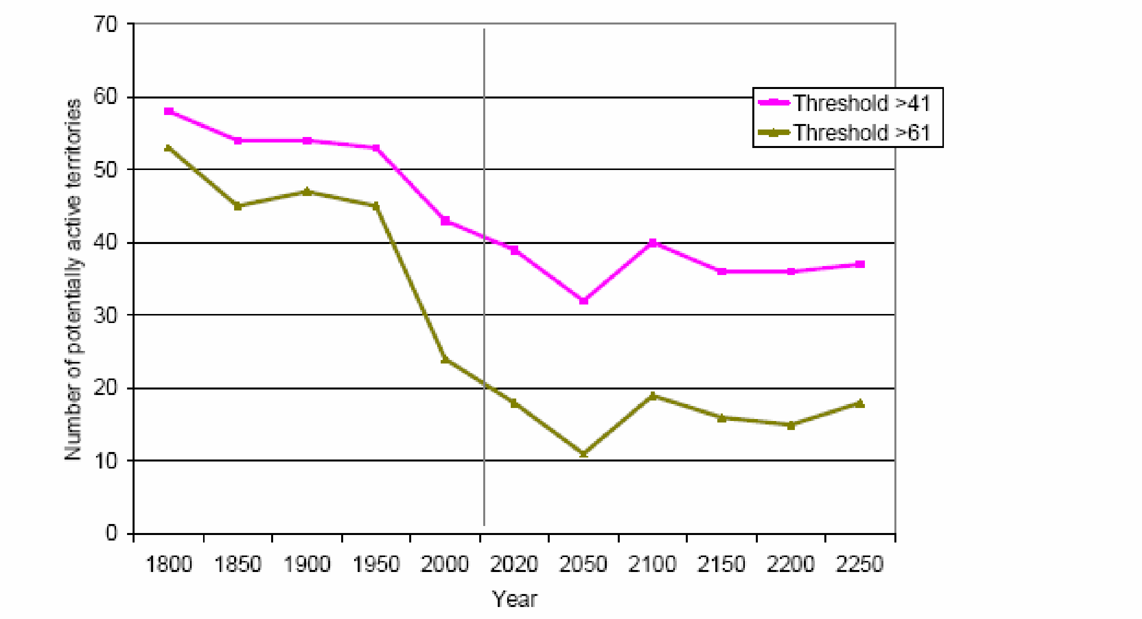
Current management plans forecast continued harvest of old growth throughout the subspecies' range. In Southeast Alaska second growth is expected to increase from 13 percent of the productive forest (current condition) to 27 percent. In British Columbia, the percentage of productive forest harvested is, and will remain, much higher, increasing from 45 to 59 percent. On the Queen Charlotte Islands 28 percent of the productive forest had been converted to second growth by 1997, but 37 percent is available for harvest under current management plans. On Vancouver Island, 49 percent of the productive forest has been converted to second-growth, and another 16 percent is expected to be harvested (Figure 10; Appendix A, Table A-9). We estimate that about 20 percent of the *habitat value* will be lost in Southeast Alaska and about 55 percent in British Columbia, compared with pre-logging conditions (Appendix A, Table A-13). We estimate that remaining (current) habitat value will be reduced by 12 percent in Southeast Alaska and by 28 percent in British Columbia (20 percent on the Queen Charlotte Islands and 31 percent on Vancouver Island), and 18 percent range-wide (Appendix A, Table A-15).

This harvest is not spread uniformly across the landscape. Instead, it is concentrated in areas designated for timber production. Thus, impacts are disproportionate in some areas.

The effects on goshawk population viability are unknown, but observations by Doyle (2005) suggest that successful breeding on the Queen Charlotte Islands requires at least 41 percent old or mature forest within a nesting territory. Modeling has predicted that the number of viable territories has already declined on the Queen Charlotte Islands (from 58 viable territories in 1800 to 10 territories in 2004). Adjustments for observed occupancy rates suggest that only 4 to 13 territories in the Queen Charlotte Islands can be expected to support breeding in any one year, given the habitat available in 2004 (Doyle 2005). Similar modeling with somewhat different parameters (Doyle and Holt 2005) predicted that viable goshawk territories will continue to decline until about 2055, then recover slightly as second growth stands mature prior to harvest (Figure 11). Simple population viability analyses for these low numbers of territories indicated that the probability of population persistence on the Queen Charlotte Islands ranged from zero to 31 percent (Doyle and Holt 2005).

Comprehensive, habitat-based population modeling is being done for Queen Charlotte goshawks in British Columbia, but results are not yet available (McClaren 2006a). We do know that a greater percentage of the forest has been harvested on Vancouver Island, however, suggesting that population declines are probably greater there than on the Queen Charlotte Islands.

Figure 11. Number of potentially viable goshawk territories on the Queen Charlotte Islands predicted over time, using two thresholds for the amount of mature and old forest within hypothetical nest territories (>41 percent and >61 percent) (Doyle and Holt 2005).



Goshawk Risk Assessment Panels -- In November, 1995, the U. S. Forest Service convened a panel of four goshawk experts to assess the likelihood that various Forest Management Plan alternatives would maintain a persistent and well distributed population of goshawks across their historical range on the Tongass National Forest (Iverson 1996). This effort was not reported in the goshawk Conservation Assessment (Iverson et al. 1996).

The assessment panel was provided information on the forest-planning process and the nine alternative plans being considered, background on goshawk ecology and habitat relationships in Southeast Alaska, and maps illustrating distribution of land use designations and projected harvests by the year 2095 for each alternative considered. The panel focused on implications of timber harvest for a raptor found at relatively low nesting densities that preferentially selects old forest and avoids early and mid-seral forests in a fragmented environment with low prey diversity. The panel generally agreed that older second growth resulting from timber rotations of 200 to 300 years could provide useful habitat, and would reduce risk to goshawks, as compared to 100-year rotations. The concept of habitat reserves was considered less critical than appropriate management of the matrix lands subject to timber harvest between the reserves (Iverson 1996).

The panel re-convened in March 1997 to consider three additional alternatives and re-evaluate four of the original alternatives (five were dropped) (Iverson 1997).

Each Forest Plan alternative was characterized by a “theme” that described what was emphasized. Possible outcomes ranged from no effect on historical distribution or viability to extirpation of the species from the Forest, with intermediate outcomes characterized by gaps in historical distribution, limitations on interaction among adjacent individuals, and confinement to refugia (Shaw 1999). For the most part, scores varied with projected harvests (Table 10), but there was recognition that longer rotations and uneven-aged management, which were emphasized in some alternatives, favored goshawk distribution and viability. Ultimately, the Regional Forester chose Alternative 11 with modifications (USDA Forest Service 1997), which remains in effect as the governing Forest Plan. Experts determined that this alternative was most likely to result in some temporary gaps in the species distribution, although there was some risk of significant, permanent gaps. There was some chance that distribution and viability would not be affected by this plan, and little concern that the species would be confined to refugia or extirpated as a result of implementing this alternative (Table 16).

Table 16. Projected harvest of old forests (1997 to 2095) and ratings for 7 Forest Plan alternatives evaluated by a risk assessment panel (Iverson 1997). Ratings are relative to a total of 100 possible for each alternative.

		Average Relative Likelihood Outcome[a]				
	Timber Harvest	Low Risk ←→ High Risk				
Alternative	by 2095 (ha)	I	II	III	IV	V
1	0	63	38	0	0	0
2	345,306	1	19	61	16	5
5	187,321	35	50	15	0	0
9	421,856	0	10	61	26	3
9’	567,693	0	8	61	29	3
10	271,249	8	40	48	5	0
11	192,226	23	48	28	3	0
Historical[b]	-167,540	88	13	0	0	0

[a] I = Well distributed breeding population across the Forest; II = low density, some temporary gaps created in the species distribution; III = Some significant, permanent gaps in distribution occur, with some limitation to population interaction; IV = populations existing only in refugia; and V = extirpation of the species from Federal land
[b] “Historical” reflects forest condition in 1900, without timber harvest.

Overutilization

The second listing factor in the *Endangered Species Act* is "overutilization for commercial, recreational, scientific, or educational purposes" (ESA Sec. 4(a)(1)(B)).

The Queen Charlotte goshawk is not known to be subject to frequent shooting or other illegal take, although occasional shooting of birds harassing poultry farms or encountered during hunting of other species probably occurs. Most of its range is very sparsely inhabited by humans and contacts with humans are relatively rare.

Goshawks are occasionally taken from the wild in Alaska for falconry, under federal and state regulations. Between 1990 and 2005, 37 goshawks were reported captured in Alaska. One was from the range of the Queen Charlotte goshawk (Douglas Island), 23 were from elsewhere in Alaska, and 13 had no specific location reported (Lawrence 2006, p. 1). Harvest of the subspecies is forbidden in British Columbia (Cooper and Stevens 2000). Take by humans appears to be rare, and is not believed to pose a threat at current rates.

Natural Enemies

The third listing factor is "disease or predation" (ESA Sec. 4(a)(1)(C)).

***Disease* –**Diseases and parasites affecting goshawks include tuberculosis, trichomoniasis, erysipelas, *Aspergillus*, lice, West Nile virus, heart failure caused by *Chlamydia tsittaci* and *Escherichia coli*, parasitic flatworms such as cestodes and trematodes, and various blood parasites (Squires and Reynolds 1997, Squires and Kennedy 2006, Reynolds et al. 2006). Beebe (1974) described goshawks from the southern portion of their range (where they coexist with pigeons) resistant to trichomoniasis, but those from the north vulnerable. We have no indication that Queen Charlotte goshawks have experienced any significant problems with disease, although there has been little or no investigation in this area. In the wild, disease-debilitated goshawks are quickly lost to predation or die where they are unlikely to be found. Thus, disease problems can go unnoticed.

Stress from other factors such as prey shortage can lower resistance and has been implicated in disease outbreaks in goshawk populations elsewhere (e.g., Redig et al. 1980), and could act similarly in *laingi* goshawks. Emerging infectious diseases (such as West Nile virus, which appears to be fatal in goshawks (Wunschmann et al. 2005)) can have significant impact on small populations, including extinction (Daszak et al. 2000).

***Predation* --** Goshawks have few natural predators because of their relatively large size, and predation does not appear to be a major threat, at least to adults. Wiens et al. (2006a) documented predation as a leading cause of mortality among juvenile goshawks in Arizona, with 46 percent of 24 deaths from fledging through dispersal from predation.

Goshawks are occasional prey of eagles (Squires and Ruggerio 1995), great horned owls (Rohner and Doyle 1992, Boal and Mannan 1994), and various mammals (Doyle 1995, Paragi and Wholecheese 1994, McGowan 1975). The probability of predation may increase during periods of low food availability (Zachel 1985, Rohner and Doyle 1992, Squires and Reynolds 1997). The great horned owl is probably the most frequent predator because of its wide distribution within goshawk range and its size, abundance, and capacity for preying on large raptors (Orians and Kuhlman 1956, Hagar 1957, Houston 1975, Luttich et al. 1971, McInvaille and Keith 1974). Although goshawks aggressively, and usually successfully, defend their nests against diurnal predators, their vulnerability increases at night. Most reports of predation on goshawks by great horned owls involve goshawk nestlings, but adults are also taken (Rohner and Doyle 1992, Doyle 2003). The magnitude of losses to great horned owls are unknown, although Boal and Mannan (1994) identified owls as the principal source of nestling mortality in their study in northern Arizona, accounting for at least 45% of 11 losses. This owl's potential to affect the fecundity of large raptors is exemplified by predation rates as high as 49% on nestling red-tailed hawks (Luttich et al. 1971).

Great horned owls initiate nesting earlier than goshawks and sometimes use old goshawk nests, displacing goshawks to alternate nests. Because alternate goshawk nests are often close together (Reynolds et al. 1994, Woodbridge and Detrich 1994), goshawks and owls sometimes nest close together. Goshawk vulnerability is probably increased under such conditions. Predation on Queen Charlotte goshawks by great horned owls has not yet been documented, and although it probably occurs, it seems likely to be less of a problem with this subspecies than with other goshawk populations because of the overall scarcity of great horned owls in the range of the subspecies (Iverson et al. 1996). Barred owls (*Strix varia*) are common in some parts of coastal British Columbia and Southeast Alaska, and may also be goshawk predators.

Predation by other species on goshawks appears to be irregular. Squires and Reynolds (1997) cite instances of predation by eagles (Squires and Ruggiero 1995), marten (*Martes americana*) (Paragi and Wholecheese 1994), and wolverine (*Gulo gulo*) (Doyle 1995). Bald eagles are abundant along marine shorelines and beach fringe forests throughout Southeast Alaska and coastal British Columbia, and may pose predation risks to goshawks foraging in this zone (Lewis 2003). While it seems unlikely that goshawk populations in the region are limited primarily by predation, this factor in combination with other stressors could be significant given the small population.

<u>Inadequacy of Regulatory Mechanisms</u>

The fourth listing factor is "inadequacy of existing regulatory mechanisms" (ESA Sec. 4(a)(1)(D)).

The *Endangered Species Act* allows listing of species outside the United States; Section 4(b) requires consideration of efforts made by foreign nations to protect species being considered for listing. Although the United States does not designate critical habitat, prepare recovery plans, or consult on Federal actions conducted in foreign nations (Rohlf 1989, pp. 173-179), several sections of the *Act* do apply to species listed in foreign countries. Section 8 encourages international cooperation (through agreements, shared expertise, research and enforcement) to conserve vulnerable species outside the United States. The prohibitions against import, trade, transportation and possession of listed species apply to anyone subject to United States jurisdiction, regardless of where the species is listed.

Because the regulatory mechanisms are different between British Columbia and Alaska, they are evaluated separately.

Southeast Alaska – Goshawks, their eggs, nests, and young are protected from take in Alaska by the federal Migratory Bird Treaty Act, except as permitted by regulations governing scientific research, falconry, and similar activities (discussed above, under Overutilization). State of Alaska laws and regulations further restrict the take and use of goshawks in Alaska. Regulatory mechanisms for direct take appear adequate.

The primary means by which goshawk *habitat* is protected in Southeast Alaska is the conservation strategy of the Tongass Land and Resource Management Plan (USDA Forest Service 1997). Elements of the plan are discussed above, under **Tongass National Forest Lands, Alaska**, Standards and Guidelines. This plan is legally binding on the Forest Service; failure to comply with it has resulted in administrative appeals and lawsuits to stop proposed actions.

Concerns have been expressed by various scientists and environmental organizations that the management regime of the current Forest Plan is inadequate to ensure the continued viability of the full range of biodiversity on the Tongass (Powell et al. 1997) and goshawks in particular (Greenwald and Bosman 2006). Some of these concerns address design of the Forest Plan; others address implementation. We discuss these separately below.

Among Powell et al.'s (1997) criticisms of the plan's design are that reserves are too small and are inadequately linked by corridors (primarily stream and beach buffers) that are too narrow to provide interior forest conditions and wind firmness. The current plan also leaves most of the largest old growth blocks vulnerable to fragmentation by roads and logging as the highest-volume stands continue to be disproportionately harvested primarily by large-scale clearcutting, a method that neither mimics natural disturbance patterns in the rainforest nor maintains old-forest habitat (Powell et al 1997). Another concern is that harvest rotations averaging 105 years as planned (USDA Forest Service 1997, FEIS p. 3-299) will not regenerate old growth characteristics in harvested stands. For goshawks specifically, there is concern that 40-ha nest buffers are inadequate to protect foraging habitat within the home range of nesting birds (Greenwald and Bosman 2006).

Goshawks would probably benefit from greater retention of large blocks of structurally diverse old growth. Connectivity among forest patches is unlikely to be problematic for goshawks directly because they can fly between patches of, but is probably critical to some of their prey such as red squirrels. These buffers may be used by foraging goshawks, but should not be considered nesting habitat, as they lack interior forest conditions apparently favored by goshawks.

In 1997, the Forest Service estimated that 80 percent of timber harvest would be by clearcutting (USDA Forest Service 1997, ROD p. 5). Harvest regimes that create smaller openings, such as single-tree and group selections, would favor goshawk conservation by largely avoiding creation of extensive blocks of dense second growth that goshawks cannot penetrate. Partial harvests, such as shelterwood cuts that leave adequate structure in the harvest unit to provide perches and hunting opportunities, would probably allow goshawks to hunt in harvested areas for several years before second growth stands filled the understory. Overstory retained in such systems, if left unharvested, might also provide nesting structures as the second growth approached maturity.

Harvest rotations averaging 105 years in even-aged stands are unlikely to provide more than a decade or two of suitable habitat at the end of each rotation. Forestwide, harvesting 16 percent of the productive old forest as planned (Table 8) would result in an "ecological rotation" of about 600 years (only 1/6 of the forest cut in any 100-year period). Still, we expect that areas with little or no habitat value, some as large as several nesting territories, are likely to be created in areas available for timber harvest (Figures 3 and 4).

Nest buffers of 40 ha protect individual nests from disturbance, but probably protect only half of the alternate nests in the nest area and inadequate post-fledging area for young birds. Flatten et al. (2001) documented 24 instances of goshawks in Southeast Alaska moving to alternate nest sites in consecutive years. Fifty four percent of these alternate nests were contained within a circle of 40 ha centered on the original ("year 1") nest; 79 percent were within a 1-km radius (314 ha). A 3,218-ha circle (3.2 km radius) was required to cover all 24 alternate nests.

McClaren et al. (2005) documented post-fledging areas on Vancouver Island ranging from 15 to 230 ha, and averaging 59 ha. Only 4 of 12 were less than 40.5 ha. Thus, the nest buffers specified for the Tongass are probably inadequate as post fledging areas in most cases.

Adult goshawks forage effectively across varied habitats. The presence of timber harvest within the home range or seasonal use area of breeding goshawks does not necessarily render the territory inviable, although lack of available prey in open areas and early seral stages does result in areas that goshawks avoid (see discussion above, under "Habitat Loss"). Thus, as the proportion of second growth increases in a territory, the quality of habitat probably decreases.

Concerns over implementation of the forest plan include complaints that old growth reserve designations have been inadequate, timber harvest and other developments have been permitted in old-growth reserves, and that pre-project goshawk surveys have been inconsistent and ineffective (Greenwald and Bosman 2006).

Goshawk surveys are required to reduce the chance that forest management activities will impact nest sites, and partial harvests are prescribed to benefit goshawks in the most intensively harvested areas (USDA Forest Service 1997). Since 1998, survey efforts have focused primarily on following up on reports of goshawks in the vicinity of proposed projects, and conducting “valley watches” at sites where no reports have been generated. Broadcast call surveys are used primarily to evaluate nest activity at known nest sites; in some Ranger Districts they are used to search for nests in project areas. Survey effort and reporting has apparently been inconsistent. Forest-wide effort and results have not been reported in recent years (Greenwald and Bosman 2006). Forest Service staff is standardizing conduct and reporting of goshawk surveys, which in many cases are likely to fail to detect nesting goshawks that are present because the birds are secretive, often unresponsive, and easily missed (Flatten et al. 2001b, Boyce et al. 2005). Once a nest is located, however, protection is automatic, with no formal, legal designation necessary.

State laws and regulations governing forest practices apply region-wide, but are less restrictive than the Forest Plan and so are relevant primarily to the 11 percent of Southeast Alaska not managed by the U.S. Forest Service or the National Park Service. Timber harvest is restricted within 100 feet of anadromous fish streams, some resident fish streams, and estuaries on State lands, and within 66 feet of such water bodies on private lands (AS 41.17.115-119). About one third of the 29,000 ha of productive forest on the Haines State Forest are protected in reserves and retention (Appendix A, Table A-9). We are aware of no other retention requirements for wildlife on lands regulated by the State of Alaska for timber harvest.

Summary - The Forest Plan clearly makes an effort to protect biodiversity in general and goshawks in particular. Important elements include Old Growth Reserves or other protected forest in every watershed open to logging, 300-meter (1,000-foot) beach buffers, 40-ha (100-acre) nest buffers, and canopy retention in heavily harvested watersheds on Prince of Wales Island. Some elements of the plan work against conservation of the goshawk (e.g., heavy reliance on clearcutting, continued fragmentation of remaining habitat, nest buffers that probably protect less than half of the alternate nests in a nesting area and inadequate post-fledging habitat, and inconsistent and ineffective survey efforts). Many areas in Southeast Alaska, however, remain unharvested, and the majority of the region’s productive old forest will remain uncut.

British Columbia – The Queen Charlotte goshawk is federally listed as threatened under Canada’s *Species at Risk Act*, which took effect in 2004. As a listed Schedule 1 species, the bird must not be killed, harmed, harassed, captured or taken. Possession and trade in the species is forbidden, as is destruction of residences (defined as nests for goshawks). Protection of listed species and their residences is automatic on federal lands, which for the Queen Charlotte goshawk is largely restricted to one national park on the southern portion of the Queen Charlotte Islands (with little productive forest) and another small park on the southwestern coast of Vancouver Island.

Protection of listed species and their residences on provincial lands is provided by provincial laws, policies, and agreements. If the federal Minister of Environment deems the provincial protection mechanisms ineffective for a listed species and their residences, an order may be made for Federal government intervention.

Under British Columbia's *Wildlife Act* (RSBC 1996, Section 34) birds, their eggs, and occupied nests are protected from possession, take, injury, molestation and destruction.

Habitat protection is also regulated at both the federal and provincial levels. The federal *Species at Risk Act* requires development of a recovery strategy, which identifies the scientific framework for recovery, and a recovery action plan, which outlines specific measures to implement the recovery strategy. Two mechanisms exist to protect habitat: identification of critical habitat, which may not be destroyed without a permit, and conservation and stewardship agreements, which may be negotiated with any entity or individual (Statutes of Canada 2002, reviewed by Smallwood 2003).

Federal recovery planning, which is underway for Queen Charlotte goshawks, has potential to make substantial contributions if it leads to implementation of meaningful conservation actions. Conservation agreements, for example, might be used to protect habitat on private or Crown land that would otherwise be lost to timber harvest. Such agreements have not yet been proposed and are strictly hypothetical at this time.

The provincial *Wildlife Act* allows the Lieutenant Governor in Council to list endangered and threatened species. The *Wildlife Amendment Act, 2004*, which has been passed but has not yet taken force, prohibits take (including "kill harm, harass, capture or take") of listed species and damage or destruction of their residences (nests). It also allows designation of land in a wildlife management area as a critical species protection area. Regulations currently being developed are expected to provide a prioritization process for listing species, but at this time the goshawk has not been listed as endangered or threatened under the Wildlife Act by the Province of British Columbia.

As a signatory to the national *Accord for the Protection of Species at Risk*, British Columbia is committed to "…provide for the development of recovery plans within one year for endangered species and two years for threatened species that address the identified threats to the species and its habitats." This commitment is being met through active participation in the federal recovery planning process. The provincial government, however, has no independent legal provisions for the recovery of provincially listed species (Wood and Flahr 2004).

Land use planning is the primary method identified by the British Columbian government for establishing protected areas and limits on development to conserve biodiversity across the Province. Land use plans can set targets for biodiversity and single species management in excess of current government policy on timber imipacts. On Vancouver Island, where a Land Use Plan was approved in 2000, 13 percent of the landscape is in protected status and eight percent is in "Special Management" zones that stress non-timber values. The remainder is in "General" (31 percent) or "Enhanced Forestry" (24 percent) zones that stress timber production, Private forestland (18 percent) that has little or no government oversight on logging methods, Agriculture (three percent), or

Settlement (three percent). It is not clear how much habitat is required to sustain goshawks on Vancouver Island, but the current land management plan allocates only a small minority (13 percent) to strict protection, much of which is at high elevation and on low-productivity sites. Little or none is in the most productive forest zones on the eastern side of the island (nearly all of which has already been logged). An approved land use plan is not yet available for the Queen Charlotte Islands.

The *Identified Wildlife Management Strategy* was developed by the British Columbia government to provide additional protection for species that require specific measures beyond the "coarse-filter" system of protected areas and the various regulations governing timber harvest generally. The Strategy is integrated into the *Forest and Range Practices Act* and its implementing regulations, the *Forest Planning and Practices Regulation* (described above, in Part III – Condition of the Forest in Southeast Alaska and British Columbia). The Strategy provides for establishment of Wildlife Habitat Areas (28 have been designated for goshawks), and allows prescription of management measures within those Areas. Non-binding recommendations for management of goshawk habitat have also been developed to help guide future planning efforts (McClaren 2004).

A significant limitation to the *Identified Wildlife Management Strategy* is a cap of one percent impact to the short-term (i.e., mature) timber supply of each Forest District, for all species covered by the Strategy. This restriction, which essentially prioritizes protection of the timber supply over the needs of species at risk, is reflected in regulations that set objectives for species at risk, wildlife and biodiversity, and riparian habitat. Each objective is prefaced by the phrase "without unduly reducing the supply of timber from British Columbia's forest…" (BC Reg 14/04, see also ***Forest Planning and Practices Regulation***, above). Notifications of the "amount, distribution, and attributes wildlife habitat required for the survival of species at risk" specify how many hectares must be protected in the otherwise harvestable land base (Table 14). The figures stated in the notices are based more on allocating one percent of the Timber Harvesting Land Base among the species requiring habitat protection than they are on analysis of true conservation needs for each species (FPB 2004). By committing such calculations to legal notifications, the one percent "policy" has begun to acquire the force of law (FPB 2004).

In the absence of completed land use planning to address the needs of goshawks, the one percent cap is likely to interfere with meaningful conservation in areas with high numbers of at-risk species and continuing threats to those species (Wood and Flahr 2004). Southern Vancouver Island, for example, is a biodiversity "hot spot," with a large number of rare and endemic species (Scudder 2003). Some of these species have habitat needs that differ from the goshawk's and yet their legitimate conservation needs must be accommodated along with the goshawk within the one percent limit. In the South Island Forest District (which covers southern Vancouver Island) Wildlife Habitat Areas are already approaching the one percent cap, indicating a need to either relax the cap, or rescind some Wildlife Habitat Areas (Wood et al. 2003, p. 53).

Because the one percent cap is on impacts to short-term timber supply, rather than the long-term supply, calculations must be based on forest stands greater than 60 years old (and therefore ready for harvest). In the South Island Forest District, less than one third of the forest is approaching economic maturity, so Wildlife Habitat Areas and other such retentions for Identified Wildlife are limited to approximately one third of one percent of the productive forest in the Timber Harvesting Land Base. Similar situations exist wherever past harvest is extensive, yet these are the areas with the greatest need for conservation (FPB 2004)

Biodiversity objectives of the *Forest and Range Practices Act* offer some opportunity to conserve goshawk habitat. A review of implementation of biodiversity measures under the *Forest Practices Code,* however, revealed significant shortcomings in implementation of several aspects of the biodiversity strategy. The lowest levels of overall implementation were found in the Coast Forest Region (FPB 2004). Current default standards for biodiversity objectives include a 40-ha limitation on individual harvest units, retention of at least seven percent of the area of all harvest units, on average, with a minimum of 3.5 percent retention in any one unit. Inoperable areas, riparian buffers, and trees retained for other reasons all count toward the biodiversity objectives, so biodiversity standards probably represent only a slight conservation advantage in most cases.

Old-growth retention objectives similarly rely, to a large extent, on forest protected under a variety of other mechanisms (including parks, inoperable areas, etc.). The government objectives specify percentages of old growth that must be maintained within landscape units approximating medium-sized watersheds. Tenure holders and other land managers are obligated to address how those targets will be met, with limited additional guidance from government.

Summary - The British Columbia government has made a significant effort in recent years to establish an integrated, cooperative system among several ministries to address conservation needs of species affected by forest management. Among the elements of this system are mechanisms to identify vulnerable species (the Queen Charlotte goshawk *is* included on the list of “Identified Wildlife”) and conserve habitat (new protected areas have been designated, including several Wildlife Habitat Areas for goshawks). While these measures may help maintain goshawk populations (or slow declines), they are limited by constraints imposed to minimize impacts to the timber industry.

The federal *Species at Risk Act* requires recovery planning, and a team is currently evaluating conservation needs of the subspecies, in order to make recommendations to government (both provincial and federal). The “Canadian Northern Goshawk *Accipter gentilis laingi* Recovery Team” is chaired by provincial biologists, and includes experts from provincial and federal government agencies, private consultants, non-government organizations, industry and First Nations (McClaren 2006a). Their work is confidential until a recovery strategy is completed and released, so little can be said about the recommendations that may be made.

Other Natural and Manmade Threats

Finally, we must consider "other natural or manmade factors affecting its continued existence" (ESA Sec. 4(a)(1)(E)) . Here we evaluate a variety of agents that could influence survival.

Competition-- Competition could affect goshawks principally with respect to food supplies and nest sites, the most common limiting factors for raptors. Several species of hawks, owls, and mammals have diets that overlap goshawk diet. Perhaps the most similar species in diet in many regions is the Cooper's hawk, and in at least some regions goshawks and Cooper's hawks space their nests at similar distances intraspecifically and interspecifically (Snyder and Wiley 1976), possibly a reflection of significant food competition. Goshawks, however, are presumably the dominant competitor in most situations, as they normally initiate nesting earlier than Cooper's hawks, and represent a direct threat of predation to Cooper's hawks. Cooper's hawks might reduce food supplies within the ranges of sympatric goshawks, especially with respect to prey the size of pigeons, jays, and flickers. However, since Cooper's hawks overlap the geographic range of the Queen Charlotte goshawk only on Vancouver Island, the impact of this species on the Queen Charlotte goshawk is likely to be minor.

Other raptors with diet and range overlap include red-tailed hawk, great horned owl, and barred owl. Their diet overlap with goshawks is less than that of Cooper's hawks (Fitch et al. 1946, Luttich et al. 1970, Smith and Murphy 1979, Janes 1984, Bosakowski and Smith 1992). These species tend to hunt more open country than the goshawk (Howell et al. 1978, Spieser and Bosakowski 1989). Progressive fragmentation and opening of forested habitats may tend to favor these competitors, and their impacts could increase in the future as habitat modifications increase. Red-tailed hawks are sporadic and great horned owls are widespread but uncommon in Southeast Alaska, especially on the islands (Iverson et al. 1996). Both species have relatively high populations on Vancouver Island, possibly reflecting more open habitats and greater fragmentation resulting from the higher levels of timber harvesting there. Barred owls are also believed to be increasing in southern British Columbia, possibly for the same reason.

A variety of mammalian carnivores, including coyotes (*Canis latrans*), lynx (*Lynx canadensis*), wolverine, raccoons, and martens (*Martes americana)* occur in various portions of the Queen Charlotte goshawk's range. These species feed on some of the same prey as goshawks, including squirrels, grouse, and other birds. Especially in years when prey populations are naturally low, the cumulative effects of predation by these carnivores on the abundance, distribution, survival, and reproduction of goshawks could be significant, although such indirect effects are undocumented.

Nest-site competition appears much less likely for Queen Charlotte goshawks than food competition. Although the subspecies exhibits preferences in nesting habitats, the sorts of trees utilized by the subspecies for nesting are not normally in limited supply, and when its nests are usurped by other species, such as great horned owls or red-tailed hawks, it is normally fully capable of moving to alternate sites or constructing alternative sites within its nesting areas. It is not uncommon for goshawks and other raptors to nest quite close to one another (Reynolds and Wight 1978).

Pesticides and Other Contaminants- Levels of organochlorine contaminants, such as DDE and dieldrin, were low in U.S. goshawks during the height of unregulated pesticide use, whereas levels in Cooper's hawks and sharp-shinned hawks were much higher and were evidently the cause of major population declines of the latter two species in the eastern U. S. (Snyder et al. 1973, Havera and Duzan 1986, Elliot and Martin 1994). The major differences in susceptibility of these species to organochlorine stress stem from dietary differences, with the greatest vulnerability experienced by the species that feed most intensively on insectivorous birds. With the relatively high component of herbivorous mammals and birds in the diet of goshawks throughout its range, this species has received significantly less contamination than its two congeners, and no goshawk populations have been known to have declined from organochlorine pesticide contamination.

With overall reduced levels of organochlorine contamination continent-wide, the distance of most of the Queen Charlotte Goshawk range from regions of intensive agriculture, and with the generally low susceptibility of the species to organochlorine stress, the probability of significant problems with these compounds is low for the Queen Charlotte goshawk. No problems with excessive egg breakage or inviability have been noted in nesting studies of Queen Charlotte goshawks (Titus et al. 1999). Treatments to kill forest pests such as pine beetles or budworms could conceivably affect goshawks or their prey, although current regulation of pesticides is intended to minimize such effects.

Natural Disasters – The Alaskan portion of the Queen Charlotte goshawk's range receives heavy and regular rainfall in most locations; risks of major habitat losses to fire are very low (Iverson et al. 1996). The Tlell fire, however, burned approximately 5,000 acres of productive forest on Graham Island in the Queen Charlottes in the late 1800s (Cortex and HiMark 2004). Other areas of comparatively drier forest types on eastern Vancouver Island may also be vulnerable to wildfire in some circumstances.

Perhaps the most significant natural habitat perturbation is occasional loss of forest to wind. Researchers in Southeast Alaska have documented distinct wind disturbance regimes, grading from exposed landscapes where recurrent, large-scale wind events prevail to wind-protected landscapes where small-scale canopy gaps predominate (Nowacki and Kramer 1998). Timber harvest can also expose previously protected stands to damaging winds. Earthquakes and volcanic eruptions represent at most localized and temporary threats that cannot be expected to pose major threats to persistence of the subspecies. Tsunami waves generated by seismic activity could eliminate habitat in portions of the subspecies range, particularly along the outside coast, but such impacts are unlikely to affect more than a few breeding territories over the foreseeable future.

Climate Change - Climate change is expected to affect forest species composition and distribution over the next several decades as warmer-adapted species such as Douglas-fir expand northward on Vancouver Island and onto the Queen Charlotte Islands, and cool-adapted coastal western hemlock forest invades alpine tundra (Hamann and Wang 2006). Conifer cover is projected to increase across Southeast Alaska (Bachelet et al. 2005). These changes should be positive for goshawks, although *atricapillus* goshawks dispersing from surrounding areas could become more numerous within the existing range of *laingi* goshawks, exerting a greater competitive influence in the warmer forests. This could be offset by expansion of *laingi* range northward in Alaska toward Yakutat, where we presume the *laingi* phenotype would retain a competitive advantage.

Climate change is expected to increase the frequency and intensity of forest fires across much of Alaska, but the effects in Southeast Alaska are not clear as they will depend largely on how precipitation is affected (Bachelet et al. 2005). Insect infestations or tree diseases might also increase, although we are not aware of any projections quantifying such changes.

Genetic Risks – Genetic analyses suggest that goshawks from Southeast Alaska and coastal British Columbia are closely tied through recent ancestry or contemporary gene flow, and potentially represent a metapopulation, genetically distinct from goshawk populations in interior British Columbia and Alaska (Gust et al. 2003). More recent preliminary analyses indicate that goshawks from the Queen Charlotte Islands are strongly differentiated from surrounding populations (including Southeast Alaska and Vancouver Island), and that there has been little gene flow into the population there from neighboring mainland or island populations (Talbot et al. 2005). These results are compatible with the observed distribution of the small, dark phenotype for which the subspecies was defined, and suggests that the Queen Charlotte Island population may have served as a source in the past, or perhaps shares ancestry with birds displaying the phenotype in adjacent populations, but with less genetic variation. It seems likely that the reported isolation of the Queen Charlotte Island population has contributed to maintaining a stronger expression of the small, dark phenotype there, as compared the rest of the subspecies’s range.

Talbot (2006) reported that goshawks on Vancouver Island show genetic similarity to *atricapillus* goshawks. To date, these potentially significant genetic data have not been reviewed by qualified taxonomists and there have been no scientific publications or other reports proposing modification of currently accepted taxonomy for the species or subspecies. Accordingly, we continue to treat the birds on both the Queen Charlotte Islands and Vancouver Island as part of the *laingi* subspecies. We interpret the genetic distinctiveness of goshawks on Vancouver Island as a reflection of genetic diversity within the subspecies, possibly from hybridization.

Metapopulations are groups of partially isolated populations that are, in general, more vulnerable to loss of genetic diversity and overall extinction than other population structures. Vulnerability in such cases is largely a function of gene flow and extinction rates among the subpopulations (Lande 1988, Frankham et al. 2002). Population dynamics are essentially unknown for the various subpopulations of Queen Charlotte goshawks, although the population on the Queen Charlotte Islands appears to be at higher risk than those elsewhere, based on its apparently small size and genetic isolation (Talbot et al 2005).

Demographic Risks **--** Security from demographic inviability is difficult to establish, and depends both on mean levels of fecundity and mortality and on largely undocumented levels of fluctuations in such parameters. Present data are inadequate to specify such parameters, but there is some indication that breeding effort does fluctuate with squirrel populations or other factors in at least some parts of the subspecies range.

Existing demographic data are inadequate to address viability. Reasonably high levels of nest success and productivity (Table 5) suggest that the present population remains viable, but measured survival rates for adult males in Southeast Alaska is the lowest reported for goshawks that we are aware of (Table 6). Several other population vital rates (juvenile survival, age at first breeding, and percentage of adults breeding) are unknown.

Prey Availability **--** Population dependent on food supplies that fluctuate tend to fluctuate themselves. Many goshawk populations, while not dependent on single prey species, exhibit strong dependence on relatively few prey types, particularly during winter. Across the northern goshawk's range, hares, grouse, ground squirrels, and red squirrels make up the bulk of the diet in many areas. Often these prey species fluctuate greatly from year to year. Such fluctuations appear to be most marked in goshawk populations of the far north where goshawk diets are often especially strongly focused on relatively few species (McGowan 1975, Doyle and Smith 1994). Goshawk populations of the far north exhibit "boom or bust" cycles, with major irruptive emigrations of individuals, especially juveniles, at times of especially poor food supplies. These populations have heightened susceptibilities to extinction if their populations are relatively small at population maxima.

Significant prey fluctuations are not limited to arctic populations. Fluctuations in red squirrel populations (which appear to be correlated with conifer cone production) on Vancouver Island have been correlated with nest occupancy (Pelletier 2000) and nest activity (Ethier 1999). Similar observations have been reported from the Kispiox region of interior British Columbia (Doyle 2003) and from the Queen Charlotte Islands (Doyle 2007). Fluctuations in red squirrels have also been tied to fluctuations in goshawk breeding effort in northern Arizona (Reynolds and Joy 1998, Salafsky et al. 2005).

Where goshawks have alternative prey, fluctuations in squirrels may be buffered. Where grouse and other species are lacking or depressed (e.g., Queen Charlotte Islands) cone crop failures could have dramatic effects on nest activity and population recruitment, increasing the vulnerability of the population.

On the Queen Charlotte Islands, sooty grouse are believed to have been the primary prey for the goshawk in the past, but grouse numbers are apparently greatly reduced from historical levels. This decline in a key prey species is believed to have resulted from forage competition (primarily for blueberry and other shrubs) from introduced deer, which have dramatically increased in number, and modified the habitat by suppressing understory growth (Golumbia et al. 2003, Doyle 2004a). Predation on adults and nests by introduced predators (raccoons and red squirrels) may further depress grouse numbers, or prevent recovery (Doyle 2004a). This has left the goshawk reliant largely on introduced red squirrels, which are subject to population fluctuations as conifer cone crops vary, and a few species of small- and medium-sized birds.

Summary of Threats

Clearcut logging significantly degrades habitat for the Queen Charlotte goshawk by creating large forest openings devoid of prey. Dense second-growth stands that follow may be suitable for some prey, but these prey are largely unavailable to goshawks because the stands are too dense for goshawks to effectively hunt. As second growth approaches economic maturity, it may become useful to goshawks for foraging and nesting, but that value is lost once the stand is harvested again. Thus, habitat quantity and quality for Queen Charlotte goshawks is largely a function of the amount and distribution of productive mature and old forest through space and time.

Habitat loss, the first of five listing factors, is a significant issue within the range of the Queen Charlotte goshawk. Harvest rates are highest in British Columbia, where 59 percent of the forest land is likely to be harvested. On Vancouver Island, most forest has already been converted to second growth. On the Queen Charlotte Islands, habitat loss has probably reduced the breeding population to 18 or fewer pairs, a precariously low number. Population viability analyses offer little hope that the population will survive. U.S. Forest Service management under the current forest plan for the Tongass National Forest in Alaska, in contrast, was judged by a panel of goshawk experts as likely to produce gaps in the distribution of the goshawk, with a slight chance that goshawks would be confined to refugia, but no risk of extinction was perceived.

Regulatory mechanisms (listing factor 4) differ greatly between Alaska and British Columbia. The Tongass Land and Resources Management Plan (USDA Forest Service 1997), which governs approximately 76 percent of the goshawk's range in Southeast Alaska, is an enforceable document that defines protected areas and management regimes for lands subject to timber harvest. Clearcut logging remains the standard, in spite of concerns expressed over its impacts to species that depend on old and mature forests. Implementation of elements designed to help conserve goshawks, such as old-growth reserves, nest buffers, canopy retention in some areas of Prince of Wales Island, and pre-project goshawk surveys, have been implemented. Surveys have been inconsistent. Old growth reserves or other protective designations cover at least 8 percent of the old forest in each watershed otherwise open for logging.

In Canada, the Queen Charlotte goshawk is listed by the federal government as a Threatened Species. This designation protects it and its residences (nests) from direct harm on federal lands (which are very limited in the range of the bird). A recovery team is currently developing a recovery strategy and action plan as recommendations to government, but no concrete actions have been proposed at this time. At the provincial level, the bird, its eggs, young, and nest are protected under the *Wildlife Act*. All harvest for falconry has been prohibited since the subspecies was provincially Red-listed in 1994. The subspecies is also listed under the *Forest and Range Practices Act* as a species at risk that is affected by forest management, qualifying it as a species of “Identified Wildlife.” This designation has allowed the Ministry of Environment to establish several protected areas around known nest sites. The total area of these “Wildlife Habitat Areas” for all Identified Wildlife combined is limited by a cap of one percent impact on the short-term timber supply (i.e., mature forest available for harvest) within each forest district. This limitation essentially prioritizes commercial timber harvest over protection of endangered and threatened species, and is likely to interfere with effective conservation in areas with large numbers of at-risk species and large amounts of immature forest (the latter affects the amount of land that can be protected). Vancouver Island meets both criteria.

Predation, disease, and competition, acting individually or in combination with other factors, could pose threats to species viability, particularly given the small populations, but we are not aware of current impacts from these sources. Natural disasters, climate change, and pesticides seem unlikely to affect population viability. Genetic relationships are not clear, but the subspecies is believed to freely interbreed throughout Southeast Alaska, across Vancouver Island, and on the Queen Charlotte Islands. There is apparently little exchange among the three populations.

Demographic risks are not well understood, but modeling indicates that minor changes in mortality, fecundity, or survival rates could have serious consequences for population viability. Given the small numbers of breeding pairs range-wide, there is little margin for sustaining sub-viable demographic rates for more than a few years.

Prey availability appears to limit Queen Charlotte goshawk populations in some parts of its range. Because of the fragmented nature of the island habitat it inhabits, prey species distributions vary. Researchers have identified food stress as a limiting factor for goshawks on the Queen Charlotte Islands, where sooty grouse are depressed by introduced deer, and on Prince of Wales Island in southern Southeast Alaska, which lacks both red squirrels and sooty grouse. Fluctuations in prey appear to affect breeding effort, and could contribute to population declines and ultimately to population extirpation given the small numbers of birds currently believed to exist on the Queen Charlotte Islands and Prince of Wales Island. Recolonization, in the case of such extirpations, seems more likely for Prince of Wales than the Queen Charlotte Islands.

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APPENDIX A. FOREST STATISTICS

Table A-1. Status of productive forest land (in ha) on Crown lands on Queen Charlotte and Vancouver Islands.

Tenure		Inoperable	Low Site Product[4].	Retention	Timber Harvesting Land Base	Total Productive Forest[1]	Total Area[2]	Decades of Old Forest Harvest
Queen Charlotte Islands (QCI)								
Timber Sale Areas								
	QC TSA	242,250	165,331	28,490	77,531	513,602	444,290	12
Tree Farm Licenses								
	TFL 25-6	20,154	4,623	1,054	23,519	49,350	53,364	3
	TFL 39-6	9,986	35,119	61,744	117,846	224,695	240,311	na
	TFL 47-BL	5,202	514	4,624	21,676	32,016	38,020	3
QCI TFLs Totals		35,342	40,256	67,422	163,041	306,061	331,695	
QCI TSA+TFL Totals		277,592	205,587	95,912	240,572	819,663	775,985	
Vancouver Island (VI)								
Timber Sale Areas								
	Kingcome	365,190	102,408	57,041	164,114	688,753	1,110,008	5
	Strathcona	142,454	9,404	44,694	159,678	356,230	395,864	4
	Arrowsmith	40,457	7,305	11,496	58,716	112,050	201,837	7
VI TSA Totals[3]		182,911	16,709	56,190	218,394	468,280	597,701	
Tree Farm Licenses								
	TFL 06	24,941	11,949	8,279	146,909	192,078	198,113	4
	TFL19	45,090	21	6,439	85,077	136,627	191,992	6
	TFL 25-1	3,599	2,134	623	23,745	30,101	32,201	7
	TFL 25-3	2,969	736	297	8,731	12,733	15,985	7
	TFL 37	20,984	2,933	36,411	90,221	150,549	196,725	4
	TFL 39-2	9,771	27,521	40,265	115,828	193,385	203,065	na
	TFL 39-4	853	7,948	8,167	29,955	46,923	51,541	na
	TFL 44	35,535	8,771	54,962	172,946	272,214	321,941	4
	TFL 46	8,998	247	3,855	64,029	77,129	90,870	3
	TFL 47-JS	5,742	1,406	9,221	71,260	87,629	101,847	2
	TFL 54	5,187	0	18,332	24,602	48,121	49,298	na
VI TFL Totals		163,669	63,666	186,851	833,303	1,247,489	1,453,578	
VI TSA+TFL Totals		346,580	80,375	243,041	1,051,697	1,715,769	2,051,279	
TSA Totals		425,161	182,040	84,680	295,925	981,882	1,041,991	
TFL Totals		199,011	103,922	254,273	996,344	1,553,550	1,785,273	
Crown Land Totals		624,172	285,962	338,953	1,292,269	2,535,432	2,827,264	

Data Source: Timber Harvesting Land Base Determination tables for each Tenure as described in Timber Supply Analysis Reports and Information Packages available at the following web sites (as of 12/2006)
for TFLs: http://www.for.gov.bc.ca/dmswww/tfl/
for TSAs: http://www.for.gov.bc.ca/hts/rco.htm (BCMF 2000, 2001a, 2001b, 2004b)

(Continued)
Table A-1 Notes (Continued)
Note 1: "Productive Forest" totals do not include lands converted to roads.
Note 2: "Total Area" of TSAs include only lands managed by BC Forest Service.
Note 3: TSA totals for VI exclude Kingcome (most of which is on BC mainland). Strathcona TSA includes a mainland portion that approximates VI portion of Kingcome, allowing a reasonable estimate of TSA lands . on VI (Method recommended by BC MoF, Niemann 2006b).
Note 4" "Low Site Productivity" is a subset of Inoperable (includes non-merchantable, uneconomic, low prod., etc.)

Table A-2. Hectares of productive forest by harvest status category within Timber Sale Areas (TSAs) and Tree Farm Licenses (TFLs) on British Columbia islands.

	Inoperable	Retention	Timber Harvesting Land Base	Total Productive Forest
VI TFLs	163,669	186,851	833,303	1,247,489
QCI TFLs	35,342	67,422	163,041	306,061
VI TSAs	182,911	56,190	218,394	468,280
QCI TSA	242,250	28,490	77,531	513,602

Figure A-1. Percentages of productive forest by category within TSAs and TFLs on British Columbia islands.

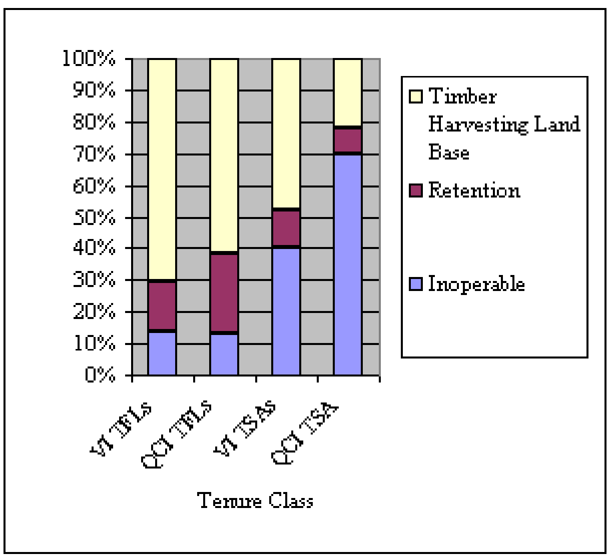

Table A-3. Private Land Assumptions and Calculations for Brtitish Columbia Islands

	Inoperable	Retention	Timber Harvesting Land Base Young	Mature	Old	Productive Forest	Total Private Land Area
Queen Charlotte Islands	874	134	4,605	569	538	6,720	8,400
Vancouver Island	79,099	15,820	541,861	5,939	148,267	790,985	939,003

Sources: QCI: Muise (2007) (total private land area)
VI: Niemann (2006a) (total private land area (BTM/BEC), productive forest, and 2nd growth on those lands)

Assumptions:

1) Area reported as "BTM/BEC Proxy" by Niemann (2006a) assumed to represent 100% of private land on Vancouver Island.
2) Percentage of productive forest on QCI private land equal to percentage of productive forest on QCI Crown lands (80%, from TSA and TFL timber supply analysis reports, see Table A-2)
3) % inoperable productive forest on private lands (QCI and VI) assumed equal to % inoperable productive forest on TFL lands for each Island group (13% on QCI and 10% on VI, Table A-2)
4) 2% of the otherwise operable productive forest on private land retained for non-timber values
5) Young forest defined as <80 yr old, Mature forest defined as 81-140 yr old, Old forest defined as >140 yr old.
% of Young and Mature second growth = % of each age class of total second growth on Crown Lands (see table below, Young = 89%, Mature = 11%) total private land second growth on VI = 608,833
On QCI, % of Private Land Productive Forest in 2nd growth assumed = % Private Prod Forest in 2nd growth on VI = 77% (see table below)
6) Mature/Old forest defined as >80 yr old, = Total Productive Forest - (Inop.+ Retention + Young)

Table A-4. Young, mature, and old forest on Vancouver Island **Crown** Lands (from Niemann 2006a)

Age Class	Area (ha)	% of Prod Forest	% of 2nd Growth
Young (<80 yr old)	696,282	36	89
Mature (81-140 yr old)	85,319	4	11
Total 2nd Growth	781,601	41	
Old (>140 yr old)	1,130,284	59	
Total Prod Forest (Crown)	1,911,885		

Table A-5.Percentage of **Private** productive forest on Vancouver Island in 2nd growth stages

Age Class	Area (ha)	% of Prod Forest
Young/Mature	608,833	77
Old (>140 yr old)	182,152	23
Total Private Prod. Forest	790,985	100

Table A-6. Status of productive forest (in ha) on British Columbia Islands. "Timber harvesting land base" is the forested area outside reserves that is operable and not retained to protect other (non-timber) values. Age classes are as defined in Table A-4.

	Reserves	Inoperable	Retention	Timber Harvesting Land Base	Timber Harvesting Land Base: Young	Mature	Old	Total Productive Forest: Ha	%	Total Land Area: Ha	%
Queen Charlotte Islands											
Crown Timber	0	277,592	95,912	240,572	151,911	27,178	61,483	614,076	90%	775,985	77%
Private	0	874	134	5,712	4,605	569	538	6,720	1%	8,400	1%
Parks	59,587	0	0	0	0	0	0	59,587	9%	223,190	22%
QCI Totals	59,587	278,466	96,046	246,284	156,516	27,747	62,021	680,383	100%	1,007,575	100%
Vancouver Island											
Crown Timber	0	346,580	243,041	1,051,697	696,282	85,319	270,096	1,715,769	62%	2,051,279	60%
Private	0	79,099	15,820	696,067	541,861	5,939	148,267	790,985	29%	939,003	27%
Parks	254,191	0	0	0	0	0	0	254,191	9%	442,558	13%
VI Totals	254,191	425,679	258,861	1,747,764	1,238,143	91,258	418,363	2,760,945	100%	3,432,840	100%
BC Island Totals	313,778	704,144	354,907	1,994,048	1,394,659	119,005	480,384	3,441,328		4,440,415	

Sources: Crown Inoperable and Retention, see Table A-1; Vancouver Crown 2nd growth, Parks and Private Lands: Niemann (2006a); QCI Private Lands, Muise 2006 and Table A-2. QCI 2nd growth and Parks: Leversee (2006)

Table A-6a. Percentage distribution of lands "open" to logging (productive forest outside reserves) and of total harvesting land base. "Unharvested" means Inoperable + Retention + Old. "THLB" means total harvesting land base from Table A-6.

	Total Ha	% of Open Lands				% of THLB		
	Open	Inoperable	Retention	THLB	Unharvested	Young	Mature	Old
QCI	620,796	45	15	40	70	64	11	25
VI	2,432,303	18	11	72	45	71	5	24
BC Total	3,053,099	23	12	65	50	70	6	24

Table A-7. Age Classes of Productive Forest in Southeast Alaska.
Percentages are of Total Productive Forest by ownership.

	Productive Forest						Total	Total	Total
	Young		Mature		Old		Productive	Non-Prod	Land
Land Owner/Manager	Area (ha)	%	Area	%	Area	%	Forest	Forest	Area
Tongass Nat'l Forest	219,000	10	7,000	0	1,981,000	90	2,207,000	1,444,111	6,290,000
Glacier Bay Nat'l Park	54	67	27	33	0	0	81	107,967	873,300
State/Private/Other	125,630	33	3,885	1	251,478	66	380,993	132,876	973,000
Totals	344,684		10,912		2,232,478		2,588,074	1,684,954	8,136,300

Notes: 1) Tongass data excludes Yakutat Ranger District (outside goshawk range), approx 7% of TNF total
2) non-prod forest on TNF outside YRD = 0.93 x total non-prod forest on TNF in Albert and Schoen 2006, Table 1
3) Glacier Bay NP total area excludes St. Elias Mountains north of Mt. Fairweather (20% of GNP)
Forest in excluded portion assumed to be 20% of Park-wide forest
4) Young = <100 yr old, Mature = 101 to 150 yr old, Old = >150 yr old
% of young and mature 2nd growth assumed = on TNF and State/Private/Other = 97% young, 3%mature
Second growth in Glacier Bay is assumed to be primary succession following glacial retreat
so 33% of forest <150 yrs old assumed to be >100 yr old
5) Data sources: TNF: Goldstein 2006 (except non-productive forest)
Other ownerships and non-prod forest: Albert and Schoen 2006, Table 1

Table A-8. Percentages of Total Area and Productive Forest by ownership in SE Alaska south of Mount Fairweather and Mount Foster.

	Total		Productive Forest	
	Area	%	Area	%
US Forest Service	6,290,000	76	2,206,000	85
Nat'l Park Service	1,092,700	13		
Glacier Bay NP			81	0
State of AK	395,800	5		
Haines State Forest			28,929	1
Native Corporations	233,500	3	187,200	7
Bureau Land Mgmt.	149,700	2		
Municipal/Private/Other	96,000	1	165,864	6
Total	8,257,700	100	2,588,074	100

Data Sources: Total Area: Albert and Schoen, 2006, Fig.9;
Productive Forest: Table A-9

Note: Municipal/Private/Other includes all ownerships other than those with data in the column above, defined differently for the Total Area and Prod Forest.

Table A-9. Estimated area (ha) and percent of productive forest protected and vulnerable to harvest by ownership/location. Percentages are of productive forest within each ownership. Young defined as <100 yrs old (Alaska) or <80 yr old (Canada) due to differences in forest growth rates. Mature defined as 101 to 150 yr old (Alaska) or 81 to 140 yr old (Canada). Old defined as >150 yr old (Alaska) or >140 yr old (Canada).

			Unharvested in Logged Matrix				Area Available for Harvest						Total	Total
	Reserves		Inoperable		Retention		Young 2nd Growth		Mature		Old Forest		Productive	Land
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Forest	Area
Tongass NF	1,399,000	63	208,000	9	179,000	8	218,000	10	7,000	0	195,000	9	2,206,000	6,288,000
Haines SF	9,362	32	2,337	8	412	1	3,985	14	120	0	12,713	44	28,929	115,828
Native Corps.	0	0	16,848	9	9,360	5	115,564	62	3,467	2	41,961	22	187,200	234,000
Glacier Bay NP	0	0	0	0	0	0	54	67	27	33	0	0	81	873,300
Other AK	9,952	6	14,928	9	6,635	4	7,027	4	299	0	126,970	77	165,864	631,602
Alaska Totals	**1,418,314**	**55**	**242,113**	**9**	**195,407**	**8**	**344,630**	**13**	**10,885**	**0**	**376,645**	**15**	**2,587,993**	**8,142,730**
Queen Charlotte Is.	59,587	9	278,466	41	96,046	14	156,516	23	31,632	5	62,021	9	680,383	1,007,575
Vancouver Is.	254,191	9	425,679	16	258,861	10	1,238,143	46	91,258	3	418,363	16	2,686,494	3,432,840
BC Totals	**313,778**	**9**	**704,144**	**21**	**354,907**	**11**	**1,394,659**	**41**	**122,890**	**4**	**480,384**	**14**	**3,366,877**	**4,440,415**
Range-wide Totals	**1,732,092**	**29**	**946,257**	**16**	**550,313**	**9**	**1,739,289**	**29**	**133,775**	**2**	**857,029**	**14**	**5,954,870**	**12,583,145**

Data sources: Tongass NF: Goldstein 2006; Haines SF: ADNR 2002 table 2-1; Native Corps: Albert and Schoen 2006; Glacier Bay NP: Albert and Schoen 2006;
Other AK: Albert and Schoen 2006;
QCI and VI, BC: Inoperable, Retention and Total Prod Forest: BC MoF Timber Supply Analysis Reports (see Tables A-1 to A-6);
2nd Growth and Reserves: Leversee 2006 (QCI) and Niemann 2006a (VI).

Assumptions and calculations:

<u>Tongass National Forest</u>

Yakutat Ranger District excluded (outside QC goshawk range)

"Falldown" (addit'l acreage determined not suitable based on field verification) divided evenly between inoperable and retention.

<u>Haines State Forest</u>

Retention (primarily for anadromous fish streams) estimated at 15% of area reported as Inoperable on Timber Harvest lands

<u>Native Corp. Lands</u>

Productive Forest = 80% of total Native Corp lands (Continued…)

Inoperable = % inoperable on combined Tongass NF and Haines SF = 0.09

Retention = 5% of Prod Forest = 0.05 x 187,200 = 9,360

2nd Growth = 95% of harvested land outside Tongass NF and Haines SF
= 0.95 x (Private/other Clear-cut & 2nd-Growth (Albert and Schoen 2006) - Haines SF 2nd Growth (ADNR 2002))
= .95 x (129,516 - 4,105) = 119,140
Young = 97% of 2nd growth, Mature = 3% of second growth (same %'s as on Tongass NF)
Old Forest = (Total Prod Forest) - (Inop.+ Rentention + 2nd Growth)

Other AK (State, Fed, Munic and Private)

Total Land area = (Private/Other) + (Glacier Bay NP) - (Haines SF); data from Albert and Schoen Table 1 and Fig 9
(20% of GBNP area outside QCGO range subtracted from totals in Albert and Schoen)
= 841,040 + 846,041 - 115,828 = 1,571,253
Total Prod Forest = (Private/Other + Glacier Bay NP (Albert and Schoen 2006)) - (Haines SF (ADNR 2002))
(Prod Forest in Albert and Schoen defined as all POG, Clearcut, Conifer<150 yr old, Conifer Forest Other, Decid Forest, and Mixed Forest, but not Muskeg forest, Muskeg woodland or Sub-alpine forest)
= 346,763 + 54,650 - 33,037 = 368,376
Reserves: Assume % Productive Forest in Reserves = % Total Land Area protected on these ownerships
% total land protected = ((Total protected area) - (protected Tongas NF + Haines SF + Native + NPS)) / (Total area - (Total Tongass NF + Haines SF + Native + NPS)) x 100 = (6,438,362 -(5,311,340+9,362+0+1,089,802) / (8,831,721- (6,794,333+216,110+233,512+1,089,802) x 100 = 27858 / 497,964 = 6%
(data from Albert and Schoen 2005, Table 6 and Fig 9; Protected Native and Haines SF from table above)
% Productive Forest protected in Resercves = 0.06 x Other AK Total Prod Forest (calculated above)
Inoperable = % inoperable on combined Tongass NF and Haines SF (9%) of land outside Reserves
= 0.09 x 368,376
Retention: Estimated at 5% of Productive Forest outside Reserves
= 0.05 x (Total Prod Forest - Reserves)
Young 2nd Growth = All Young 2nd growth reported in Table A-7 outside Tongass NF, Haines SF, GBNP and Native Corp lands
= 399,000- (Tongass NF +Haines SF + Native +GBNP)
Mature = All Mature 2nd growth reported in Table A-7 outside Tongass NF, Haines SF, GBNP, and Native Corp lands
= 37,870 - (Tongass NF + Haines SF + GLNP + Native)
Old = Old forest in Table A-7 outside Tongass NF, Haines SF, GBNP and Native Corp lands and not Inoperable or Retention

QCI and VI, BC

Mature Available for Harvest = Total Prod Forest - (Inoper + Retention + 2nd Growth)

Table A-10. Habitat Value Calculations using BCMF Definition of Productive Forest (from Table 11)

Location	Non-Prod Forest	Productive Forest (ha) Reserves	Inoperable	Retention	2nd growth	Available Old Forest	Historical Habitat Value	Current Habitat Value	Future 50 Habitat Value*	Future 100 Habitat Value**	% Productive Forest Harvested	Remaining
Alaska	1,684,954	1,418,314	242,113	195,407	355,515	376,645	3,851,709	3,536,099	3,322,437	3,095,352	14%	86%
QCI	45,899	154,233	278,466	96,046	188,148	62,021	813,338	641,812	510,901	510,901	24%	76%
VI	121,588	254,191	425,679	258,861	1,329,401	418,363	2,777,685	1,583,646	1,098,804	1,098,804	49%	51%
BC	167,487	408,424	704,144	354,907	1,517,549	480,384	3,591,023	2,223,397	1,609,705	1,609,705	44%	56%
Rangewide	1,852,441	1,826,738	946,257	550,313	1,873,064	857,029	7,442,731	5,765,487	4,932,142	4,705,057	31%	69%

Habitat Value Discounts applied to Forest Categories (Habitat Value = sum of (1-discount) x hectares in each category, by scenario)

Non-Prod. 0.25 for historic, current and future (e.g., 0.75 x 2,065479 for Alaska, all scenarios)

Reserves 0 for historic, current and future (e.g., 1.0 x 1,559,724 for Alaska, all scenarios)

Inoperable 0 for historic and current, 0.15 for portion harvested in future (e.g., 0.85 x 250,617 for Alaska Future100)

Retention 0 for historic, 0.5 for portion harvested (current and future) (e.g., 0.5 x 96,046 for Alaska Future 100)

2nd growth 0 for historic, 0.85 for current and future (e.g., 1.0 x 356,285 for Historic, 0.15 x 356,285 for Alaska Current, Future 50 and Future 100)

Old Forest 0 for historic and current, 0.85 for portion harvested in future (e.g., 1.0 x 372,265 for Alaska Current; 0.15 x 372,265 for Alaska Future 100; (0.5 x 1.0 x 372,265) + (0.5 x 0.15 x 372265) for Alaska Future 50)

Notes: *Future 50 assumes half of remaining available old forest harvested in Alaska, all available harvested in Canada

**Future 100 assumes all available old forest harvested in Alaska and Canada

Table A-11. Historic (year 1900) Habitat Value calculations using Leversee (2006) definitions of Productive and Non-Productive Forest (from Table 12).

	Non-Prod Forest	Prod. Forest	Historical Habitat Value	Historical Habitat %
Alaska	1,684,954	2,587,993	3,851,709	52%
QCI	347,793	447,156	708,001	10%
VI	748,340	2,283,389	2,844,644	38%
BC	1,096,133	2,730,545	3,552,645	48%
Range-wide	2,781,087	5,318,538	7,404,353	100%

Table A-12. Distribution of Range-wide Habitat Value (percent) at four time intervals.

	Historical	Current	Future 50	Future 100
Alaska	52	61	67	66
QCI	11	11	10	11
VI	37	27	22	23
BC	48	39	33	34

Table A-13. Percentage reductions in habitat value from historical conditions.

	Current	Future 50	Future 100
Alaska	8	14	20
QCI	21	37	37
VI	43	60	60
Canada	38	55	55
Rangewide	23	34	37

Table A-14. Percentage of historical range-wide habitat value in each geographic region, historically (1900), currently (2005) and in the future (2100).

	Historical		Current		Future	
	Value	%	Value	%	Value	%
SE Alaska	3,851,709	52%	3,536,099	48%	3,095,352	42%
Queen Charlottes	813,338	11%	641,812	9%	510,901	7%
Vancouver Island	2,777,685	37%	1,583,646	21%	1,098,804	15%
totals	7,442,731	100%	5,761,557	77%	4,705,057	63%

Table A-15. Projected declines in habitat value from current conditions (2005 to 2100).

	2005	2050		2100	
	Value	Value	% Decline	Value	% Decline
SE Alaska	3,536,099	3,322,437	6%	3,095,352	12%
Queen Charlottes	641,812	510,901	20%	510,901	20%
Vancouver Island	1,583,646	1,098,804	31%	1,098,804	31%
BC Total	2,223,397	1,609,705	28%	1,609,705	28%
Rangewide	5,765,487	4,932,142	14%	4,705,057	18%

Table A-16 . Timber supply forecasts for Queen Charlotte and Vancouver Islands, 2000 - 2050.

Management Unit	**Name**	**Increase (decrease)** Cubic m/year	%
Queen Charlotte Island			
TSA25	Queen Charlotte TSA	(48,200)	-10.1
TFL39	Haida	(134,338)	-3.7
TFL47	Duncan Bay	8,240	1.0
	Total for QC Islands	**(174,298)**	
Vancouver Island			
TSA33	Kingcome TSA	(545,683)	-41.4
TSA37	Strathcona TSA	(279,600)	-22.4
TSA38	Arrowsmith TSA	(94,000)	-26.3
TFL06	Quatsino TFL	(173,299)	-12.1
TFL19	Tahsis TFL	(214,900)	-22.9
TFL25	Naka TFL	(120,000)	-17.6
TFL39	Haida TFL	(134,338)	-3.7
TFL44	Alberni TFL	(130,000)	-7.6
TFL46	West Coast TFL	-	0.0
TFL54	Maquinna TFL	-	0.0
	Total for Vancouver Island	**(1,691,820)**	
	Total for BC Islands	**(1,866,118)**	

Data Source: "Detailed Information" link in BCMF 2004a, p. 35.

Table A-17 Mature and Old Forest Trends

	1900	2005			2100				
	Original (Ha)	Current (Ha)	% of 1900	% Loss From 1900	Future (Ha)	% of 1900	% Loss from 1900	OG Harvest 2005-2100	% Loss from 2005
SE AK	2,587,993	2,243,363	87%	13%	1,965,657	76%	24%	376,645	12%
VI	2,760,945	1,448,351	52%	48%	1,200,895	43%	57%	418,363	17%
QCI	680,383	527,752	78%	22%	471,624	69%	31%	62,021	11%
BC	3,366,877	1,976,103	59%	41%	1,672,519	50%	50%	480,384	15%
Range-wide	5,954,870	4,219,466	71%	29%	3,638,176	61%	39%	857,029	14%

APPENDIX B. Glossary

Active nest - Nest with eggs, young, or a brooding adult.

Breeding density – Synonymous with Nesting density

Breeding dispersal – Movement of a breeding animal between breeding (nest) sites or groups (Greenwood and Harvey 1982)

Breeding season home range – Area used by an animal during the portion the year between initiation of courtship and dispersal of the young.

Canopy closure – Percentage of the ground surface covered by trees, when viewed from above

Canopy cover – Synonymous with Canopy closure

Economically mature forest – Synonymous with Mature forest

Falldown – (Tongass National Forest) The difference, usually a reduction, between the number of acres planned for timber harvest and those actually harvested

Falldown – (British Columbia Ministry of Forests) The difference between the current allowable annual cut and the long term (past) harvesting level.

Fecundity – The ability of an organism to produce offspring. Total number of offspring produced during the life of an organism.

Fledgling – A young bird that has left the nest, is feathered, and still depends on its parent(s) for food. It is a fledgling from the time it leaves the nest (or makes it first flight, by some definitions) until it is independent of all parental care. In goshawk productivity studies, number of fledglings is often estimated by counting nestlings within 10 days of estimated fledging date (as fledglings can be difficult to locate).

Forest – Land with canopy cover by trees of at least 10 percent

Forest stand - An area of forest of similar characteristics that can be distinguished from adjacent areas of forest

Habitat capability – The number of animals that a defined area of habitat can support. For goshawks, capability of various areas has been estimated for breeding pairs, nesting areas, territories, and home ranges.

Habitat value – A numerical value describing relative value of a geographic area as habitat for a species of wildlife. Developed for this status review to compare quality of past, current and projected future goshawk habitat. Calculated as the sum of hectares of productive forest in various categories, with discount factors applied to reflect lower value for second growth, fragmented, and vulnerable forest

High-volume productive forest – (Tongass National Forest) Averages 31,400 board feet per acre. Dominant trees are over 30 meters tall (100 feet), canopy cover is 65-95 percent, and understory production is moderate (USDA Forest Service 1996).

High-volume forest – Synonymous with High-volume productive forest

Home range – Area used by an individual animal, sometimes defined for specific periods (e.g., breeding season home range, winter home range, annual home range)

Low-volume productive forest – (Tongass National Forest) Averages 15,700 board feet per acre. It is characterized by relatively open forests, tree heights of 20 meters (60 feet) or less and a very brushy understory (USDA Forest Service 1996).

Low-volume forest – Synonymous with Low-volume productive forest

Matrix – Land outside nature reserves, parks or other protected status available for timber harvest or other management activities

Mature forest – Second-growth forest that has reached culmination of mean annual increment (growth rate has begun to slow). Individual trees have not reached maximum size, canopy is typically uniformly dense, and there is usually little understory unless the stand has been thinned. Minimum age depends on site productivity, and ranges from about 50 years on some areas of Vancouver Island to about 150 years on colder or otherwise less productive sites. So named because economics are usually maximized by harvesting such stands (i.e., they are economically mature).

Mature sawtimber – Synonymous with Mature forest.

Medium-volume productive forest - (Tongass National Forest) Averages 25,100 board feet per acre and is characterized by uneven-aged trees of 20-30 meters (60-100 feet) with numerous gaps in the forest canopy. The open canopy results in an abundant understory but the forest floor is still subject to snow burial.

Multi-story canopy – Upper layer of the forest formed by the tops of trees that vary significantly in height. The upper surface of the forest is uneven, with gaps between large trees in which shorter trees grow.

Natal Dispersal – Permanent movement of an individual from its birth site or group to the place where it reproduces or would have reproduced if it had survived and found a mate (Greenwood and Harvey 1982)

Nest activity rate - Number, proportion, or percentage of known nest territories with eggs, nestlings or incubating adults on a nest

Nest area (Reynolds et al. 2006): an 8-12 ha area surrounding a nest that includes roosts and prey plucking sites)

Nest area occupancy – Synonymous with Territory occupancy

Nest area vacancy – Synonymous with Territory vacancy

Nest site: (Flatten et al 2001): nest, tree, and forested area surrounding the nest that includes prey handling areas, perches and roosts, and may contain $\geq$1 alternate nest (approx 5-15 ha in SE AK)

(Reynolds et al 2006): habitat immediately surrounding the nest,

Nest stand (Reynolds et al 2006): the stand of trees homogeneous in vegetation composition and structure that contains a nest

Nest success rate: percentage of active nests producing at least one fledgling or advanced nestling

Nest tree: a tree containing a nest

Nesting area (Flatten et al. 2001 Table 1): the landscape area up to 804 ha that includes all nest sites and alternate nests used by a goshawk pair or individual within its breeding home range (analogous to "territory" as defined by some authors)

Nesting attempt – nest in which eggs are laid

Nesting density – Number of nest areas or territories in a given area, sometimes expressed as a mean distance between adjacent nest area (or territory) centroids.

Nestling – A young bird that has not left the nest (i.e., between hatching and fledging)

Non-productive forest – (BC Ministry of Forests) Land capable of supporting trees greater than 5 m tall at maturity and canopy cover greater than 10 percent, but incapable of producing a merchantable stand within a defined period of time

(Tongass National Forest) Forest that produces less than 20 cubic feet of wood fiber per acre per year, or with less than 8,000 board feet per acre (Synonymous with Scrub forest)

Occupancy - Synonymous with Territory occupancy

Old Forest - Forest characterized by several age classes of trees, including dominant trees that have reached the maximum size typical for the site, accumulations of dead, dying, and decaying trees and logs, and younger trees growing in gaps between the dominant trees. Typically at least 250 years old or older.

Old Growth Forest – Synonymous with old forest

Peer review – A process of critical review of a draft of a scientific report, done by scientists with expertise in the field addressed by the report, that evaluates the scientific rigor of the methods, accuracy of the statements made, and interpretation of the results expressed by the author(s), prior to publication of the report. Typically used by scientific journals prior to acceptance of papers for publication, and increasing used by government agencies prior to publication or release of unpublished reports.

Productive forest – (BC Ministry of Forests) Forest capable of producing a merchantable stand within a defined period of time

(Tongass National Forest) Forest capable of producing at least 20 cubic feet of wood fiber per acre per year, or having greater than 8,000 board feet per acre

(Leversee 2006) Forest in which an average 100-year-old tree exceeds 12.5 meters tall (i.e., site index > 12.5)

Productive old-growth – (Tongass National Forest) Old forest (see definition, above) with at least 8,000 board feet of wood fiber per acre Productive old-growth forest is further divided into four volume strata (Low volume, medium volume, high volume, and very high volume).

Productivity - The number of fledglings (or advanced nestlings) per occupied territory, occupied nest, active nest, or successful nest. For comparison among studies, we use fledglings per active nest (which is commonly reported in goshawk literature)

Published – Printed in a journal, magazine, book, or as a bound monograph by a scientific, commercial, or government printer. Does not include unbound reports produced by agencies, consultants or others.

Scrub forest – (Tongass National Forest) Forest that produces less than 20 cubic feet of wood fiber per acre per year, or with less than 8,000 board feet per acre

Second growth – Forest that regenerates after the original stand has been harvested

Stand – Synonymous with Forest stand

Successful nest - Nest which produces at least one fledgling

Survival rate – Proportion of a cohort alive at the end of a specified period of time (e.g., year, month, or season), usually expressed as a number between zero and one, without a unit (e.g., 0.72)

Territory - Area around a nest which is defended against other goshawks. Territory size is sometimes inferred from observed spacing of adjacent nest areas

Territory occupancy - Presence of one or more adults in the vicinity of a nest stand during the breeding season

Unproductive forest – (Tongass National Forest) Synonymous with Scrub forest

Use area - Area for which there is evidence of use by an individual animal. May not include the entire home range if sampling is inadequate

Vacant Territory – Absence of adults in the nest area. Often difficult to rigorously establish in goshawks

Very high-volume productive forest - (Tongass National Forest) Averages 39,000 board feet per acre. The description of this type of forest stand is similar to high-volume productive forests.

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