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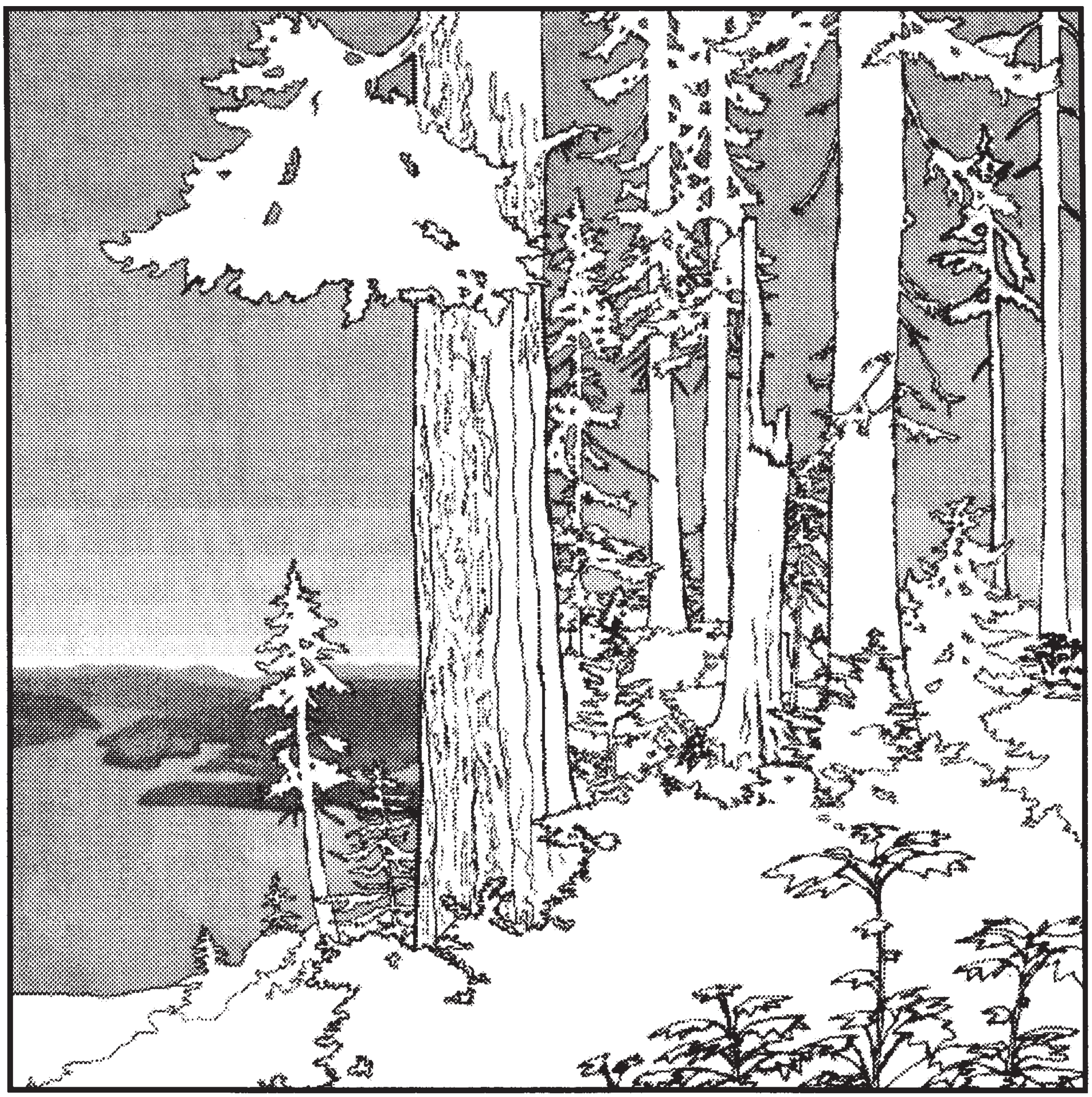
Conservation Assessment for the Northern Goshawk in Southeast Alaska

George C. Iverson, Gregory D. Hayward, Kimberly Titus, Eugene DeGayner, Richard E. Lowell, D. Coleman Crocker-Bedford, Philip F. Schempf, and John Lindell



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Conservation and Resource Assessments for the Tongass Land Management Plan Revision

Charles G. Shaw III, Technical Coordinator

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Abstract

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The conservation status of northern goshawks in southeast Alaska is examined through developing an understanding of goshawk ecology in relation to past, present, and potential future habitat conditions in the region under the current Tongass land management plan. Forest ecosystem dynamics are described, and a history of forest and goshawk management in the Tongass National Forest is reviewed. Nearly 900,000 acres of the most productive old-growth temperate rain forest in southeast Alaska (public and private lands) have been harvested during the past 90 years and changed to early seral conifer forests. Goshawk habitat relations are described through a review of the goshawk literature. Significant preliminary findings of a habitat relation study in southeast Alaska include the following: goshawks select productive old-growth forests with > 60 percent of all adult goshawk telemetry relocations occurring in this cover type; nonforest, clearcut, and alpine cover types were least used and were avoided relative to their availability; and the median breeding season minimum convex polygon use areas of adult goshawks was about 10,000 acres. Goshawks predominantly use gentle slopes (70 percent of relocations) at elevations below 800 feet (54-74 percent of relocations); 24 percent of relocations occurred in riparian habitat zones, and nearly 20 percent of all relocations occurred within the beach fringe habitat extending 1,000 feet inland from the ocean shoreline. Goshawk nesting habitat is a nonrandom subset of the landscape with a significantly higher proportion of productive old-growth forest within a 600-acre analysis area surrounding known nests. The probability of persistence of goshawks has declined over the past 50 years owing to habitat loss and likely will continue to decline under current management plan regimes; however, the goshawk population likely is not in immediate peril. The predicted consequences of several alternative habitat management approaches are compared. This analysis suggests that long rotation forestry (e.g., 300 years) and uneven-aged silvicultural management may maintain habitat characteristics important to sustaining goshawk populations well distributed across the region. Although habitat reserves are not considered an essential component of a forest-wide goshawk conservation strategy, reserves, in combination with extended rotations, may be important where the intensity of past management actions has precluded the opportunity to attain a desired combination of forest age classes achieveable under long rotations. Reserves are most likely critical if extensive clearcut logging continues.

Keywords: Northern goshawk, *Accipiter gentilis laingi*, habitat, conservation, assessment, management.

Preface

This assessment synthesizes the best available science information regarding the ecology and habitat relations of the northern goshawk (*Accipiter gentilis*) in southeast Alaska. By building on these relations, it examines the conservation status of the goshawk relative to past, present, and anticipated habitat conditions throughout southeast Alaska. Finally, it provides management considerations for sustaining goshawk populations across the Tongass National Forest. This conservation assessment was chartered under the Tongass [National Forest] land management plan (TLMP) revision and the interagency memorandum of understanding (MOU) among the Alaska Region of the Forest Service (FS), the Alaska Region of the U.S. Fish and Wildlife Service (FWS), and the Alaska Department of Fish and Game (ADF&G) to conserve species tending toward listing under the Federal or State endangered species acts.[1]

Revision efforts for the TLMP resumed in fall 1994 with a focus on five major land management issues considered to be inadequately addressed in the existing TLMP: wildlife viability, fish and riparian habitat, caves and karst, alternatives to clearcutting, and socioeconomic considerations. Goshawk conservation is an important component within the wildlife viability issue.

Concern for goshawk population viability in southeast Alaska evolved during the past decade and culminated with the petition to list the Queen Charlotte goshawk (*A. g. laingi*) as an endangered species under the Endangered Species Act. The FWS concluded in 1995 that listing the goshawk was not warranted at that time owing to insufficient information, but stated that "...without significant changes in the existing Tongass National Forest Land and Resource Management Plan, the longterm viability of the Queen Charlotte goshawk may be seriously imperiled" (USDI Fish and Wildlife Service 1995). Specific management recommendations or strategies for managing goshawk habitat were not a component of the charters for this assessment and are not included in this report. This synthesis of available information provides planners and the public with a scientific basis for evaluating the consequences of habitat management choices. It presents ecological relations as well as management considerations that should be examined in crafting and evaluating an ecosystem management plan that sustains all resources, including goshawks. Although this assessment presents some new and preliminary results of current research, its main use is as a synthesis of current information to assist conservation planning and not to report the results of original research.

This assessment represents a collaborative product of management and research biologists. The authors brought experience in managing and investigating goshawks plus a variety of perspectives from several government agencies. Consensus was obtained on the science and conclusions commensurate with information data available through early 1996. Ongoing goshawk inventories and studies in the Tongass National Forest will continue to provide new knowledge, and this document represents an incremental step in understanding goshawk ecology. Adaptive management can be a useful tool to respond to new information.

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[1] The primary objective of the MOU was to foster interagency cooperation for the conservation of candidate and sensitive species to avoid the need for listing and protection under the Endangered Species Act. The goshawk, in addition to the marbled murrelet (*Branchyramphus marmoratus*) and Alexander Archipelago wolf (*Canis lupus ligoni*), were identified as priority species for conducting a conservation assessment to achieve MOU objectives.

Contents

The Forest Ecosystem and Its Management

The coastal forests of southeast Alaska are part of the temperate rain forest that extends along the Pacific coast from northern California to Cook Inlet in Alaska (Alaback 1991). Most of the forest is composed of old-growth conifers dominated by western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Borg.) Carr). The region is characterized by a cool and wet maritime climate where precipitation ranges from 60 to 235 inches per year and is distributed throughout the year without noticeable droughts (Harris and Farr 1974). Climate strongly influences forest development within southeast Alaska. Fire is generally absent (Harris and Farr 1974), moisture is not limiting to regeneration, and windthrow is common (Harris 1989). Southeast Alaska is characterized by steep rugged topography and coastal fjords. The Alexander Archipelago consists of over 22,000 islands ranging from less than 0.01 acre to over 1,750,686 acres (Prince of Wales Island) with over 11,000 miles of shoreline (fig.1). Together these attributes represent features of large-scale landscape heterogeneity.

Conifer forests of the Tongass National Forest (NF) are characterized by fine-scale habitat heterogeneity created by mountainous terrain, wetlands, and various disturbance regimes (see below) that have resulted in a naturally fragmented landscape mosaic. Because of the considerable precipitation, landform diversity has a significant influence on drainage patterns and thus local site vegetation characteristics. Well-drained sites generally have higher forest site productivity, whereas nonforested peatlands (muskegs) generally occur on benches, terraces, or gentle terrain where poorly drained, deep organic soils predominate. Forests of intermediate productivity form transitional ecotones between the well-drained productive forests and poorly drained nonforest areas. Local landform diversity and drainage patterns also contribute to an irregular pattern of fine-scale habitat heterogeneity. For example, imbedded within a highly productive forest, benches of poorly drained soil may occur in small patches (e.g., each less than an acre). Conversely, in an otherwise poorly drained extensive peatland, a narrow riparian corridor of well-drained soils may support a highly productive stand of large trees.

The Tongass NF contains about 16.9 million acres, representing over 85 percent of southeast Alaska. Of the total Tongass acres, 59 percent are classified as forested land with at least 10 percent tree cover, and 41 percent are nonforested land, including rock and ice, alpine areas, and peatland.

Natural Disturbance Regimes

The natural disturbance regimes of the temperate rain forests of southeast Alaska are poorly understood. A comprehensive review of disturbance in temperate rain forests is provided in Alaback (1996), Nowacki and Kramer (in prep.), and Veblen and Alaback (1996). Wind is the primary disturbance agent (Harris and Farr 1974), but other disturbances such as landslides, debris flows, soil slumping, insects, fungi, and snow breakage also influence forest structure; all contribute to a fine-scale habitat heterogeneity. The forest environment is dynamic and characterized by frequent small-scale disturbances (Brady and Hanley 1984). These foster “gap phase” regeneration (Watt 1947), where individual or small groups of trees die or are blown down by wind, thereby creating canopy gaps (Alaback and Tappeiner 1991). Frequent small-scale disturbances may be punctuated by large wind storms causing extensive damage (Harris 1989).

Figure 1—Southeast Alaska vicinity map.

Relatively frequent, low-magnitude natural disturbances, such as the death of single trees or small groups of trees, create small gaps in the overstory canopy. Light penetrating through these canopy gaps and reaching the forest floor stimulates microcyclic succession within the gap. Canopy gap openings range from 0.1 to 0.2 acre and represent an average of 9 percent of the forested land area (Ott 1995). Over time and in the absence of major stand replacement disturbances (e.g., 300-500 years; Deal et al. 1991), gap dynamic processes occur across the stand, but at any one point in time the stand is characterized by multiple canopy openings in various stages of succession. Thus, within a stand, trees of all ages occur in this shifting steady state mosaic (Bormann and Likens 1979), with the death of old trees balanced by the growth of new trees. Most dominant trees typically exceed 300 years of age (Farr et al. 1976), and in some stands, dominant trees may range from 450 to nearly 800 years of age (Farr et al. 1976, Alaback and Juday 1989).

The rain forest is also subject to less frequent but higher intensity wind disturbance events that may result in nearly complete stand replacement (Alaback 1982, Deal et al. 1991). These events generally are associated with fall or winter storms (Harris 1989). A range of windthrow severity occurs and depends on many factors, including soil type, elevation, wind direction and strength, forest type, and local topography (Harris 1989). Catastrophic windthrow (with an intensity that spares little residual structure) can affect large areas up to hundreds of acres, and intermediate events (with significant residual trees withstanding the event) can cover tens of acres (Harris 1989; Nowacki and Kramer, in prep.). The long-term rate of catastrophic disturbance affecting the productive old-growth forest has been estimated at an average of 0.3 percent per decade (Nowacki and Kramer, in prep.). Nowacki and Kramer (in prep.) also report on a preponderance of multicohort stands that may exist in landscape positions that are highly susceptible to repeated catastrophic events with apparent return intervals that are shorter than the time necessary for complete development of the full complement of old-growth characteristics. These events and the resulting regeneration generally result in a single-cohort or multicohort generation stand (Oliver 1981, Deal et al. 1991). A combination of both major and minor disturbances can contribute to stand development (Deal et al. 1991).

Forest Stand Development

Oliver (1981) outlines a conceptual model of forest stand development following stand-replacing disturbance that is generally applicable to the temperate rain forest of southeast Alaska. Stand development occurs in four general stages: stand initiation, stem exclusion, understory reinitiation, and old growth. Each stage is briefly reviewed below as a component of secondary forest succession resulting from major disturbance events (e.g., large-scale windthrow). The stages also may be generally applicable to small-scale disturbances (canopy gap dynamics), although the fine scale structure may result in a multigeneration stand (Deal et al. 1991). Figure 2 illustrates a conceptual chronosequece of secondary forest succession in forests of southeast Alaska.

Stand initiation—Immediately after a disturbance, secondary forest succession begins as new individuals and species grow from sprouts, seeds, or advanced regeneration and continue to appear for several years. In southeast Alaska, the wet and moderate climate permits hemlock surviving from the previous stand to rapidly regenerate (Harris 1974) within 2 to 3 years after a disturbance. Shrub and herb biomass production increases for up to 10 to 15 years after disturbance. Gradual overstory dominance by hemlock and spruce results in canopy closure after 25 to 35 years, nearly eliminating all tree seedlings, shrubs, and herbs (Alaback 1982).

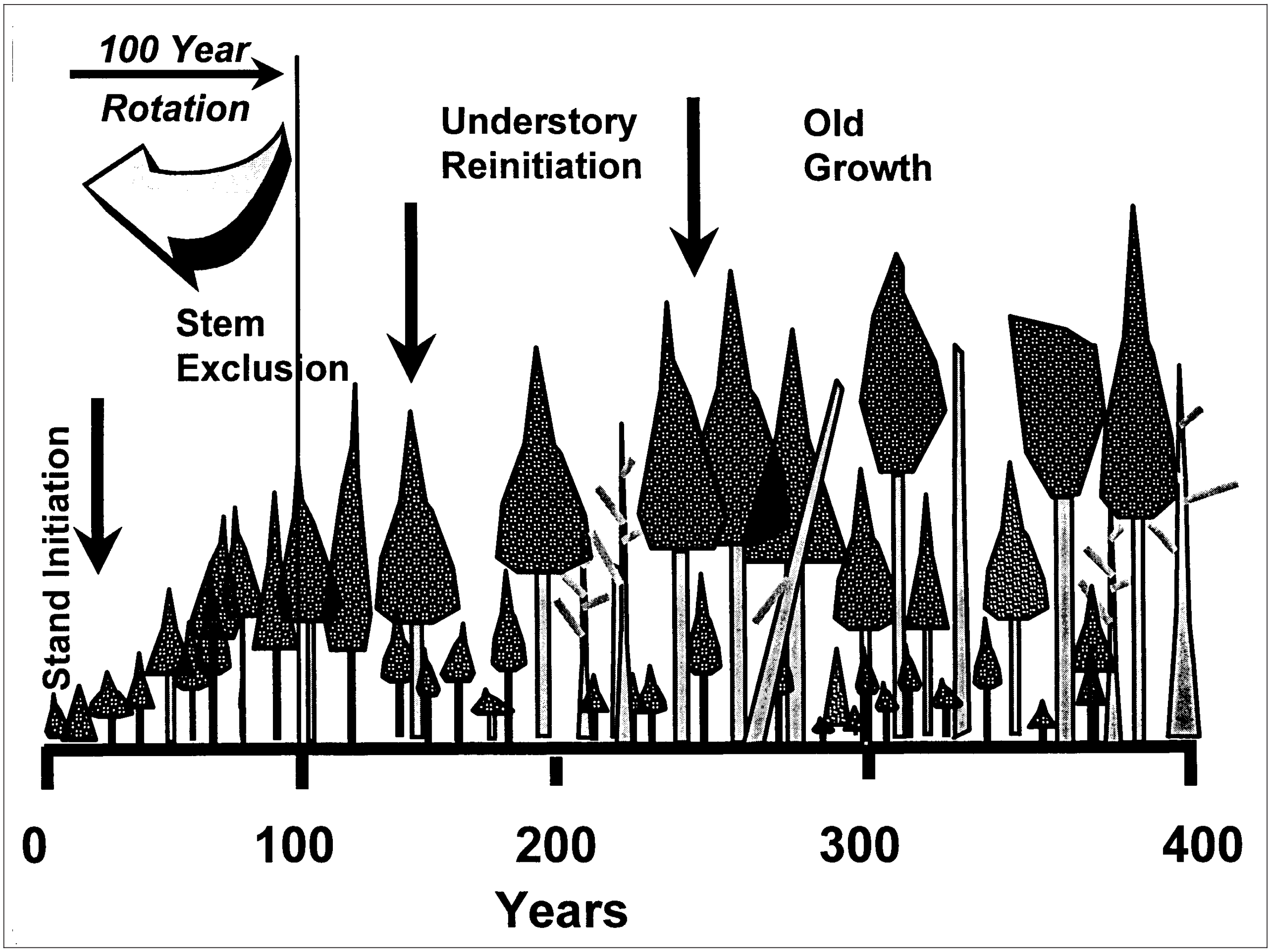

Figure 2—Forest developmental stages in the temperate rain forest of southeast Alaska.

Stem exclusion—During this phase new individuals or new species do not appear. Competition for growing space results in the death of many existing individuals with surviving individuals growing larger and expressing dominance. Overstory canopy closure occurs with little light penetration to the forest floor (< 1 percent open sunlight; Alaback and Tappeiner 1991), which results in an understory poor in vegetative abundance or diversity. In southeast Alaska, hemlock and spruce dominate the closed canopy overstory, and the understory is dominated by a carpet of ferns with little other vegetation—a stage that may persist for over 100 years (Alaback 1982).

Understory reinitiation—During this phase of stand development, shade-tolerant shrubs, such as *Vaccinium* spp., capable of surviving under low light intensity develop first. Eventually evergreen herbs or short shrubs, such as *Cornus* spp., *Rubus* spp., and *Tiarella* spp., begin to appear. Advance regeneration reappears in the understory but grows very little. In southeast Alaska, this phase generally begins by stand age 140 to 160 years (Alaback 1982). The mature, even-aged forest stage represents the peak in gross timber volume, after which biomass accumulation begins to decline (Alaback 1982). Tree growth rates begin to decline as mortality increases (Taylor 1934), resulting in the opening and vertical stratification of the overstory canopy (Alaback 1984). Many structural features of old growth, such as large standing and down snags and an all-aged stand with a multilayered canopy, have not yet developed.

Old growth—In the absence of catastrophic disturbance, overstory trees die in an irregular pattern from a variety of agents, including insects, drought, pathogens, or wind. Some understory trees begin growing into the overstory. Death of overstory trees from internal factors or autogenic effects, without the influence of external disturbances, is a characteristic condition of old-growth forests (Oliver 1981). The old-growth stage of stand development has a number of characteristic structural features (Alaback and Juday 1989, USDA Forest Service 1992a): large and old standing trees, a diversity of tree size classes, large downed logs, a multilayered canopy with irregular canopy gaps, and a diverse understory.

The minimum stand age necessary to attain the large tree component of the old-growth stand ranges from 150 to 260 years for the major forest types in southeast Alaska (USDA Forest Service 1992a). Dominant trees in the old-growth stands of southeast Alaska generally exceed 300 years. Old growth has the greatest horizontal and vertical variation in structure with both large and small trees growing in separate and intermixed patches (Alaback 1982). This structure takes at least two cohorts of dominant trees or 300 to 500 years to fully develop (Alaback 1990). Ages when specific stages of stand development begin are approximations and may differ owing to differences in local site characteristics. Factors such as aspect, elevation, soil type, drainage, and past disturbances (Alaback 1982) can affect overstory and understory development patterns within these broad successional stand development stages. Studies to date have emphasized highly productive, well-drained sites. Studies of poorly drained sites or high-elevation sites in similar forest types in other regions suggest that stand development and regeneration may take double the time as compared to productive sites (Alaback 1996). Riparian sites in particular appear to take the longest times (up to 600 years) to recover both structural diversity and species diversity (Alaback 1996).

Forest Inventory

An ecologically based inventory describing the structure and composition of forest resources within the Tongass NF does not exist. The existing Tongass NF vegetation inventory (Julin and Caouette, in prep.) is characterized primarily by timber production capability; productive versus nonproductive forests. (These terms are further defined in table 7 relative to goshawk habitat use analyses). Productive forest sites are by definition capable of growing 20 cubic feet per acre of usable timber volume per year and include both old growth and younger seral stages. Productive old-growth forest represents nearly 30 percent of the total 16.9 million acres on the Tongass NF. Unproductive forests comprise about 21 percent of the Tongass NF. Of the 5.05 million acres of productive old-growth forest remaining in the Tongass NF, about 54 percent is western hemlock; 38 percent is hemlock (including mountain hemlock, *Tsuga mertensiana* (Bong.) Carr.)-Sitka spruce; 4 percent is Sitka spruce; and less than 2 percent is western redcedar (*Thuja plicata* Donn ex D. Don) and Alaska-cedar

(*Chamaecyparis nootkatensis* (D.Don) Spach) (USDA Forest Service 1996a). Productive forests are primarily associated with the western hemlock, western hemlock-Alaska-cedar, Sitka spruce, western hemlock-redcedar and mountain hemlock plant association series (Martin et al. 1995). Unproductive forests are primarily associated with the mixed conifer, mountain hemlock and lodgepole pine (*Pinus contorta* Dougl. ex Loud.) plant association series (Martin et al. 1995).

Productive forests can be stratified into four volume strata (Forest-wide scale) based on average net timber volume content expressed in thousand board feet per acre (Mbf/acre) (Julin and Caouette, in prep.). These four strata also are broadly indicative of ecological site productivity: (1) low volume = 15.7 Mbf [+/- 1.9 Mbf, 95% confidence interval (CI)]; (2) medium volume = 25.1 Mbf (+/-1.9, 95% CI); (3) high volume = 31.4 Mbf (+/-2.5, 95% CI); and (4) very high volume = 39.0 Mbf (+/- 3.2, 95% CI). The Forest-wide average across all four classes is 27.3 Mbf (+/- 1.4 95% CI). These four strata are identified in the Tongass NF Geographical Information System (GIS) database and were used for the northern goshawk (*Accipiter gentilis*) habitat use analysis (see “Analysis of Northern Goshawk Ecology in Southeast Alaska,” below). The minimum mapping resolution of generally homogeneous forest stand polygons was 1 to 10 acres; however, the average polygon size Forest-wide ranged from 60 to 115 acres (Julin and Caouette, in prep.).

Forest stands in the GIS forest inventory also are classified into one of four classes of approximate stand age based on timber size class. The characterization of stand size is independent of stand origin and may include both silvicultural stand management (primarily clearcut even-aged timber harvest) and natural disturbance events, especially large-scale windthrow. The timber size classes are not entirely coincident with the four stages of secondary forest succession discussed above. (1) Seedling-sapling is less than 5 inches in diameter at breast height (DBH), closely approximates the stand initiation stage of forest development (fig. 2), and includes early clearcuts. There are presently 208,000 acres of this stand age in the Tongass NF. (2) Poletimber contains trees from 5 to 9 inches DBH. Poletimber stands range from about 30 to 80 years of age and represent the stem exclusion stage of forest development (fig. 2). There are an estimated 196,000 acres of this stand age in the Tongass NF. (3) Young-growth sawtimber is over 9 inches DBH but less than 150 years of age. Most stands in this age class are in the stem exclusion stage, although some features of understory reinitiation may begin to occur in the latter stages of this age class from about 100 to 150 years, depending on site productivity. An estimated 149,000 acres of this forest structure currently occur in the Tongass NF. (4) Old-growth sawtimber is classified as being over 150 years old. Because the full complement of features associated with old-growth forests do not occur until about 250 years, the old-growth sawtimber timber age class may by definition include stands in the understory reinitiation stage of forest development ranging in age from 150 to 250 years that resulted from large-scale windthrow events. Broad-scale habitat use analysis (see “Analysis of Northern Goshawk Ecology in Southeast Alaska”, below) predicated on ecological features of forest stand structure is, therefore, limited by a nonecological resource inventory classification scheme and a coarse mapping resolution unable to depict the fine-scale heterogeneity characteristic of the temperate rain forest.

History of Forest Management in Southeast Alaska

Because goshawks generally are associated with forested habitats, an understanding of the timber harvest history across southeast Alaska is important for assessing the effects of habitat alteration on the conservation status of goshawks. Before Russian occupation and continuing into recent times, Alaska natives have harvested trees for constructing canoes, framing and planking homes, carving totem poles, and other personal subsistence applications. Beginning with Russian occupation in the 1790s, trees were cut to produce charcoal and construct forts, homes, and ships. By 1853, three sawmills were operating in Sitka. Early Russian logging was primarily selection harvest with some clearcuts for fuelwood and charcoal, primarily along beaches and rivers.

Russian holdings were sold to the United States in 1867, and by 1900 there were 14 wood processing mills in operation with an annual tree harvest of about 8 million board feet (MMbf). Most harvest was used for sawtimber and pilings. Interest in developing a pulp industry evolved in the 1920s. Efforts to establish a pulp industry were successful, with the preliminary award by the U.S. Department of Agriculture, Forest Service, in 1948 of a 50-year sale of 1.5 billion cubic feet of timber to the Ketchikan Pulp Company (KPC). The Ketchikan pulpmill was completed in 1954, and this signaled the beginning of large-scale timber harvest operations in southeast Alaska. The Forest Service soon entered into three additional long-term contracts. Only the KPC long-term contract remains in effect as of this writing.

Average annual harvest from 1909 through 1990 was 197 MMbf. Since industrial scale timber harvest began in 1955, however, the total annual harvests have been substantially higher, averaging 394 MMbf/year (range 167 to 588 MMbf). The average volume per acre of timber harvested between 1955 and 1990 was about 41,500 Mbf (USDA Forest Service 1991). Forests capable of producing this high net volume of timber are considered the most highly productive sites in the Tongass NF.

About 5.6 million acres of productive forest occur within the current boundaries of the Tongass NF (USDA Forest Service 1996a). About 405,000 acres of productive old-growth forest were harvested between 1954 and 1995 (USDA Forest Service 1996a). A total of 1,895 MMbf saw-log volume was reported harvested from 1909 to 1954 (USDA Forest Service 1991). Assuming the average volume per acre was not lower than the mean of 41,500 board feet/acre harvested from 1954 to 1990, an estimated total of 45,000 acres was harvested from 1909 to 1954. Thus an estimated total of 450,000 acres of productive old-growth forest has been harvested in the Tongass NF since 1909, generally on sites with the highest timber production capability and largest trees (high and very high timber volume strata). This level of timber harvest activity represents a significant transition of old-growth and mature forests, with structurally diverse and complex stands, to early (0-35 years) seral stages of forest succession on nearly half a million acres of productive forest lands.

Timber harvest has not been evenly distributed across the Tongass NF. There are 21 biogeographic provinces within the Tongass NF (USDA Forest Service 1996a), and several have had little or no harvest (e.g., Admiralty Island and the mainland provinces). Other provinces have had substantial timber harvest activity (e.g., northeast Chichagof and Prince of Wales Islands). The risk assessment section (see “Management Considerations,” below) provides additional information on the magnitude and distribution of timber harvest in the Tongass NF.

Nearly 750,000 acres of lands previously contained within the Tongass NF have been conveyed to the State of Alaska or to Native Corporations (USDA Forest Service 1996a). About 60 percent of these lands were harvested by 1995 (Knapp 1992, USDA Forest Service 1996b). Thus, an estimated 900,000 acres of productive old-growth forests (15 percent of the total), and generally on the most productive sites, in southeast Alaska have been converted to early seral forests.

Clearcut, even-aged management with opening sizes from 20 to 60 acres or more has been the predominant silvicultural technique used to harvest timber in southeast Alaska, with only incidental use of uneven-aged management techniques (USDA Forest Service 1996a). Forests where tree harvesting has occurred are being managed with a rotation age (harvest age of a regenerated stand) of generally 100 years or less. Thus, stands managed for timber production emphasis will cycle through only the stand reinitiation and stem exclusion stages of stand development (fig. 2). The old-growth stage will not reoccur on these lands.

The intensity of forest management for timber production emphasis differs significantly from the natural disturbance regimes. The absence of uneven-aged silvicultural management techniques has precluded most opportunities to emulate the small-scale disturbance processes to regenerate or retain remnants of old-growth structure coincident with timber harvest. Even though even-aged clearcut harvest may generally emulate a catastrophic windthrow event, the rate of early seral forest stage creation (clearcutting) over the past 40 years has increased by about 5 to 10 times over estimated rates of natural disturbance (Nowacki and Kramer, in prep.). Specific consequences of this departure from the scale and frequency of natural disturbance events to the composition, structure, function, and distribution of the old-growth forest and associated biota are unknown in southeast Alaska.

History of Northern Goshawk Management in the Tongass National Forest

Interest in the conservation status of the goshawk in the Alaska Region began in 1986 when the northern goshawk was recommended as a management indicator species for the revision of the Tongass Land Management Plan (TLMP). A review of habitat relations suggested a close association with spruce-hemlock forests and interior spruce forests, and old-growth forests were rated as the most important forest successional stage for both nesting and foraging (Sidle and Suring 1986). The goshawk was not selected as a management indicator species for the TLMP revision owing to a lack of specific information and great monitoring difficulty. The review also suggested that the goshawk should be considered a Forest Service “sensitive species” in the Alaska Region.

In 1990, the Alaska Department of Fish and Game (ADF&G) recommended that at least one old-growth-associated forest raptor with a large home range be added to the Alaska Region sensitive species list and be considered in the TLMP revision process. The northern goshawk was specifically identified along with other forest birds of prey. The ADF&G also recommended initiation of a study on the effects of forest fragmentation on birds of prey. The Ketchikan Area of the Tongass NF supported this recommendation and began a cooperative study with ADF&G in 1991. The study adopted a Tongass-wide perspective in 1992 as a result of the difficulty in locating nesting goshawks in the Ketchikan Area, the identification of nests elsewhere in the Tongass, and the emerging regional and national interest in the issue.

In November 1991, the northern goshawk was designated a category 2 candidate species to be reviewed for possible addition to the Federal list of endangered and threatened species throughout its range. By inclusion as a subspecies, the Queen Charlotte goshawk (*A. g. laingi*) also was designated as a category 2 candidate species. Category 2 candidates were species and subspecies for which the U.S. Fish and Wildlife Service (FWS) had information indicating that listing may be appropriate, but conclusive data on biological vulnerability and threat were not then available to support such actions. The FWS no longer maintains a list of category 2 candidate species (USDI Fish and Wildlife Service 1996).

The Alaska Natural Heritage Program also has recognized the potential sensitivity of the goshawk population in southeast Alaska and ranks the Queen Charlotte goshawk as a "T1/T2" species (West 1993). This ranking indicates that this subspecies is either imperiled globally or critically imperiled globally.

Interim goshawk habitat management guidelines for the Tongass NF were issued by the Regional Forester in August 1992 (USDA Forest Service 1992b), in recognition of the national category 2 designation and of the potential for adverse effects from Forest Service land management actions on key elements of goshawk habitat. Because specific habitat use information from southeast Alaska was not available, these guidelines relied on concepts developed for goshawk habitat management in National Forests in the Southwest United States (Reynolds et al. 1992). Tongass NF habitat guides established a 600-acre postfledgling area (PFA) around known nests and limited early seral forest stands to no more than 5 percent of the PFA. Management guidelines for a 6,000-acre potential foraging area surrounding the nest were suggested to minimally maintain components of forested habitats. An interagency goshawk meeting reviewed these guides and suggested that all nesting habitat was essential and that no timber harvest should be permitted within the PFA. The original 1992 guidelines allowing 5 percent harvest of the PFA were reissued by the Regional Forester in 1993 without modification (USDA Forest Service 1993).

Forest Service interim management guidelines were repeatedly identified as inadequate to sustain goshawk habitat by the FWS in project-specific environmental reviews such as those for timber sales. The FWS suggested that to sustain a viable goshawk population in southeast Alaska, a landscape management approach should be adopted by the Forest Service in lieu of nest-by-nest management.[1]

The Alaska Region of the Forest Service formally designated the Queen Charlotte goshawk as a sensitive species in January 1994, as a result of a viability concern over the declining trend in goshawk habitat within portions of the Tongass NF. Sensitive species designation by the Regional Forester triggered the requirement that all projects conduct biological evaluations to assess potential impacts of proposed management activities. The Queen Charlotte goshawk also was designated a species of special concern by the ADF&G in 1994.

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[1] Fish and Wildlife Service correspondence. On file with: Ecological Services, 3000 Vintage Blvd., Suite 201, Juneau, AK 99801.

On May 9, 1994, the FWS received a petition from the Southwest Center for Biological Diversity and nine additional organizations and individuals to list the Queen Charlotte goshawk as endangered pursuant to the Endangered Species Act (ESA). The primary reason was concern over the loss of habitat owing to timber harvest in southeast Alaska. The FWS concluded in their 90-day finding that the petitioners had presented substantial information indicating that listing may be warranted. The FWS initiated a more comprehensive review of goshawk conservation status for a required 12-month finding for the petitioned action. During the public comment period ending February 28, 1995, both the Forest Service and ADF&G submitted comments to the FWS recommending that the goshawk did not warrant listing. On May 29, 1995, the FWS concluded that listing was not warranted at that time because of insufficient information. However, the FWS also stated that "...without significant changes in the existing Tongass National Forest Land and Resource Management Plan, the long-term viability of the Queen Charlotte goshawk may be seriously imperiled" (USDI Fish and Wildlife Service 1995).

The Forest Service sponsored an interagency workshop in June 1994 to consider the conservation status of the goshawk in southeast Alaska and to develop habitat management recommendations for Tongass NF lands. The recent listing petition and the expiration of the 1993 interim guidelines were principal factors in convening the workshop. Workshop participants concluded that the status of the goshawk was unknown, but that the population probably was declining as a result of habitat loss of old-growth forests from timber harvest. They also concluded that the goshawk was not likely significantly threatened at that time because of the abundance of available habitat, the likelihood of locating additional nests, and the conservation benefits of following habitat management recommendations provided by workshop participants. Two principal recommendations were developed at the workshop. First, the Forest Service should develop a long-term goshawk conservation strategy as an interagency effort. Second, in the absence of a comprehensive assessment and strategy, the FS should adopt a conservative management approach and preserve management options around identified goshawk nests. Interim habitat management recommendations included no commercial timber harvest within the home range of goshawks (as determined by radio telemetry) or, lacking telemetry data, within an empirically derived radius around current and historical goshawk nests: 2 miles in the northern half of the Tongass, and 8.4 miles in the southern half. These recommendations (USDA Forest Service 1994a) were considered an interim approach until a full assessment and strategy was developed.

The Forest Service immediately incorporated components of the recommendations from the interagency goshawk workshop into the 1994-95 timber sale schedule developed in June 1994. As an interim approach to retain management options, all planned timber harvest activity within the recommended home ranges around historical nests (1986 to 1993), and within a 600-acre zone around newly discovered nests (1994), was deferred. Timber harvest was also deferred in large and medium habitat conservation areas identified pursuant to a landscape conservation strategy to maintain habitat to support well-distributed viable populations of old-growth-associated wildlife species (Suring et al. 1993). Protection of habitat reserves and known goshawk nest sites represented primary components of the preferred alternative of a draft environmental assessment issued in September 1994 that proposed interim direction as a TLMP amendment (USDA Forest Service 1994b). A final environmental assessment has not been issued and there are no specific goshawk habitat management guidelines.

A followup workshop of the same participants was convened in October 1994 to reconsider the June recommendations in light of additional inventory, nest site, and study information. Similar but refined recommendations were made (USDA Forest Service 1994c). Where telemetry data were available, the combined male and female breeding season home range was to be protected. Instead of the 2.0- and 8.4-mile-radius home ranges, a Forest-wide, 2.9-mile-radius home range was recommended for all historical and current nest sites in the absence of telemetry data. These recommendations also were considered interim until a complete assessment could be completed.

Participants at this workshop reiterated their recommendation that development of a thorough assessment of goshawk conservation status was essential to better define the habitat components important to sustaining goshawks on the Tongass. Findings from that assessment would represent important considerations for the TLMP revision to manage habitat to sustain viable goshawk populations. This assessment represents the product of that workshop recommendation.

Management Update Since Assessment Initiation

This interagency assessment was initiated in January 1995. At that same time the Forest Service was deliberating on components of a final Environmental Assessment to specifically address goshawk habitat conservation. As described above, the FWS issued a finding on May 29, 1995, that listing the goshawk as endangered was not warranted at that time. Shortly thereafter, Congress passed legislation in the Fiscal Year 1995 Rescissions Bill (Section 502, Public Law 104-19) that prevented the Forest Service from implementing habitat conservation areas on the Tongass NF and limited goshawk nest protection to 300 acres in fiscal year 1995. This law effectively precluded, for at least the remainder of the Federal fiscal year, implementation of interim habitat conservation areas or goshawk nest protection measures under consideration as a TLMP amendment. Language from Public Law 104-19 expired as of September 30, 1995. A proposal to make Section 502 provisions permanent was under Congressional consideration in the Fiscal Year 1996 Appropriations Bill but was not enacted. By mid-1995, progress on the TLMP revision and this assessment indicated that an interim amendment was unnecessary and that goshawk conservation could be fully addressed in the TLMP revision.

In September 1995, authors of the petition to list the Queen Charlotte goshawk as endangered filed suit in court to challenge the FWS finding that listing the goshawk was not warranted. In September 1996 the court decided in favor of the plaintiffs and remanded the not warranted listing decision back to the FWS for reconsideration.

Review of Northern Goshawk Ecology in North America

Introduction

There is substantial literature describing the biology and ecology of goshawks in Europe and North America. The scientific information regarding goshawk population status, trends, and life history accumulated before 1987 was reviewed by Reynolds (1989), who focused on goshawk nesting habitat use, diet, nesting success, and estimates of density. Likely threats to populations of goshawks in western North America were identified. In 1992, as a part of the management strategy developed by the Northern Goshawk Scientific Committee, the Forest Service published a more thorough treatment of the relation of goshawks to habitats and prey in forests of the Southwest (Reynolds et al. 1992). This management strategy emphasized the dynamics of Southwestern forests and the link between forest structure and the abundance of primary goshawk prey. The report also stressed the similarities and differences in forest areas used by breeding goshawks and divided the home range into a nesting area, postfledging family area (Kennedy et al. 1994), and a foraging area. The management strategy was critically reviewed by Braun et al. (1996) who concluded that the scientific basis for the management recommendations and the recommendations themselves were sound and represented the basis for adaptive management that strives for a naturally functioning ecosystem.

In 1993, the Tongass NF released a report of an interagency committee on management of wildlife associated with old-growth forests in southeast Alaska (Suring et al. 1993). This report included a chapter on goshawks, which reviewed knowledge of goshawk ecology in the context of forest management of the Tongass NF and made management recommendations for goshawk conservation (Crocker-Bedford 1993). Following a peer review of the report (Kiester and Eckhardt 1994), the goshawk chapter was updated (Crocker-Bedford 1994). Also in 1993, the Cooper Ornithological Society sponsored a national symposium on the ecology and management of northern goshawks (Block et al. 1994).

Goshawk ecology and biology is currently being synthesized in a comprehensive review and assessment of goshawk ecology in North America (Reynolds et al., in prep.). This document will describe diverse aspects of goshawk life history, ecology, and biology in different forest types and geographic settings. It also will critically evaluate the conservation status of goshawks in North America.

Considering the scope of the North American goshawk assessment (Reynolds et al., in prep.) and the number of previous reviews of goshawk ecology, we only highlight those aspects of earlier reviews and recent scientific publications most applicable and relevant to management of goshawks in southeast Alaska. For other reviews of the scientific literature on goshawk ecology and management, see Arizona Game and Fish (1993), Reynolds (1989), Reynolds et al. (1992), Reynolds et al. (in prep.), and Crocker-Bedford (1994).

Review of Technical Knowledge

Distribution—The northern goshawk inhabits boreal and montane forest throughout much of the Northern Hemisphere in boreal, temperate, and highland subtropical areas (Beebe 1974). In North America, goshawks are broadly distributed from Mexico northward through most of the conterminous United States, Canada, and Alaska (Brown and Amadon 1968, Palmer 1988, Johnsgard 1990). Southeast Alaska likely represents the periphery of North American populations. As noted by Lawton et al. (1994), many aspects of species demography, and persistence probabilities, differ at the center versus the edge of a geographic range. In general, species exhibit higher density and occupy a greater proportion of suitable habitat near the center of their geographic range.

Systematics—In North America, most authorities recognize three subspecies of goshawks (Johnsgard 1990). *Accipiter gentilis apache*, a group of North American goshawks with the largest body size and more robust feet, occurs in a long, narrow, geographic range extending from southern Arizona south to Jalisco in the mountains of Mexico. The Queen Charlotte goshawk (*A. g. laingi*) is the smallest bodied form (Johnson 1989) that breeds on Queen Charlotte and Vancouver Islands (Taverner 1940) and may extend north to Baranof Island in southeast Alaska (Webster 1988) or Prince William Sound in south-central Alaska (Jones 1981). The northern goshawk, *A. g. atricapillus*, is intermediate in size and inhabits most of the North American range of the species. The American Ornithologist's Union (1957) recognizes *A. g. laingi* and *A. g atricapillus*.

Until recently, public, scientific, and management attention focused principally on *A. g. atricapillus*, largely to the exclusion of *A. g. laingi* and *A. g. apache*. Many inferences concerning goshawk ecology and potential response to management in southeast Alaska therefore must come from knowledge of the species elsewhere and be modified by the data originating from the local population.

As noted above, most authors suggest that a portion, if not all, of the goshawks in southeast Alaska belong to the Queen Charlotte subspecies *A. g. laingi*. Webster (1988) examined seven specimens from southeast Alaska, from as far north as the Taku River near Juneau, of which five were dark forms suggesting affinity to *A. g. laingi*. Whaley and White (1994) thoroughly examined 10 morphological variables in museum specimens to determine the amount and pattern of measurable geographic variation in goshawks across their range in North America. The study focused on evaluating clinal patterns in morphology and relating these to potential selective pressures; they did not emphasize distinguishing subspecies. Their analysis demonstrated the small size of *A. g. laingi* relative to goshawks collected from the nearby mainland and elsewhere on the continent. The subspecies *A. g. laingi* does not seem to be as small as suggested by Beebe (1974), but goshawks in this geographic region tend to be smaller than individuals from populations elsewhere in North America. A recent preliminary study was unable to detect significant genetic variation among samples representing the three described subspecies obtained from across North America (Gavin and May 1995). This preliminary genetic study did not address goshawk taxonomy, however. Because both *A. g. laingi* and *A. g atricapillus* may occur within the southeast Alaska region considered in this assessment, we refer to the goshawk population of southeast Alaska as the northern goshawk, or just goshawk.

Abundance—Only a few North American studies have produced reliable estimates of goshawk relative abundance. The majority of estimates are based on searches for active nests and often are based on the assumption that all nesting pairs were located. Pair densities across the goshawk's range varied from 28.5/100 square miles in Arizona (Crocker-Bedford and Chaney 1988), 7.4/100 square miles in Colorado (Shuster 1976), an average of 17 to 18/100 square miles in Oregon over 2 years (DeStefano et al. 1994a), 9.3/100 square miles in Oregon (Reynolds and Wight 1978), 7.3/100 square miles in New Mexico (Kennedy 1989), 1.1 to 3.2/100 square miles over multiple years in California (Bloom et al. 1986), to 0.3 to 2.4/100 square miles over multiple years in central Alaska (McGowan 1975). In northern Arizona, Reynolds et al. (1994) measured 59 nearest-neighbor distances, which averaged 1.9 miles. In northern California, nearest-neighbor distances averaged 2.0 miles (Detrich and Woodbridge 1994).

During a peak prey year, 40 goshawk pairs occupied 154 square miles in the southeast Yukon Territory, based on goshawk sightings during the breeding season, which likely included nonbreeders (Doyle and Smith 1994). Doyle and Smith (1994) also examined variations in goshawk abundance across years. An index of breeding goshawk abundance changed by more than a factor of four over a 2-year period in response to cyclical changes in hare (*Lepus americanus*) populations.

Breeding biology—Several factors can influence whether goshawks attempt to reproduce in any given year, including the availability of sufficient prey, adult mortality, the availability of suitable mates, and the availability of suitable and unoccupied nesting habitat. The male captures nearly all prey during preincubation, egg laying, and incubation periods (Beebe 1974), and unless prey is sufficiently abundant to permit the female to cease hunting altogether during the early nesting and incubation periods, nesting does not occur (Beebe 1974, McGowan 1975, Doyle and Smith 1994). Prey availability also can influence nesting success and productivity (Reynolds and Meslow 1984, Widen 1989, Doyle and Smith 1994). Adult mortality and the availability of suitable mates can influence the ability of birds to locate or replace a mate.

Where migratory, many goshawks return to nesting territories by mid-March (Beebe 1974). In Oregon, goshawks appeared at their nests in late March and early April (Reynolds and Wight 1978), and in interior Alaska, birds were observed near nest sites as early as March (McGowan 1975). Courtship flight displays involve both sexes and occur before and during nest repair or construction. Goshawks usually are silent but become vocal during the reproductive period. The dawn call is a series of woodpeckerlike clucks, closely and evenly spaced. During flight displays, the birds scream a loud, clear gull-like “kree-ah, kree-ah” call in an evenly spaced, continuous sequence (Beebe 1974).

Goshawks build large nests averaging about 3 feet across and up to 3 feet deep. Nests consist of sticks and bark (Beebe 1974) and usually are situated well below the canopy of the nest tree, within the lower quarter of the canopy of the nest site (Hall 1984). Goshawks may use the same nest for multiple years, build a new nest in the same or different stand, or repair an old nest. Both sexes participate in nest construction and repair. Alternate nests may be loosely clustered within a single stand or widely separated in different stands (Beebe 1974, McGowan 1975, Woodbridge and Detrich 1994). In interior Alaska, nest construction or repair occurred from mid to late April (McGowan 1975). Alterations in forest structure caused by disturbances such as timber harvest (Reynolds 1989, Crocker-Bedford 1990), stand size and level of fragmentation (Woodbridge 1988, Woodbridge and Detrich 1994), annual fluctuations in the abundance of prey (McGowan 1975, Doyle and Smith 1994), and adult mortality can influence whether goshawks reoccupy a particular nest site or stand.

Goshawks begin egg laying in early to mid April, and three to five eggs are laid at 48- to 72-hour intervals (Beebe 1974). In northern Nevada, egg laying was completed by May 1 (Younk and Bechard 1994). Incubation is initiated with the laying of the first egg and lasts 29 to 32 days (Beebe 1974, McGowan 1975, Reynolds and Wight 1978). Eggs hatch by mid to late May (Beebe 1974). In interior Alaska, the range of hatching dates was May 13 to June 25 (McGowan 1975).

Estimates of the length of the nestling period differ geographically but range from 35 to 42 days, with males fledging first (McGowan 1975, Reynolds and Wight 1978, Newton 1979, Johnsgard 1990, Kenward et al. 1993, Boal and Mannan 1994). Variation in fledging ages may be related to nestling condition, geographic location, or different definitions of branching and fledging (Boal and Mannan 1994). Fledging is preceded by a branching period when juveniles leave the nest platform but remain in the nest tree, walking or hopping onto branches near the nest (Newton 1986, Boal and Mannan 1994).

The postfledging period spans the approximate 4-week time between nest desertion and full independence. During this period, juveniles are fed and protected by the adults while they complete their growth and develop the skills necessary for independent existence (Newton 1986). Juvenile dispersal is enabled by completion of feather growth, is accelerated by food shortage, but probably results from behavioral maturation when food is abundant (Johnsgard 1990, Kenward et al. 1993).

Juveniles were considered to have dispersed when they ventured farther than 0.9 mile from the nest without returning (Kenward et al. 1993). Juvenile dispersal from nest sites occurs from 65 to 90 days after hatching. Juvenile females disperse significantly later than juvenile males. Males may disperse even earlier when food supply is poor, and dispersal may be associated with the beginning of active hunting (Kenward et al. 1993).

Seasonal movements—Goshawks in many populations remain in the same area throughout the year; however, recent studies suggest geographic variability in seasonal movement patterns. During two winters, four adult goshawks that nested in Wyoming moved up to 114 miles from their breeding areas to winter in a variety of habitats in Colorado (Squires and Ruggiero 1995). In the Yukon, goshawks remained within the 154-square-mile study area some winters but became nomadic during a prey decline (Doyle and Smith 1994). In Arizona, Reynolds et al. (1994) described goshawks as sedentary year round.

Dispersal—In Arizona, juveniles begin dispersing from the nest areas in mid-August (Reynolds et al. 1994). Kennedy et al. (1994) intensively monitored initial juvenile postfledging movement. During the period from 4 to 8 weeks after fledging, 75.9 percent of locations were within 880 yards of the nest. Six of seven juveniles monitored for several months remained on the Kaibab Plateau where they hatched, and one moved 100 miles before dying. In Sweden, the maximum distance that juveniles moved from their nest averaged 19 miles for males (n = 7) in rabbit-rich areas and 20 miles (n = 20) elsewhere; the average maximum distance for female young was 5 miles (n = 12) in dense rabbit areas and 14 miles (n = 22) elsewhere (Kenward et al. 1993). In south-central Sweden, recoveries of banded birds indicated that six of eight juveniles dispersed over 35 miles (Widen 1985). Based on 303 recoveries of juveniles banded in northern Sweden, 44 percent dispersed more than 35 miles (Hoglund 1964 as reported in Widen 1985). In contrast, only 4 percent of the juveniles in Germany dispersed over 35 miles (Glutz et al. 1971 as reported in Widen 1985). In central Alaska, dispersal by eight juveniles averaged 14 miles (McGowan 1975).

Detrich and Woodbridge (1994) examined adult fidelity to nesting territories for 9 years in northern California. Territory occupancy by females ranged from 1 to 7 years, and by males from 1 to 3 years. The authors note the difficulties in monitoring males and suggest that the male values are biased low. Among females relocated in different territories, movements ranged from 3.4 to 8 miles (n = 22). Males that moved and were relocated (n = 13) moved from 2.6 to 6.4 miles. These values are biased low, owing to the difficulty in relocating banded birds that move long distances.

Diet—Studies of goshawk diet in North America emphasize breeding season prey captures. Winter diets cannot be inferred from breeding season data. Furthermore, because of the potential differences in prey consumed by the male away from the nest and prey delivered to the nest, quantitative characterizations of diet may be biased. During the breeding season, goshawks prey predominantly on medium-size birds and mammals (mammals averaging 16 ounces and birds averaging 7 ounces) in Oregon (Reynolds and Meslow 1984). In central Alaska and the Yukon, snowshoe hare (*Lepus americanus*) dominate goshawk diets; goshawk population abundance and productivity respond dramatically to cyclic changes in snowshoe hare abundance (Doyle and Smith 1994, McGowan 1975). Reynolds et al. (1992: appendix 2) summarize goshawk diets in North America based on five studies from California, New York and Pennsylvania, Oregon, Arizona, and New Mexico. Examples of important prey in North America include snowshoe hare and other lagomorphs, tree and ground squirrels, woodpeckers, jays, and thrushes.

Based on observational data and inferences from a variety of studies, Widen (1989) concluded that goshawk populations are generally food limited. McGowan (1975), in Alaska, and Doyle and Smith (1994), in southwest Yukon, reached the same conclusion. Ward and Kennedy (1996) conducted a feeding experiment in New Mexico that further supports the hypothesis of food limitation; nestling survival increased at nests where food was supplemented in one of two years. Crocker-Bedford (1990) found reduced reoccupancy after timber harvest in the landscape around nests sites despite protection of nest stands; he attributed this to changes in foraging opportunities. Food limitation has been demonstrated in other raptor species as well (e.g., Hirons 1985, Korpimaki 1987).

The assertion that goshawks are food limited contrasts with the past emphasis placed on management of goshawk nest sites. Recently, however, the goshawk management plan for the Southwestern United States and the goshawk strategy recommended for the Tongass NF (Crocker-Bedford 1993) stress foraging habitat management or management of prey populations. The Southwest plan, in particular, places primary emphasis on providing habitat for a variety of prey populations over the long term.

Habitat use—Throughout North America, goshawks typically nest in various forest types generally associated with mature or old-growth coniferous or deciduous forest structures having relatively dense canopies (Shuster 1980; Jones 1981; Reynolds et al. 1982; Moore and Henny 1983; Erickson 1987; Speiser and Bosakowski 1987; Kennedy 1988; Crocker-Bedford and Chaney 1988; Hayward and Escano 1989; Reynolds 1983, 1989; Marshall 1992). Most studies of habitat use concentrate on forest structure at the nest tree and in the immediate vicinity. Far less is known about roosting and foraging habitat used during the breeding season and about important habitat use in winter.

Goshawks in the Western United States nest in the upper Sonoran through the Hudsonian life zones. Studies from several states suggest that the species nests in large coniferous or deciduous trees in older stands. Nesting stands have a high degree of canopy closure (Reynolds 1989:97). Studies of nesting habitat can be biased if samples of nests are located mainly through activities related to timber harvest (e.g., Hayward and Escano 1989). Reynolds et al. (1992) characterize the nest area (the habitat covering about 30 acres immediately around the nest) as typically on a northerly aspect in a drainage or canyon and often near a stream. The importance of a cool microsite (north exposure and near water) seems important mainly in more southern latitudes of the species' range. Variation in nesting habitat is evident when comparing nest sites used in Nevada, which are in parklike aspen with little understory and high canopy closure (Younk and Bechard 1994), to nest sites in Oregon, which are in stands with the complex structure of old-growth forest (Reynolds et al. 1982). Some evidence suggests that reoccupancy of nest stands is related to nest stand size. In northern California, reuse of nest stands was measurably lower in clusters of stands smaller than 26 acres (Woodbridge and Detrich 1994).

Habitat within the postfledging family area (Kennedy et al. 1994) is not as well defined as nesting habitat. This larger landscape (approximately 420 acres surrounding the nest area) inherently includes a wider range of vegetation compared to nest areas due to its greater size. Reynolds et al. (1992) suggest that this area should include patches of dense trees, developed herbaceous or shrubby understories, and habitat attributes (snags, downed logs, small openings) critical for many goshawk prey. Kenward et al. (1993) also reported that fledglings generally remain within 0.6 mile of the nest tree until they begin to actively hunt, at which time they disperse.

Not enough data are available to allow a definitive characterization of goshawk foraging habitat. Until recently this aspect of habitat use was virtually unstudied in North America (Fischer 1986). Crocker-Bedford and Chaney (1988) suggest that stands with large trees and dense canopies are used for nesting in Arizona because these sites are associated with similar stands for foraging. Management guidelines for goshawk foraging areas in the Southwest (Reynolds et al. 1992) recommend a landscape interspersed with mature forest and small forest openings. Reynolds et al. (1992) note, however, that few data exist on goshawk foraging.

Several recent studies indicate the range of habitats used for foraging. Hargis et al. (1994) found that goshawks in eastern California use home ranges having more patchy vegetation than random sites and includes diverse open habitats. There was no statistically distinguishable habitat selection within the home range of 6 of 11 radio-marked goshawks in northern Arizona (Bright-Smith and Mannan 1994). The most obvious pattern was an increase in relative preference for forest types with increased canopy closure. In a study examining goshawk productivity in five study areas in Oregon, DeStephano et al. (1994a), recorded higher fledging rates in the area dominated by lodgepole pine than in areas dominated by more typical mixed-conifer forest. In the boreal forest of central Sweden, adult males and females foraged less in young and middle-aged stands than expected, based on availability, and used mature forest approximately twice as frequently as its availability; furthermore, a majority of successful foraging attempts were documented in mature forest (Widen 1989). Widen (1989) concluded that increased prey availability did not lead to the preference for mature, taller forest; older forests did not exhibit higher prey densities, but the more dense, younger forests may have impaired goshawk hunting. In contrast, some studies in North America have found higher densities of some small mammals in old forest (Carey and Johnson 1995, Hayward and Hayward 1995).

During the breeding season, foraging goshawks include an extensive area in their home range. Graham et al. (1994) suggest that goshawk home ranges in the Southwestern United States need 6,900 acres of mid-aged, mature, and old forest interspersed with openings and patches of small trees. In northern Arizona, home ranges of 14 male goshawks averaged 3,800 acres (range 2,121 to 5,730 acres) during the breeding season (based on a 95-percent harmonic mean) (Bright-Smith and Mannan 1994). Two males in eastern California used areas of 1,600 and 1,724 acres (based on an adaptive kernel estimator) (Hargis et al. 1994). Three male goshawks in New Mexico used 5,200 ± 1,567 acres during the breeding season (Kennedy et al. 1994). Reynolds et al. (1992) characterize goshawk home ranges as 5,000 to 6,000 acres.

Few studies provide estimates of winter season home ranges. In the boreal forest of central Sweden, Widen (1985) studied relocated goshawks from September to June and estimated home ranges by using the minimum convex polygon. Male winter ranges averaged 12,600 acres (range 4,400 to 19,800 acres, n = 23), and female ranges averaged 15,300 acres (range 7,900 to 22,700 acres, n = 20). Home ranges outside the breeding season averaged 20,480 acres for males and 7,872 acres for females in California, representing a three- to four-fold increase over breeding season home ranges (Keane and Morrison 1994).

Demography and breeding biology—Goshawk demography has received less attention by scientists in North America than habitat use. Productivity, as measured by the number of fledglings per nest, is the vital rate most easily quantified. Studies throughout western North America indicate that production ranges from 0 to 2.8 young fledged per nest (table 1). Kennedy (1989) reports nestling mortality of 25 percent. In an experiment with food supplementation at some nests, Ward and Kennedy (1996) observed nestling survival ranging from 37 to 100 percent over 2 years with the lowest survival occurring in nests not supplemented with food. Long-term survival rates of fledglings and recruitment rates into the adult population are unknown. DeStefeno et al. (1994b) examined adult goshawk mortality but found a lack of fit to the capture-recapture model.

The general lack of demographic data precludes attempts to model population persistence or examine persistence qualitatively. Several authors (Crocker-Bedford 1990, Patla 1990, Reynolds et al. 1992, Ward et al. 1992) have reported loss of nesting areas and predicted declines in local or state populations.

Characteristics of the nonbreeding portion of the population—Estimates of goshawk abundance focus on the breeding portion of the population because survey methods are designed to detect breeders. Sampling of nonbreeding individuals requires different methods, and efficient techniques are unavailable. Nonbreeding individuals may play significant roles in goshawk demography, however, as they do in other species (Newton 1991:5). Nonbreeding individuals may buffer populations during stress, stabilize breeding population abundance by quickly filling in when breeders die, or serve to quickly increase the breeding density during periods of prey abundance.

Table 1—Productivity of goshawks in North America as measured by the mean number of young fledged per nesting attempt

Location	Number of nests	Productivity	Source
Alaska	33	2.0	McGowan 1975
Oregon	48	1.7	Reynolds and Wight 1978
Oregon	3-6[a]	0.3-2.2	DeStefano et al. 1994a
Oregon	10	1.2	Bull and Hohmann 1994
Nevada	88	2.2	Herron et al. 1985
California	127	1.7	Bloom et al. 1986
New Mexico	16	0.9	Kennedy 1989
Arizona	19[b]	2.1	Crocker-Bedford 1990
Arizona	12	0.5	Crocker-Bedford 1990
Arizona	83	2.2	Reynolds et al. 1994
Nevada	36	2.2	Younk and Bechard 1994
Yukon, Canada	11	2.8[c]	Doyle and Smith 1994

[a] Range from 5 sites studied over 2 years.
[b] Study included 19 control territories and 12 treatment territories.
[c] Value reported here was peak prey year; no young were produced in poor prey years.

Although it is difficult to estimate the proportion of the adult population made up of nonbreeders, several studies in Europe have indicated a substantial portion of the population does not breed. In Sweden, Kenward et al. (1990) found that many adults are nonbreeders, especially females. In Finland, Linden and Wikman (1983) estimated that 35 to 52 percent of the goshawks are nonbreeders, with the higher proportion occurring during periods of low grouse populations. Similarly, Widen (1985) estimated one-third of the adult, sedentary population in Sweden is nonbreeding.

Metapopulation structure—We are unaware of literature that discusses goshawk population dynamics in a metapopulation framework. Because of the relatively continuous nature of goshawk habitat and the scale of the use of the landscape by individuals, goshawk dynamics may not fit a metapopulation framework.

Population limitations—Although several authors (Widen 1989, Reynolds et al. 1992, Doyle and Smith 1994) emphasize the role of prey in limiting goshawk populations, abundance and distribution may be limited by a variety of factors. Reynolds (1989) examined threats to goshawk populations and discusses nesting habitat, foraging habitat, pesticides, and human disturbance. Marquiss and Newton (1982) discuss the importance of human persecution (shooting, trapping, poisoning) in the status of goshawks in Great Britain.

Reynolds et al. (1992) stressed the importance of prey in limiting goshawk populations. During periods when prey availability limits populations, exploitative competition with other carnivores could influence goshawk abundance and distribution. A number of avian and mammalian predators consume prey taken by goshawk, and potential competitors include lynx (*Lynx rufus*) (Ward and Krebs 1985) and great horned owls (Marti et al. 1993). The link between great horned owls and goshawks through consumption of similar prey was illustrated in studies of cyclic prey populations in Canada (Rusch et al. 1972). Reynolds (1979), Bosakowski (1990), and Siders and Kennedy (1994, 1996) examined habitat use by sympatric accipiter populations, and Reynolds and Meslow (1984) discuss food characteristics of three coexisting accipiters. Schoener (1984) examined size ratios of coexisting accipiters throughout the world; he found little evidence for the constant ratios hypothesized by Hutchinson (1959). The degree to which accipiters influence the distribution or abundance of one another is not established, however.

Changes in habitat structure may directly and indirectly influence population status. Young forests lack the physical structure necessary for the large goshawk nest platform. Forest structure immediately around the nest and in the landscape may influence the probability of predation on nestlings and adults as well as influence the thermal environment, which is tied to energy budgets and ultimately to productivity. Forest structure also influences the abundance and accessibility of prey. In the long term, vegetation condition at the landscape scale will influence goshawk populations. Reynolds et al. (1992) emphasize this concept by focusing on desired forest conditions and the link between forest structure and prey availability.

Natural predation also could limit population growth. In northern Arizona, predation by the great horned owl (*Bubo virginianus*) was the single most important cause of nestling mortality (Boal and Mannan 1994). Great horned owls and eagle owls (*B. bubo*), in particular, prey on both adult and young goshawks (Rohner and Doyle 1992, Tella and Ma–osa 1993, Boal and Mannan 1994). Goshawks foraging in open habitats may be vulnerable to a wide range of larger hawks or eagles. In Colorado, Squires and Ruggiero (1995) found a dead, radio-marked goshawk that appeared to have been killed (but not eaten) by a large raptor. Ward and Kennedy (1996) suggest that female nest attentiveness is responsible for lower nestling mortality at nests with food supplementation. When food was more abundant, females spent more time near the nest and presumably were able to defend against predators more effectively.

Williamson and Rausch (1956) suggest potential competitive relations between goshawk and ravens (*Corvus corax*) in response to four observations of the species occurring together in nonaggressive flight. Recent observations in Wyoming suggest that goshawks will consume carrion (Squires 1995), a resource also used by ravens.

Competition for nest sites also could be important (Crocker-Bedford 1990). Kenward (1996) speculates that fewer raptors may compete for nest sites with goshawks in Europe than in North America, and this may explain why goshawks in Europe often nest in more open environments than in North America.

Species response to timber harvest—The mechanism for inferred impacts of timber harvest on goshawks has not been established. Several factors may contribute to decreased productivity and density in goshawk populations following particular changes in forest structure and composition: (1) increased predation on adults and young goshawks as hiding cover is reduced and potential predator populations increase (e.g., great horned owls); (2) loss of cool thermal conditions at nest sites; (3) reduced prey abundance or availability, or both; (4) increased competition as predators that adapt to more open forest become abundant; and (5) increased disturbance and human-caused mortality due to increased access from the timber harvest road network.

Many authors who have studied goshawks in the Western United States have suggested that extensive timber harvesting may result in reductions in goshawk abundance (e.g., Hennessy 1978, Reynolds et al. 1982, Moore and Henny 1983, Hall 1984, Bloom et al. 1986, Woodbridge 1988, Crocker-Bedford 1990, Patla 1990). Two studies document reduced nest reoccupancy after timber harvesting (Crocker-Bedford 1990, Patla 1990). Other studies quantify lower breeding density in more fragmented coniferous forest (Bloom et al. 1986), or reduced nest reoccupancy in smaller stands (Woodbridge and Detrich 1994). Some studies compared more-harvested home ranges to less-harvested home ranges and found less reoccupancy and lower reproduction when greater harvest occurred in the landscape around the nest (Crocker-Bedford 1990, Patla 1990, Ward et al. 1992). Reynolds (1989) suggests that timber harvest threatens goshawk populations through loss of both breeding and wintering habitat.

Goshawks typically nest in stands with higher canopy densities and larger trees relative to other forested stands within a locale (see previous discussion). Goshawks also exhibit strong fidelity to their nesting stands, though they may alternate among nests and stands over a series of years (Reynolds and Wight 1978, Woodbridge 1988, Crocker-Bedford 1990, Woodbridge and Detrich 1994). Nest site fidelity is also lower where nest stands are smaller and more fragmented (Woodbridge and Detrich 1994).

Some authors suggest that goshawk populations may be limited by prey consumption (McGowan 1975, Mueller and Berger 1967, Kenward 1982, Widen 1985, Kenward and Widen 1989, Doyle and Smith 1994). Limitation might be due to the absolute abundance of prey or prey availability, which is related to forest structure that impedes goshawk flight or provides prey escape cover (Reynolds and Meslow 1984, Fischer 1986, Kenward and Widen 1989, Crocker-Bedford 1990, Reynolds et al. 1992, Austin 1993). The goshawk's ability to capture prey therefore may be altered by forest management that changes prey vulnerability (Reynolds 1989, Widen 1989, Crocker-Bedford 1990).

Moore and Henny (1983) suggest that timber harvest could increase nest site competition with raptors adapted to open habitat. More goshawk nest sites became used by red-tailed hawks (*Buteo jamaicensis*), great horned owls, or great grey owls (*Strix nebulosa*) in harvested areas than in unharvested locales (Crocker-Bedford 1990, Patla 1990). Great horned owl predation on goshawks may increase if portions of the canopy of nesting stands are removed (Reynolds et al. 1982, Moore and Henny 1983) or if nesting stands become smaller or more fragmented (Woodbridge and Detrich 1994).

Response to human disturbance—Goshawks actively defend their nest site against intrusion by humans, frequently attacking or calling loudly when a person ventures within a 20- to 25-acre area around the nest (Reynolds 1983). The impact of disturbance on occupancy and productivity has not been established, however.

Analysis of Northern Goshawk Ecology in Southeast Alaska

Systematics, Distribution, and Abundance

Systematics and distribution—The best available information indicates that in southeast Alaska, the Queen Charlotte goshawk subspecies occurs from the U.S.-Canadian border at Dixon Entrance, north through the coastal mainland and islands of the Alexander Archipelago, to Icy Strait and Lynn Canal (Webster 1988, Titus et al. 1994) and west to Peril Strait.[2] Preliminary examination of morphological and plumage characteristics of 35 goshawks (17 adults, 18 juveniles) captured at nest sites in southeast Alaska between 1991 and 1993 suggests that a gradient of characteristics exists between the Queen Charlotte goshawk and northern goshawk, with birds becoming darker and smaller from north to south and east to west (Titus et al. 1994). For example, goshawks captured in the northern areas of southeast Alaska, (e.g., Juneau), possess some characteristics of the northern goshawk, but these goshawks were still within the range of characteristics considered descriptive of the Queen Charlotte subspecies. These data suggest that a “cline” may exist within the southeast Alaska population, possibly in response to characteristics of the temperate rain forest environment.

Breeding and nonbreeding range—The southernmost confirmed northern goshawk nest (in southeast Alaska) was located at Port Refugio on eastern Suemez Island; the northernmost confirmed northern goshawk nest was located near the Lace River, about 50 miles north of Juneau (Titus et al. 1994). Though not confirmed, observations indicate that goshawks nest on southern Prince of Wales and Gravina Islands in southern southeast Alaska, north to near Skagway.[2] Taverner (1940) and Beebe (1974) characterize the Queen Charlotte goshawk as nonmigratory. Radio-telemetry results indicate that most goshawks nesting in southeast Alaska remain in the region year-round (Titus et al. 1994, ADF&G 1996). Of 26 radio-marked adult goshawks, individuals were located a maximum of 2.8 to 58.7 miles (median 7.58 miles) from their respective nest sites. The maximum movement of individual juvenile goshawks from their respective nest sites after fledging and throughout their first winter ranged from 7.2 to 101.1 miles (median 33 miles) (Titus et al. 1994).

Abundance, population trend, and density—There are insufficient quantitative data to determine abundance or population trend for goshawks in southeast Alaska. Speculation of goshawk abundance in southeast Alaska has ranged from 100 to 800 pairs (Crocker-Bedford 1990, 1994; Iverson 1990). Titus et al. (1994) characterized goshawk densities in southeast Alaska as low.

Goshawk survey results—Data collected from standardized goshawk surveys provide some indication of the success rate for locating goshawk nests in southeast Alaska. The Regional Forester for the Alaska Region issued direction to survey for goshawks and emphasized the importance of locating goshawk nests before land management activities occur, such as finding nests while preparing timber harvest units (USDA Forest Service 1992c). The Region adopted a survey protocol similar to the technique described by Kennedy and Stahlecker (1993) where tape-recorded goshawk calls are played at broadcast stations within a study area during the nesting season to elicit responses from nesting goshawks.

[2] Personal communication. 1996. R. Lowell.

For this analysis, only confirmed nests with goshawks observed at the nests were considered. Bird detections believed to be goshawks, but not associated with nests, were not included because reliability differed among observers. Highly probable nests were not considered. This analysis therefore is consistent with the "confirmed nest pool" described by Titus et al. (1994). For each home range, only the first nest found was included in the summary. New nests used as alternates to previously known nests were not considered because knowledge of the previous nest biased the likelihood of finding the alternate nest. Similarly, new nests found by following radio-collared birds were not considered. The following analysis began in July 1992 and continued through September 1994.

Twenty nests met the stated criteria (i.e., new territories found July 1, 1992, to September 1994). In four cases, the initial detection occurred during broadcast surveys for goshawks. In 12 cases, the initial goshawk detection occurred during some type of timber preparation activity, such as layout of a harvest unit boundary or road, timber volume cruise, fish stream analysis or buffer layout, soil surveys, or wildlife analyses other than goshawk surveys. In four cases, the initial goshawk detection did not relate to either timber harvesting or goshawk surveys: The Mitchell Creek nest (Petersburg Ranger District [RD]) and Margaret Lake nest (Ketchikan RD) stemmed from sightings related to fish habitat activities, and the Blueberry and Point Bridget nests (Juneau RD) stemmed from sightings related to recreational activities.

Data for the four nest locations resulting from initial goshawk detections during broadcast surveys appear in table 2. Table 2 also shows the number of broadcast survey stations in each Ranger District of the Tongass NF. Data from all broadcast survey stations were totaled, including data from efforts to find alternate nests relative to known nests, as well as from surveys that followed up on detections from sale preparation activities. Thus, the number of broadcast survey stations in table 2 is greater than the number that led to the four nest locations in table 2, and the "success" rate cannot be calculated by determining the number of nests per broadcast station. Data for the 12 nests located as a result of goshawk detections during timber preparation activities are shown in table 3. Also shown are the millions of board feet (MMbf) of timber prepared from July 1, 1992, to September 30, 1994, as recorded in the Alaska Region timber management database. In general, the amount of timber prepared for sale is positively related to personnel field effort and serves as a surrogate for goshawk "survey" effort.

In the northwest region (Sitka and Hoonah RDs), only one nest was found during preparation of 385 MMbf for sale. A large proportion of the timber sale preparation here occurred in watersheds with substantial historical timber harvest.[3] After goshawk detections during timber sale preparation, relatively little effort was made to locate nest sites in the northwest and northeast Tongass regions—in the Hoonah and Sitka RDs, usually less than a day by two people (average about one-half day each by two people; see footnote 3). Efforts to locate goshawk nests after initial observations were generally greater in the southwest and southeast Tongass regions. In the Ketchikan RD, 5 to 10 days by a crew of two people was typical of the amount of time allocated to nest searches after an initial observation.[4] In the Thorne Bay RD,

[3] Personal communication, May 1, 1995, T. Schenck, wildlife biologist, Chatham Area, Sitka, AK 99835.

[4] Personal communication, May 4, 1995, K. Burns, wildlife biologist, Ketchikan RD, Ketchikan, AK 99901.

Table 2—Goshawk survey broadcast stations and related nest discoveries in southeast Alaska, 1992-94[a]

Ranger District (RD) or subregion	Broadcast stations	Nests located
	Number	
Sitka RD	960	1
Hoonah RD	506	0
Total, northwest Tongass NF	1466	1
Yakutat RD	248	0
Juneau RD	789	1
Admiralty National Monument	255	1
Total, northeast Tongass NF	1292	2
Petersburg RD	2338	0
Wrangell RD	459	0
Total, central Tongass NF	2797	0
Thorne Bay RD	1405	0
Craig RD	1461	0
Total, southwest Tongass NF	2866	0
Ketchikan RD	1005	1
Misty Fiords National Monument	179	0
Total, southeast Tongass NF	1184	1
Total, Tongass NF	9605	4

[a] Only new nest discoveries (new territories) resulting from initial goshawk detections during the broadcast surveys are included.

10 to 20 staff days were spent in efforts to find active nests after reported detections of goshawks, though 3 days by a crew of two biologists was more typical.[5] The Craig RD spent nearly 20 staff days following up on goshawk detections in the vicinity of Old Franks Lake. Followup survey effort in the central Tongass region was generally intermediate, where typically 2 days by a two-person crew were spent following up on goshawk reports.[6] Therefore, the fewer nests located in the Ketchikan Area were likely not due to less effort. Despite generally greater nest search effort following reports of goshawk detections, the southern Tongass (especially the Thorne Bay and Craig RDs) exhibited a lower relative nest discovery rate, based on the volume of timber prepared, than did the central portion of the Tongass.

The locations prepared for timber harvest and surveyed for goshawks were not randomly chosen; thus the variation among different areas of southeast Alaska could be due to the characteristics of the specific locations searched, which may

[5] Personal communication, May 5, 1995, C. Ford, wildlife biologist, Thorne Bay RD, Thorne Bay, AK 99919.

[6] Personal communication, May 5, 1995, E. DeGayner, regional wildlife ecologist, Petersburg, AK 99833.

Table 3—Timber sale field preparation and related goshawk nest discoveries, 1992-94

Ranger District (RD) or subregion[a]	Timber prepared	Nests located
	MMbf[b]	*Number*
Sitka RD	331	0
Hoonah RD	54	1
Total, northwest Tongass NF	385	1
Yakutat RD	0	0
Juneau RD	1	0
Admiralty National Monument	1	0
Total, northeast Tongass NF	2	0
Petersburg RD	124	9
Wrangell RD	49	0
Total, central Tongass NF	173	9
Thorne Bay RD	122	1
Craig RD	82	0
Total, southwest Tongass NF	204	1
Ketchikan RD	83	1
Misty Fiords National Monument	0	0
Total, southeast Tongass NF	83	1
Total, Tongass NF	847	12

[a] After initial detection, the effort to locate nests differed considerably among Ranger Districts.
[b] MMbf = million board feet.

not be representative of the most typical or common habitats of southeast Alaska. For example, many timber sale preparation activities in the southern region (where the majority of goshawk surveys occurred) were in areas that had experienced considerable previous timber harvest and had highly modified landscapes. In contrast, most new nests on the central region were located through surveys in areas that often contained less past timber harvest.[7] Information on goshawk relative abundance collected during the past 7 years suggests that goshawks exist as a relatively low-density population in southeast Alaska. Since the first confirmed goshawk nest was located on Suemez Island in 1989, a cumulative total of only 36 goshawk nesting areas have been located in southeast Alaska (table 4), despite intensive survey efforts. Most known active nests were located in 1994 when 21 active nests were monitored; despite active monitoring of historical nest areas as well as searches for new nest sites, the number of active nests located dropped to only 10 in 1995.

[7] Personal communication, May 5, 1995, C. Flatten, wildlife biologist, ADF&G, Ketchikan, AK 99901.

Table 4—Numbers of active goshawk nests, by year, and cumulative number of all identified nesting areas (including active and inactive nests) in southeast Alaska

Year	Active goshawk nests	Goshawk nesting areas
	Number	*Cumulative number*
1989	1	1
1990	0	1
1991	3	7
1992	3	8
1993	8	16
1994	21	33
1995	10	36

Goshawk surveys in wilderness and roadless areas—Because many goshawk nests have been located in southeast Alaska as a result of timber sale preparation activities (e.g., 58 percent; ADF&G 1996) an evaluation was needed to determine if this sample of nests was representative of the relative density of goshawks throughout the region. Lands not subject to timber harvest, typically wilderness areas or areas set aside by the Tongass Timber Reform Act (TTRA), also may contain goshawks. Schempf et al. (1996) conducted a preliminary survey of goshawks with the following objectives:

- Sample wilderness and roadless areas not subject to timber harvest for nesting goshawks.
- Determine representative detection rates for goshawks in the coastal forests of southeast Alaska through standardized methods.
- Quantify prey species and habitat characteristics at each broadcast point.

Schempf et al. (1996) surveyed 724 points in 62 plots for goshawks during summer 1995, covering about 26 square miles, by broadcasting conspecific taped goshawk calls and using a survey protocol similar to that employed by the Forest Service (FS) (USDA Forest Service 1992c). They obtained responses at four stations in one plot by a single adult goshawk for a detection rate of 1.6-percent per plot and a station detection rate of 0.15 percent. Their results were lower than the 1.15-percent goshawk detection rate reported by Kvaalen and Iverson (1994) that summarized a FS goshawk survey effort that used the FS survey protocol, primarily in timber sale preparation areas. Detection rates reported by Kvaalen and Iverson (1994) are likely biased overestimates because many detections were related to previously reported goshawk observations and suspected nest sites. Schempf et al. (1996) reported that detection rates using comparable techniques were 9 times higher in Arizona (Joy et al. 1994) and 7 times higher in Idaho (Patla and Trost 1995) than in southeast Alaska and concluded that low detection rates relative to other regions suggests a low density and widely dispersed population of goshawks in southeast Alaska. Schempf et al. (1996) also concluded that their data could not support the hypothesis that wilderness and roadless areas of the Tongass NF support a substantial reservoir of goshawks that may buffer population losses from lands intensively managed for timber harvest.

Goshawk breeding biology in southeast Alaska—Relocation data collected throughout the year from goshawks radio tagged in southeast Alaska suggest that adults do not migrate and they begin to frequent nest stands in late February and early March (ADF&G 1996). Pairs engage in courtship flight displays before and during nest repair (Beebe 1974). During the current southeast Alaska study, only one goshawk flight display was documented involving an adult male; that occurred on June 15, 1994, following a failed nesting attempt at a nest site near Port Refugio on Suemez Island (see footnote 2, p. 22).

Goshawk nesting chronology in southeast Alaska was estimated by backdating from estimated dispersal dates of 21 juveniles radio tagged at 15 nest sites between 1992 and 1994 (Titus et al. 1994). Juvenile goshawks were considered to have dispersed when they moved more than (>) 0.9 mile from the nest without returning (Kenward et al. 1993). Dispersal dates were estimated as the midpoint between the date of the first relocation > 0.9 mile from the nest and the date of the last relocation less than (<) 0.9 mile from the nest. Age at dispersal was estimated by comparing observed morphological development of 14 juvenile goshawks at nine nest sites with the age-specific characteristics given by McGowan (1975). Fledging dates for southeast Alaska juveniles were calculated by using nestling periods of 36 days for males and 42 days for females, based on the 35- to 42-day range reported for the goshawk nestling period (McGowan 1975, Reynolds and Wright 1978, Newton 1979, Johnsgard 1990, Kenward et al. 1993, Boal and Mannan 1994). The date of egg laying was estimated by using an incubation period of 30 days (Beebe 1974, McGowan 1975, Reynolds and Wight 1978).

In southeast Alaska, egg laying was estimated to occur between April 12 and May 24 (ADF&G 1996). Based on the apparent age of nestlings when first observed, the mean hatching date for 21 juveniles at 15 nests was June 3 (range, May 12 to June 23) (ADF&G 1996). Mean estimated fledging date for 21 juveniles in southeast Alaska was July 13 (range, June 23 to August 4) (ADF&G 1996). Mean estimated postfledging period for 14 juveniles was 40 days (range, 35 to 47 days) (ADF&G 1994). In southeast Alaska, estimated dispersal from nest sites occurred 76 to 82 days after hatching and the mean estimated age at dispersal for 7 males was 75 days, and for 7 females was 82 days (Titus et al. 1994). Mean estimated dispersal date for 21 radio-tagged southeast Alaska juveniles was August 21 (range August 2 to September 13) (ADF&G 1996).

Patterns of Goshawk Movements, Habitat Use, and Habitat Selection Based On Radio Telemetry

Radio-telemetry methodology—Before 1992, no information was available on habitat use or movement patterns of goshawks inhabiting the Tongass NF. Between 1992 and 1995, ADF&G biologists radio tagged 67 goshawks, including 61 (33 adults, 28 juveniles) captures at 23 nest sites, and 6 (2 adults, 1 juvenile, 3 immatures) captures away from nest sites (ADF&G 1996). Between June 17, 1992, and January 1, 1996, goshawks were located 2,333 times by using fixed-wing aircraft and standard aerial radio-tracking techniques (Kenward 1987, Samuel and Fuller 1994). Mountainous terrain, the lack of a road system, and goshawk movement patterns precluded the use of ground-based telemetry. In contrast to ground-based tracking techniques, aerial tracking minimizes occasions when goshawks cannot be relocated owing to long-range movements or restricted observer access. Aerial tracking surveys generally covered 400 to 600 square miles, but often were increased substantially (doubled) to relocate birds that went undetected in the principal use area. Error associated with relocation points is estimated to be up to 300 feet, based on historical tracking experience in a variety of radio-telemetry projects in southeast Alaska (Schoen and Kirchhoff 1983).

Observers collected information on cover type based on their estimate of the location of the telemetry signal. Observers also plotted telemetry location on maps and aerial photographs that were subsequently transposed into the Tongass NF GIS. The GIS maps were then edited by investigators who collected the data by using check maps. This editing protocol minimized errors. The GIS provided a land cover classification system to assign a cover type and physiographic information (e.g., slope, aspect, and elevation) to each relocation.

Goshawk movements—Relocation data collected from 26 adult goshawks radio tagged at nest sites in southeast Alaska between 1992 and 1994 suggest that most goshawks do not undergo long-range annual migration (ADF&G 1996). Some adults were monitored for more than 1 year for a combined total of 38 bird years (i.e., 1 bird monitored for 1 year). Of the total 38 bird years, 28 extended throughout the winter, indicating that the birds did not migrate out of the region. Of the remaining 10 birds, 2 died in fall, 6 were lost during fall or early winter (migratory status unknown), and 2 either had their transmitters stop functioning or fall off, or they died (ADF&G 1996). Two of the six adult goshawks whose radio signals were lost during fall or early winter were subsequently relocated the following spring with functioning radio transmitters. It could not be determined if these two individuals moved outside Alaska, or if they remained in Alaska but beyond the range of aerial tracking flights. Researchers studying goshawks elsewhere have noted that migration often is tied to regional fluctuations in prey, and winter irruptions in more southerly regions sometimes occur as a result of reductions in the availability of prey to the north (Beebe 1974, McGowan 1975, Doyle and Smith 1994). Several ornithologists have speculated that the Queen Charlotte goshawk does not migrate (Taverner 1940, Beebe 1974, Jones 1981, Webster 1988).

Adult goshawks exhibited two separate patterns of seasonal movement at nest sites in southeast Alaska. Some adults used winter and breeding season areas that overlapped extensively, and others used largely exclusive winter and breeding season areas with little or no overlap. Eleven of 15 adults (7 males, 4 females) radio tagged in 1992 and 1993 and monitored through winter had breeding season and winter use areas that overlapped extensively. These birds expanded the size of breeding season use areas during the nonbreeding season but continued to use their breeding territories and nest sites. Although this pattern of seasonal movement was documented for both sexes, it was most prevalent among adult males. Six of eight adult males radio tagged at nest sites and monitored throughout winter maintained loose, year-round associations with their respective breeding season use areas. Of the two adult males with the greatest documented winter movements away from breeding sites, 58.7 and 26.8 miles, both were deserted by females, who then selected new mates at different nesting territories. During the breeding season immediately following desertion of their mates, these two males maintained use areas similar to those documented the preceding year but were nomadic during the ensuing winter. It is not known if these two males successfully remated or attempted to nest during the next breeding season.

Radio-tagged adult females exhibited seasonal movement patterns (previous paragraph) but had a greater tendency to be nomadic than did adult males. Some females moved from their breeding season home range during fall and winter, and one established a winter use area 33.5 miles from the previous nest, the maximum distance documented. There was no evidence, however, of migration or consistent seasonal movements (Titus et al. 1994). Four of seven adult females radio tagged at nest sites in 1992 and 1993 and monitored throughout the winter had seasonal use areas that overlapped extensively. Three others used exlusive winter and breeding season areas with little or no overlap; their movements from breeding areas to winter areas occurred during or immediately after the fledgling-dependency period.

Site fidelity—Seventeen instances of renesting in successive years were documented between 1992 and 1995 in southeast Alaska (ADF&G 1996). These included 13 sites where the active nest occurred in the same territory in successive years and 4 sites where the active nest occurred in a different territory. Both members of the previous years nesting pair were known to be present at 5 of 13 instances where the same territory was reoccupied. The identity of only one pair member was known at two sites and the identity of neither pair member was known at six sites. All four instances where the active nest occurred in different territories in successive years involved radio-tagged adult females with spatially separated seasonal use areas. These females selected new mates and established breeding territories within previously documented winter use areas. Distances between sequential-year nests for these four females ranged from 2.3 to 26.9 miles. Radio-tagged adult males have not moved to a new breeding territory to date and have displayed greater nest site fidelity than adult females.

Adult goshawk movements suggest a complex pattern of nomadism and site tenacity that differs between sexes. The pattern is similar to the more extensively documented pattern observed in boreal owls (*Aegolius funereus*). In this northern owl, food stress favors nomadism and nest site scarcity favors site tenacity, resulting in different movement patterns for males and females: females exhibited nomadism and males exhibited site tenacity (Lundberg 1979, Lofgren et al. 1986).

Nest site abandonment during the fledgling dependency period—Between 1992 and 1995, there were three instances in which adult goshawks abandoned nest sites and care of young during the fledgling dependency period. In all three cases, adult females abandoned care of fledglings and began movements toward winter use areas spatially separated from breeding season use areas. Adult males continued to provide for fledglings until dispersal (ADF&G 1996). Some Cooper's hawks exhibit this pattern, which may be associated with females in poor condition (Kelly and Kennedy 1993).

Juvenile postfledging movements—Between 1992 and 1995, 28 radio-tagged fledgling goshawks (8 males, 20 females) at 19 nest sites in southeast Alaska were monitored for postfledging movements by using fixed-wing aircraft. These movements were assumed to begin when juveniles moved > 0.9 mile from their nests and did not return for at least 2 days (Kenward et al. 1993). Juveniles were monitored at irregular intervals through autumn and winter or until signals were lost, radio packages were shed, or the birds died.

Of the 28 juveniles captured and radio tagged, 23 moved > 0.9 mile from the nest while being monitored. Four juveniles could not be relocated after moving from the nest area, and one died during the fledgling-dependency period. The mean maximum dispersal distance for 23 juveniles relocated after dispersing from nest sites was 39 miles with a range of 7 to 101 miles. Both the lengths of time when individual juveniles were monitored and the number of relocations varied greatly. The monitoring period for 23 juveniles relocated after dispersal ranged from 9 to 319 days (mean 126 days). Mean and maximum dispersal distances from the nest likely are underestimates because transmitter failure or long-range movements beyond the range of tracking flights prevented documentation of greater dispersal distances. Following initial nomadic movements away from 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.

Size of goshawk use areas—Aerial radio-telemetry relocation estimates were used to calculate the size of adult goshawk use areas during the breeding season from 15 March through 15 August (table 6). Sample sizes used to estimate size of the use areas were relatively small (mean = 26 relocations per individual) and were limited by costs and weather associated with aerial radio telemetry. The advantage of these data was that goshawks were relocated even if they were some distance away from their nest area, such as over a ridge or mountain where ground-based telemetry likely would not locate the individual. We estimated the size of use areas by calculating minimum convex polygon (MCP) areas, and 90-percent and 50-percent mononuclear probability polygons (MPP) (White and Garrott 1990). We assumed that all telemetry relocations were independent because in most all instances telemetry flights were conducted at intervals of 24 hours or more. The number of use areas was greater than the number of radio-tagged adult goshawks because some birds used different areas in different years, and these were considered separately.

The median size of female use areas (9,469 acres) were only slightly smaller (table 5) than those of males (11,425 acres) (table 6) during the breeding season. There was considerable variation in the size of use areas among individuals, even though some individual relocations were eliminated for goshawks that had very large use areas because they abandoned their breeding season use area before completion of the breeding period (table 5). Median 50-percent MPPs were much smaller for females (96 acres) than for males (1663 acres), indicating a female affinity for the immediate nesting area during much of the breeding season. The size of these breeding season use areas is larger than generally described for the species (see “Review of Northern Goshawk Ecology in North America,” above). Twelve of 17 adult females had use areas > 6,000 acres during the breeding season (table 5). By contrast, home range size for goshawks in other regions was smaller than found in southeast Alaska. Bright-Smith and Mannan (1994) estimated mean breeding season home range size for 11 male goshawks at 4,342 acres in Arizona, and Austin (1993) estimated mean home range size at 5,989 acres in California. Caution needs to be used in comparing among studies, because radio-telemetry locations were obtained in southeast Alaska from aircraft whereas other researchers usually used ground-based telemetry methods.

Table 5—Use areas for adult female goshawks during breeding (nesting) and nonbreeding seasons, as determined by the 100-percent minimum convex polygon (MCP) area and 90-percent and 50-percent mononuclear probability polygons (MPP)

Bird	Relocations	100% MCP	90% MPP	50% MPP
	Number		– – – – – – – – – – *Acres* – – – – – – – – – –	
Breeding season:				
BBF1	67	8,369	2,659	22
BJF1	19	214,313	149,696	175
BJF1	19	4,690	1,285	96
AF12	10	6,701	3,976	74
ECF1	62	17,001	16,042	7
MCF1	20	6,714	5,674	895
MPF1	18	3,652	3,193	519
NCF1	34	5,844	2,439	37
PBF1	9	492	334	89
PBF1	20	11,495	4,994	27
PRF1	16	4,562	3,005	586
RNF1	13	9,469	8,471	487
RRF1	25	203,391	46,974	10,608
SLF1	29	59,552	42,354	4,455
SLF1	28	13,371	5,372	86
TRF1	44	10,408	9,301	44
WPF1	9	16,259	16,010	4,478
Mean	26	35,076	18,928	1,335
Median	20	9,469	5,372	96
n	17			
SD	17	66,728	36,337	2,782
Nonbreeding season:				
BBF1	42	64,049	32,074	9,084
BJF1	40	31,185	22,768	3,754
ECF1	36	25,748	22,825	10,247
MCF1	23	2,436	2,105	52
MPF1	35	34,026	14,253	6,484
NCF1	25	8,377	6,291	2,471
PBF1	16	213,300	67,706	10,588
PRF1	10	4,416	3,499	667
RNF1	106	59,503	37,955	16,403
RRF1	27	255,258	161,359	6,047
RRF2	13	452,200	445,281	227,879
SLF1	35	79,444	74,205	17,695
SLF1	24	105,019	53,029	17,663
TCF2	27	411,675	172,825	872
TRF1	68	30,048	27,404	8,703
WPF1	16	5,977	1,567	603
Mean	34	111,416	71,572	21,201
Median	27	46,764	29,739	7,594
n	16			
SD	24	144,870	112,441	55,442

Table 6—Use areas for adult male goshawks during breeding (nesting) and nonbreeding seasons, as determined by the 100-percent minimum convex polygon (MCP) area and 90-percent and 50-percent mononuclear probability polygons (MPP)

Bird	Relocations	100% MCP	90% MPP	50% MPP
	Number		*– – – – – – – – – – Acres – – – – – – – – – –*	
Breeding season:				
BBM1	63	10,089	7,897	2,182
BJM1	27	16,282	10,596	1,910
BPM1	22	6,813	3,432	467
ECM1	30	10,539	6,192	979
FCM1	44	10,255	6,531	840
HCM1	22	12,311	8,224	1,834
LRM1	39	23,853	18,429	2,780
MCM1	12	10,532	6,798	618
MIM1	14	8,063	6,533	1,198
MPM1	19	9,417	7,653	2,120
NCM1	62	21,108	11,085	1,475
RNM1	38	15,133	11,720	6,647
RRM1	30	38,375	29,529	5,293
SLM1	40	48,185	17,312	1,493
TRM1	25	26,341	24,933	5,716
WPM1	9	4,440	3,109	734
Mean	31	16,983	11,248	2,268
Median	29	11,425	8,061	1,663
n	16			
SD	16	12,062	7,576	1,919
Nonbreeding season:				
BBM1	39	26,341	11,055	3,699
BJM1	57	60,961	32,321	8,535
BPM1	34	29,825	20,043	3,973
ECM1	18	36,300	16,717	1,075
FCM1	23	26,638	13,620	7,124
LJM1	22	29,405	23,070	8,715
LRM1	18	38,474	24,028	3,534
MCM1	27	442,069	50,236	6,099
MPM1	28	14,945	11,584	2,698
NCM1	25	14,841	7,979	1,893
PBM1	11	16,385	14,861	2,916
RNM1	54	561,667	430,702	11,690
RRM1	24	94,913	54,561	25,452
SLM1	20	157,726	152,859	51,521
TRM1	25	71,586	55,203	12,859
Mean	28	108,138	61,256	10,119
Median	25	36,300	23,070	6,099
n	15			
SD	13	165,806	108,462	13,004

The size of use areas also ranged greatly among individuals during the nonbreeding season from 16 August through 14 March; mean and median sizes of both adult female and adult male use areas were much larger than during the breeding season (tables 5 and 6). Ninety-percent MPP use areas eliminated 10 percent of the outermost location estimates, but even these median areas exceeded 20,000 acres for both sexes. Only 4 of 18 female use areas were < 10,000 acres, indicating that these birds make extensive movements over large areas during autumn, winter, and early spring. No male MCP use areas were < 10,000 acres and only 1 of 15 90-percent MPPs was < 10,000 acres. There are few North American nonbreeding season data to compare with those presented here.

We also examined the size of local areas used by juveniles after leaving the nest but prior to permanent departure from the nesting area. Our objective was to evaluate the concept of the postfledging area concept reviewed earlier (see “Review of Northern Goshawk Ecology in North America,” above) to determine if this behavior and relation occurs in southeast Alaska. We assumed that juveniles departed the nest area when they moved > 0.9 mile from their nests and did not return for at least 2 days (Kenward et al. 1993). The average MCP of radio-marked juveniles having over five relocations was 58 acres (n = 7, range 6 - 253 acres, SD = 88.5), much smaller than the 400- to 600-acre value reported by Kennedy et al. (1994). These estimates may be conservative owing to a limited number of relocations; many juveniles are captured and radio marked after fledging but before dispersal.

Habitat use and selection within seasonal use areas—We recognize that habitat selection processes occur at a variety of spatial scales (Hilden 1965, Johnson 1980). However, we examined only habitat selection within seasonal use areas (home ranges) by comparing patterns of habitat use with estimates of habitat availability (ADF&G 1996). Habitat use was defined as the proportion of goshawk telemetry relocations occurring in each habitat cover type. Habitat availability was defined as the proportion of each habitat cover type occurring within the 100-percent MCP for each bird within a season (breeding and nonbreeding) and year. Individual goshawks were the sampling unit, and a different number of relocations were collected from each goshawk throughout the year.

Minimum convex polygons (MCP) were produced for each adult goshawk by using the GIS to estimate areas used by goshawks. Because of high variability in our sampling intensity and the spatial patterns exhibited by individual birds, we do not feel we described home ranges adequately for many birds; we thus prefer to use the term “use areas” rather than “home ranges.”

Within the MCP use area for each individual goshawk, five landscape positions and eight habitat cover types were discerned by using GIS (table 7). Very high volume and high volume old-growth cover types were pooled for a seven-variable analysis. In all analyses, very high volume was never different from high volume (P > 0.05), which may be due to coarse similarities in vegetation structure among these two classes relative to other cover types. This data set constituted the within-use-area habitat available to an individual bird. Not all goshawks had all cover types available in their seasonal use area. For instance, at broader levels of habitat selection (Hilden 1965) alpine habitat is theoretically available to all birds in southeast Alaska. However, some birds have selected seasonal use areas without alpine habitat; thus they have no opportunity to select this type within the scale of our habitat use analysis.

Table 7—Landscape position and habitat cover types as determined by the Tongass NF GIS and used for goshawk radio-telemetry habitat analyses

Cover type or landscape	Code	Description
Landscape position:		
Riparian	R	200- to 300-foot buffers on each side of anadromous and resident fish streams
Beach and estuary fringe	B1	Habitat zone 0-500 feet inland from the shoreline and 0-1000 feet inland from estuaries
Extended beach fringe	B2	Habitat zone 500-1000 feet inland from the shoreline
Alpine	A	Alpine, rock, and nonforest above 2,000 feet elevation
General upland	G	General upland areas not included in any defined zone
Vegetation structure:		
Productive old-growth forest—		Old-growth forest capable of producing > 20 cubic feet of wood fiber per acre per year
Very high productivity[a]	VH	Very high volume old-growth: $\bar{x}$ = 39,000 Mbf/acre[b]
High productivity[a]	H	High-volume old-growth: $\bar{x}$ = 31,400 Mbf/acre
Moderate productivity[a]	M	Moderate volume old-growth: $\bar{x}$ = 25,100 Mbf/acre
Low productivity[a]	L	Low-volume old-growth: $\bar{x}$ = 15,700 Mbf/acre
Scrub forest	S	Unproductive old-growth forest producing < 20 cubic feet of wood fiber per acre per year
Clearcut	C	Mostly clearcut but also primary succession areas
Mature sawtimber	MS	Approximately 75- to 150-year-old sawtimber stands
Nonforest	N	< 10-percent tree cover

[a] See Julin and Caouette (in prep.) for further clarification of timber volume categories.
[b] Mbf = thousand board feet.

We considered the breeding season to occur from 16 March through 15 August. All telemetry locations for adult goshawks were used including those associated with females during incubation. These form a small percentage of the entire data set. Some goshawks moved > 15 miles from their nest site during the breeding season. Movements by individuals > 24 miles from the nest site during the breeding season suggested fundamental shifts in use areas (primarily by females) or nomadic movements and were eliminated as data points in the estimation of MCP use areas. For the breeding season compositional analyses, our sampling units were individual goshawks. Habitat use by an individual goshawk within a season was considered unique and if the bird moved to a different nesting area between years it represented an additional sample unit. For the breeding season analysis, 14 adult female goshawks represented 17 goshawk sampling units and 16 adult male goshawks represented 16 sampling units (tables 5, 6).

We considered the nonbreeding season to occur from 16 August through 15 March. All telemetry locations for 31 adult goshawk sampling units during the winter season (tables 5, 6) were used to determine an MCP use area for estimating abundance of available cover types.

Habitat use—We described patterns of habitat use within use areas by analyzing seven habitat cover types. Estimates of goshawk habitat use were made by the proportion of radio-telemetry relocation points occurring in each cover type. The habitat selection analyses used a log-ratio difference test developed by Aebischer et al. (1993) and was based on the compositional analyses of Aitchison (1986). We chose this method to take advantage of the use of each goshawk as the sampling unit, to minimize the problems of nonindependence of proportions, to scale the test for selection by the use-availability difference between each animal, and then to test for between group (e.g., sex, season, study location) differences.[8]

The compositional analysis method of Aebischer et al. (1993) uses the log-ratios of use habitat composition paired with its corresponding log-ratios of available habitat composition. We then used a linear model MANOVA, to test for various differences in model parameters. The MANOVA model tested for the overall null hypothesis that use and availability did not differ among all cover types. If differences were noted based on Wilks' lambda (λ), then we performed a series of t-tests and Wilcoxon rank tests measuring the difference between random use among all pairs of habitat variables. This approach allows one to assess patterns of differences in paired habitat variable combinations. Finally, we followed Aebischer et al. (1993) and Johnson's (1980) methods to rank cover types. Tied ranks were not permitted because of the antisymmetry properties and independence of the log-ratios. Like the descriptions of Aebischer et al. (1993), our data sets were composed of some missing cover types that are not permitted in the log-ratio analyses. Rather than removing these from the analysis, we substituted the value of 0.0001 for missing cover types, which was much smaller than any corresponding real habitat value.

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[8] The compositional analysis program was developed by J. Blick using WINSAS (1993); ADF&G, Box 240020, Douglas, AK 99824. Contact K. Titus for information.

Table 8—Ranking matrix of habitat selection by adult goshawks that tests for within minimum convex polygon (MCP) use area selection compared with individual radio-telemetry relocations[a]

Cover type[b c]	VH/H_x	M_x	MS_y	S_y	L_y	N_z	C_z	Rank[d]
Very high/high productivity (VH/H)	0	+	+++	+++	+++	+++	+++	6
Moderate productivity (M)	–	0	+++	+++	+++	+++	+++	5
Mature sawtimber (MS)	—	—	0	+	+	+++	+++	4
Scrub forest (S)	—	—	–	0	+	+++	+++	3
Low productivity (L)	—	—	–	–	0	+++	+++	2
Nonforest (N)	—	—	—	—	—	0	+	1
Clearcut (C)	—	—	—	—	—	–	0	0

[a] +++ = selection for a habitat type $P < 0.05$; — = selection against a habitat type $P < 0.05$; + = positive selection, not significant; – = negative selection, not significant.
[b] Habitat cover types are further described in table 7.
[c] Habitat cover types with the same subscript letter (x, y, z) do not differ significantly ($P > 0.05$).
[d] Greatest value = highest rank.

We treated most individual goshawks equally in terms of weighting for the compositional analyses regardless of the number of radio-telemetry relocations for that bird. Exceptions were those birds for which multiple years of data existed and we knew they moved to different use areas between years. This approach had some effect of weighting, in that the seven birds that moved to different areas during the nesting season and for which more relocations existed counted >1 time in the analysis. We performed a seven-variable analysis to test within-use-area habitat selection with tests for season and sex effect.

Our sample of 64 goshawk sampling units was based on 1,906 radio-telemetry relocations that ranged from 9 to 106 relocations per bird per season, each at least 1 day apart. Goshawks with less than 11 relocations were removed from the analysis, leaving 59 goshawk sampling units. Based on the seven-variable analysis, there was overall habitat selection by goshawks (MANOVA, $P < 0.0001$) (table 8). There was no seasonal effect ($P = 0.189$) and no sex effect ($P = 0.341$) in the model. Patterns of selection for specific habitat variables indicated selection for very high/high volume old-growth forest and medium-volume old-growth forest relative to their availability within goshawk use areas; they were the two highest ranked cover types. Mature sawtimber (older second growth), scrub forest, and low volume old-growth forest were selected significantly less than the two higher volume old-growth forest types. Nonforest and clearcut or early succession habitat cover types were statistically avoided relative to availability and were the lowest ranked cover types. Pooling mean differences for all goshawks by each of the seven habitat variables allows a depiction of relative habitat selection and compliments the statistical test we performed based on Aebischer et al. (1993). Combining both

Table 9—Goshawk use of various cover types throughout the year in southeast Alaska

Cover type[b]	No.	Percent use mean SD[c]	Percent available mean SD[c]
Very high/high productivity	59	32.2 (18.5)	23.1 (13.9)
Moderate productivity	59	26.4 (12.8)	19.5 (8.2)
Mature sawtimber	59	2.6 (6.8)	1.4 (2.8)
Scrub forest	59	19.5 (13.3)	27.6 (14.1)
Low productivity	59	9.3 (10.7)	6.6 (5.7)
Nonforest	58	5.9 (8.7)	13.9 (14.8)
Clearcut	58	3.7 (9.6)	8.9 (11.5)

[a] Percent availability is the proportion of each cover type represented in the MCP use area.
[b] Cover types are further described in table 7.
[c] Standard deviation (SD) given in parnetheses.

breeding and nonbreeding seasons, a mean of 23 percent of the use areas was composed of very high and high volume old-growth while 32 percent of the mean telemetry relocations were in this habitat type (table 9). In contrast, a mean of 14 percent of the combined breeding and nonbreeding season use areas was in nonforest habitat types, but only 6 percent of the mean telemetry relocations were in this type. These values, averaged across birds, support the results from the compositional analysis.

We interpret these results as indicating a strong pattern for selection of very high to moderately productive old-growth forest with a combined 58 percent of all habitat use occurring in these cover types. Mature sawtimber, scrub forest, and low productive old-growth combined represented 30 percent of all goshawk relocations and were used relative to their availability within goshawk use areas. A total of 19.5 percent of the radio-telemetry relocations occurred in scrub forest. The GIS-defined scrub forest habitat cover type contained a variety of vegetative types and some smaller patches of productive old-growth forest too small to be mapped in GIS. Visual inspection of goshawk relocation points on aerial photographs indicated that the point was often in a patch of productive old-growth forest imbedded within a larger scrub forest polygon. Because of this mapping resolution limitation, data may overestimate the use of scrub forest and underestimate the use of productive old-growth forest patches contained therein. Only 9 percent of goshawk relocations occurred in nonforest and clearcut, and these habitat cover types were avoided relative to other cover types.

Our analyses did not indicate any differences between adult male and adult female habitat selection, and seasonal effects could not be detected. The established non-breeding season was 7 months, and we did not perform a seasonal habitat analysis during periods of deep mid-winter snowpack that occur periodically across central and northern southeast Alaska.

Table 10—Ranking matrix of habitat selection by adult goshawks that tests for within minimum convex polygon (MCP) use area selection compared with individual radio-telemetry relocations among 5 levels of landscape position in southeast Alaska[a]

Landscape position[b c]	R_x	G_x	$B1_x$	$B2_{xy}$	A_y	Rank
Riparian (R)	0	+	+	+	+++	4
General upland (G)	–	0	+	+	+++	3
Beach and estuary fringe (B1)[d]	–	–	0	+	+++	2
Extended beach fringe (B2)[e]	–	–	–	0	+	1
Alpine (A)	—	—	—	+	0	0

[a] +++ = selection for a habitat type P < 0.05; — = selection against a habitat type P < 0.05;
+ = positive selection, not significant; – = negative selection, not significant.
[b] Landscape positions are further defined in table 7.
[c] Landscape positions with the same subscript letter (x, y) do not differ significantly (P > 0.05).
[d] Extends 500 feet inland from shoreline.
[e] Extends from 500 to 1,000 feet inland from the shoreline.

We also analyzed goshawk occurrence within five landscape positions (table 7) by radio-marked goshawks relative to the availability of those landscapes within the MCP use areas. Based on the five-variable analysis, there was an overall habitat selection for landscape position by goshawks (MANOVA, P < 0.0001). Patterns of selection indicated an avoidance of alpine relative to the four remaining features except the extended beach zone (table 10). Alpine represented only 6 percent of goshawk habitat use, and alpine represented 10 percent of the available landscape within use areas (table 11). There were no significant differences among the four remaining landscape positions (table 10). Riparian zones were the highest ranked habitat and represented 24 percent of all goshawk relocations, whereas riparian habitats were only 19 percent of the available habitat in goshawk MCPs (table 11). Use of the riparian habitat zone may be underestimated because when a goshawk was relocated in the relatively small area of overlap where a riparian zone intersects the beach zone, we assigned the relocation to the beach habitat zone. Relative use of the combined beach and extended beach zones by goshawks (15 percent) was nearly double its availability as a landscape zone within goshawk MCPs (8 percent), thereby suggesting a selection for this ecological interface between the terrestrial and marine environments. Failure to detect a significant relation may by due to relatively high variability in use of these habitat types (table 11). We did not detect any effect by season (P = 0.4129) or sex (P = 0. 3460).

Analysis of habitat edge—Fragmentation of forest habitats and the ecological influence of resulting edge is an issue relative to goshawk conservation and habitat relations in southeast Alaska (Crocker-Bedford 1993). We recognize that at least two distinct edge types exist and may differ functionally and structurally relative to goshawk habitat relations. Natural forest edge represents the ecotone among productive and nonproductive (scrub) forest lands or between forest and nonforest lands. Induced edge is primarily the abrupt edge created by clearcut timber harvest and adjacent old-growth forest. Edge effects on goshawks, if any, may persist until canopy height of seral conifer stands attains 50 to 75 percent of the adjacent mature or old-growth forest. Abrupt edges can be created through natural disturbance events such as catastrophic windthrow (see "The Forest Ecosystem and Its Management," above).

Table 11—Goshawk use of various landscape positions throughout the year in southeast Alaska[a]

Landscape[b]	No.	Percent use mean (SD)[c]	Percent availability mean (SD)[c]
General upland	59	54.9 (18.3)	61.4 (14.5)
Riparian	59	24.2 (17.0)	19.4 (7.7)
Beach and estuary fringe[d]	59	9.5 (14.7)	4.6 (6.1)
Extended beach fringe[e]	59	5.3 (7.7)	4.1 (4.9)
Alpine	59	6.1 (10.4)	10.5 (13.3)

[a] Percent availability is the proportion of each landscape position represented in the MCP use area.
[b] Landscape positions are further described in table 7.
[c] Standard deviation (SD) given in parentheses.
[d] Extends 500 feet inland from shoreline.
[e] Extends from 500 to 1,000 feet inland from the shoreline.

We used goshawk telemetry relocation data and systematic points from the GIS grid database (20-acre pixel resolution) within each goshawk MCP to test the hypothesis that natural and induced edges have no effect on goshawk habitat use patterns. The ADF&G (1996) reports that goshawks in southeast Alaska exhibit less selection for productive old-growth forest that is close to clearcuts than for productive old-growth forest >600 feet from clearcuts, but the ADF&G was unable to find differences in selection between productive old-growth forest edges compared with productive old-growth forest interior patches. They concluded that all ecotones are not structurally and functionally similar for goshawks. Our analysis includes data collected since that initial ADF&G analysis (nearly double the goshawk relocation data points) as well as the earlier data. Forest edge was defined in GIS as the polygon boundary between productive old-growth forest and unproductive scrub forest or nonforest.

Mean distances to the nearest clearcut edge were compared among goshawk relocation points determined by using radio telemetry and systematically located points (GIS grid points) within the goshawks MCP use areas. Only goshawks with clearcuts in their MCP were included in these analyses. Points (relocation or systematic) within clearcuts were not used, because we were interested in goshawk response to the old-growth forest immediately adjacent to the clearcut, and not the clearcut habitat that goshawks avoid (see tables 8, 9).

Point-to-old-growth edge distances were similarly measured but only for points within old growth. Means were compared by using a mixed factor analysis-of-variance appropriate for unequal sample sizes (SAS Type III; Milliken and Johnson 1984). In the analysis, point type (location vs systematic), season (breeding vs nonbreeding), and sex were fixed effects and individual goshawks were random effects with points nested within goshawk ranges. Because of the unequal sample sizes, sums-of-squares and degrees-of-freedom were adjusted by using Satterthwaite's method prior to conducting tests (Milliken and Johnson 1984). Also, because of skewed data, point-to-clearcut and point-to-edge distances were transformed to natural logarithms before analyses. Geometric means (i.e., on the original scale) are presented.

Table 12—Mean point-to-clearcut edge distances for goshawks and systematic points within their minimum convex polygon use areas

Sex	Season	Point type	Mean (geometric)	F (df)[a]	p[b]
			Feet		
F	Breeding	Goshawk	1631.5	2.97 (1, 12.2)	0.110
F	Breeding	Systematic	1656.9		
F	Nonbreeding	Goshawk	2355.1	1.50 (1, 20.0)	0.235
F	Nonbreeding	Systematic	1810.7		
M	Breeding	Goshawk	2031.3	0.11 (1, 10.8)	0.742
M	Breeding	Systematic	1965.6		
M	Nonbreeding	Goshawk	2269.6	1.51 (1, 9.6)	0.248
M	Nonbreeding	Systematic	2504.6		

[a] F statistic, df = degrees of freedom.
[b] p = probability level.

The difference in point-to-clearcut edge distances between goshawk locations and systematic points varied among seasons and between sexes (season*sex*type interaction, $F_{1,53}$=5.24, p=0.026), but, when goshawk and systematic points were compared separately for each season-sex combination, there were no differences (table 12, figs. 3-6). Point-to-old-growth edge for goshawk relocations and systematic points were not affected by season, including interactions (p>0.05); however, point-to-old-growth edge differences between locations and systematic points were affected by sex (sex*type interaction, $F_{1,106.7}$=4.71, p=0.032). In separate analyses for each sex, no difference in mean point-to-old-growth edge for goshawk locations and systematic points was found (table 13, figs. 7, 8).

This inability to discern selection for or against edge and interior forest patches or clearcut edges may result from several factors. Goshawks may not be selecting for edges or for the interior of large forest patches or clearcut edges. They may be selecting forested areas based on structure and not location relative to edge. Alternatively, goshawks may be selecting or avoiding edge, but our analyses, scale of resolution, and sampling error may preclude our recognizing a pattern. Finally, a pattern may exist but more samples are needed to discern it.

Pattern of Topographic Characteristics of Goshawk Habitat Use

We examined goshawk telemetry relocation data to determine if goshawks differentially select or avoid topographic features across the landscape within their use areas. The slope, aspect, and elevation of each goshawk relocation point was identified in GIS to obtain the proportional use of each feature. Availability was quantified by using systematically located grid points from GIS within the same goshawk's MCP use area. Use was compared to availability by using the composition analysis (Aebischer et al. 1993) described earlier. Elevation was divided into six classes: 0-500 feet; 501-800 feet; 801-1200 feet; 1201-1500 feet; 1501-2000 feet; and over 2000 feet. Slope was divided into four classes: 0-35 percent; 36-55 percent; 56-75 percent and over 75 percent. Aspect had five classes—the four cardinal directions (north, south, east, and west) and level terrain.

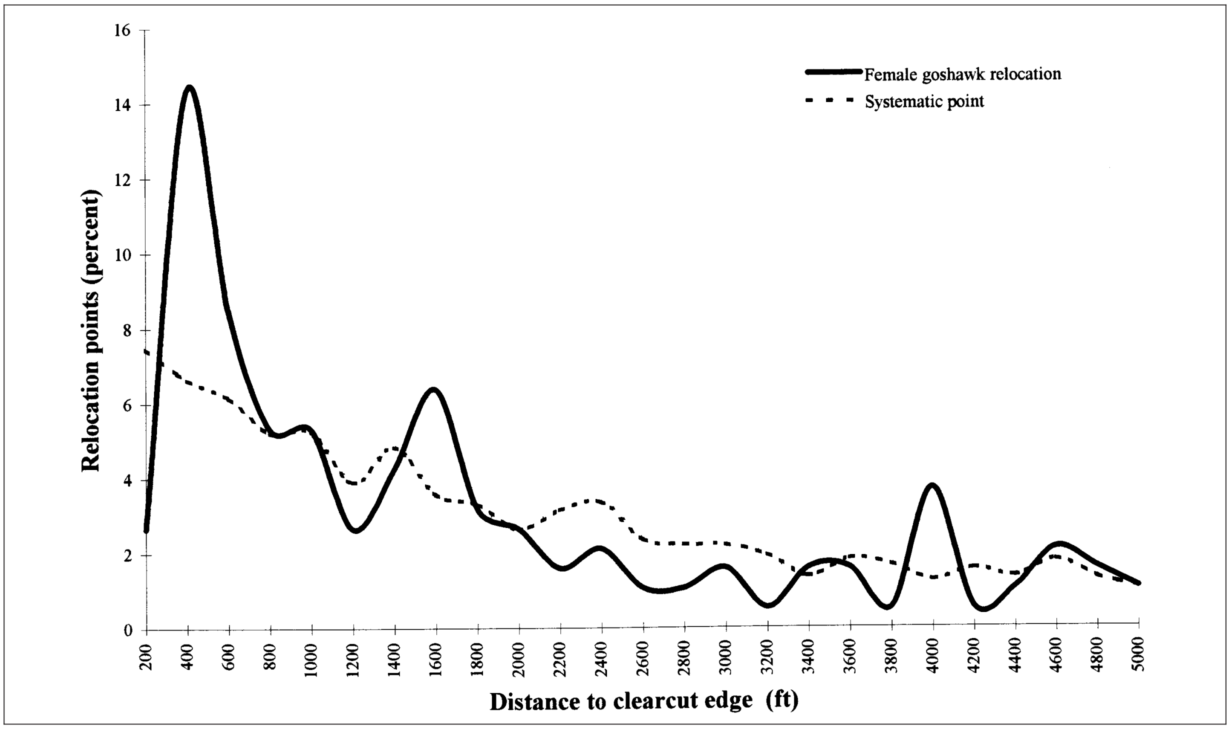

Figure 3—Distance to clearcut edge of breeding season relocations of female goshawks and systematic points within the goshawk minimum convex polygon.

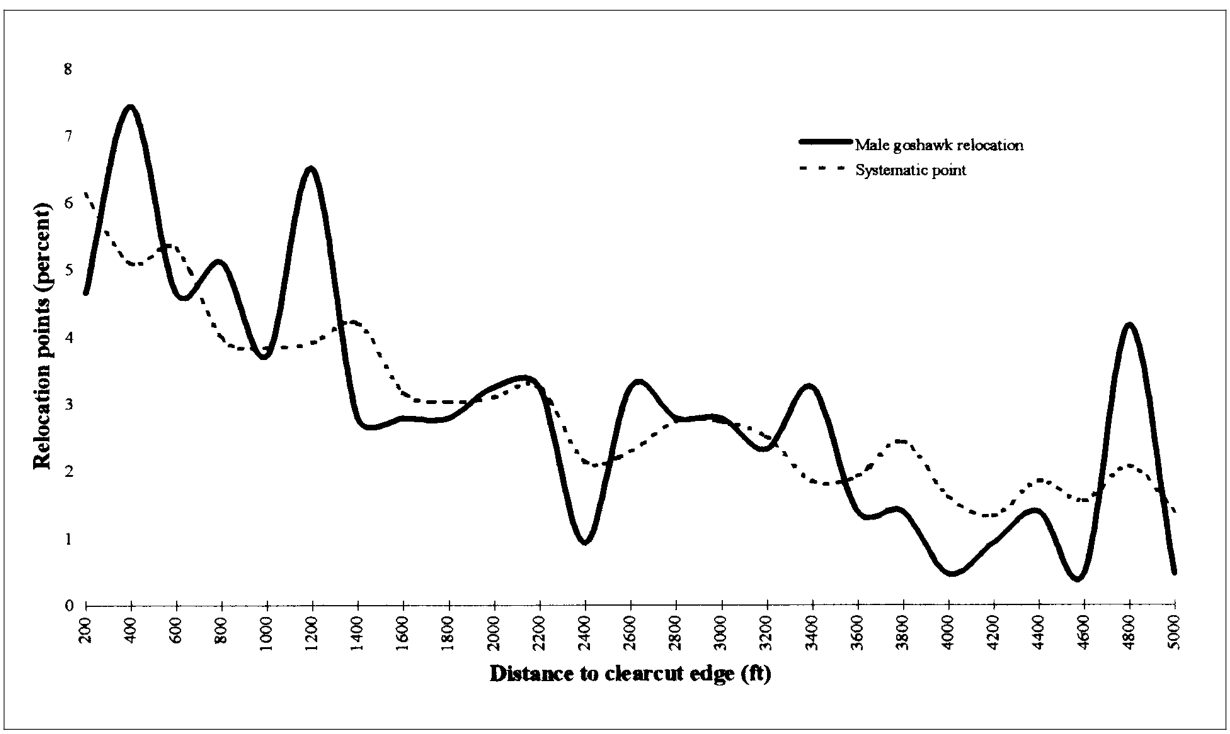

Figure 4—Distance to clearcut edge of breeding season relocations of male goshawks and systematic points within the goshawk minimum convex polygon.

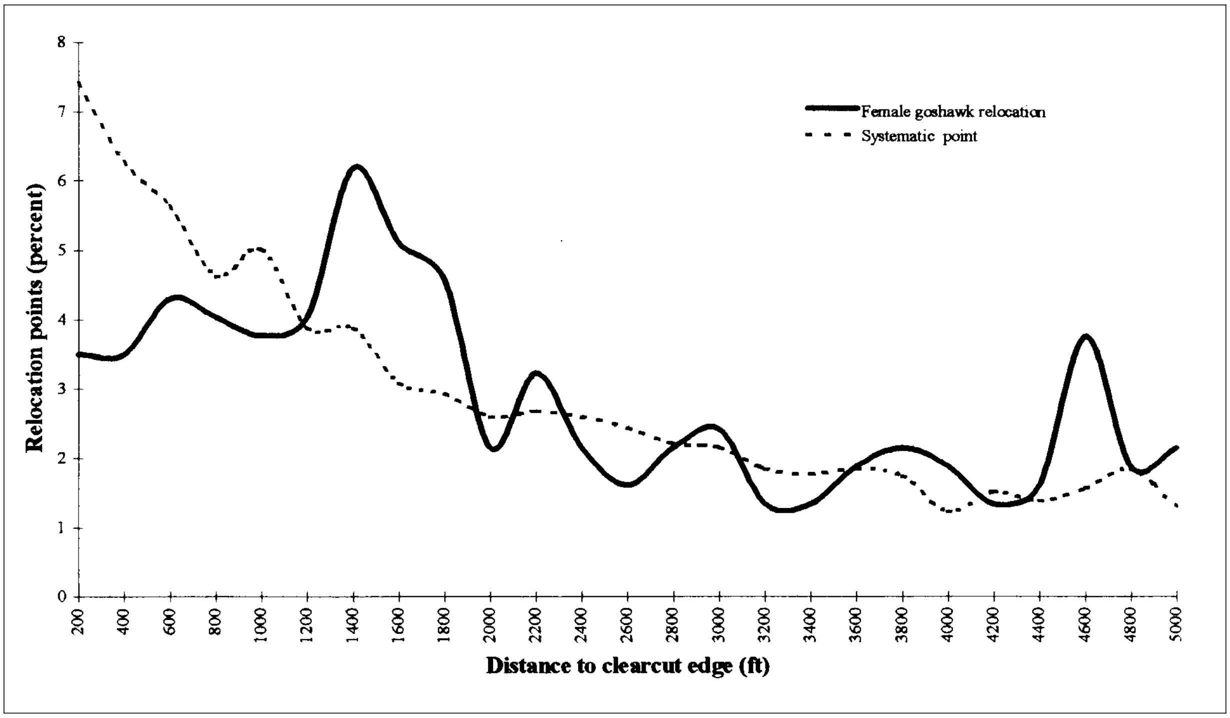

Figure 5—Distance to clearcut edge of winter relocations of female goshawks and systematic points within the goshawk minimum convex polygon.

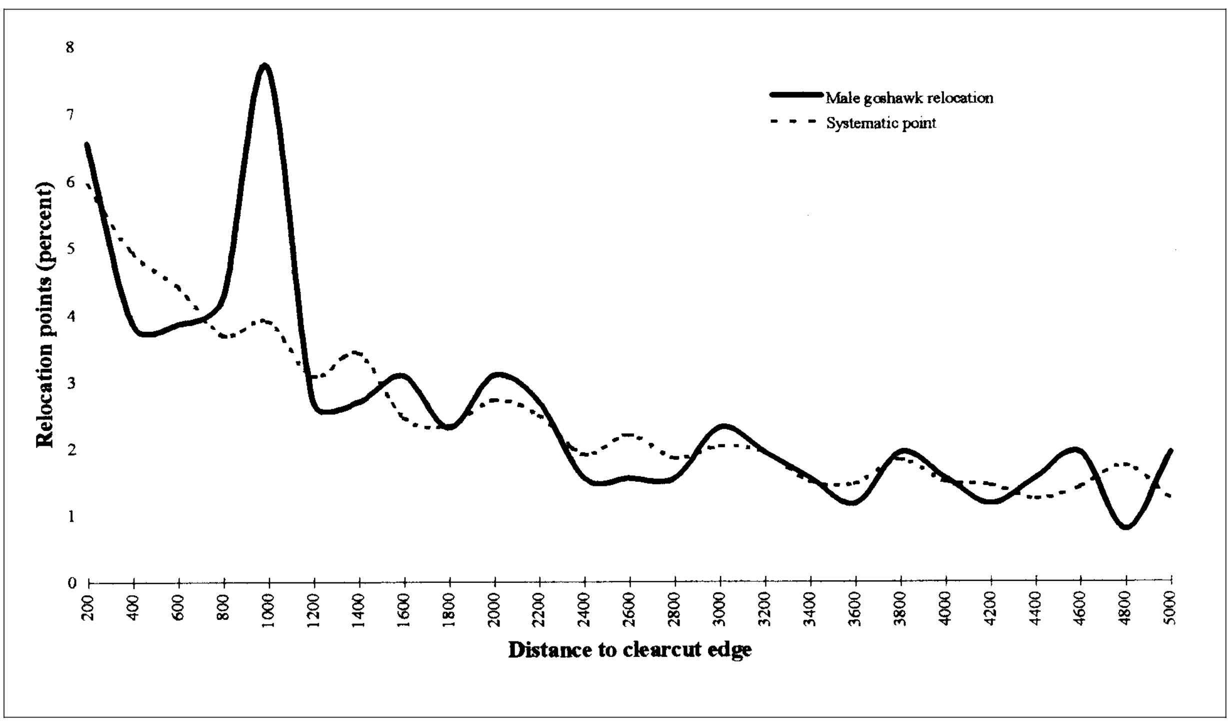

Figure 6—Distance to clearcut edge of winter relocations of male goshawks and systematic points within the goshawk minimum convex polygon.

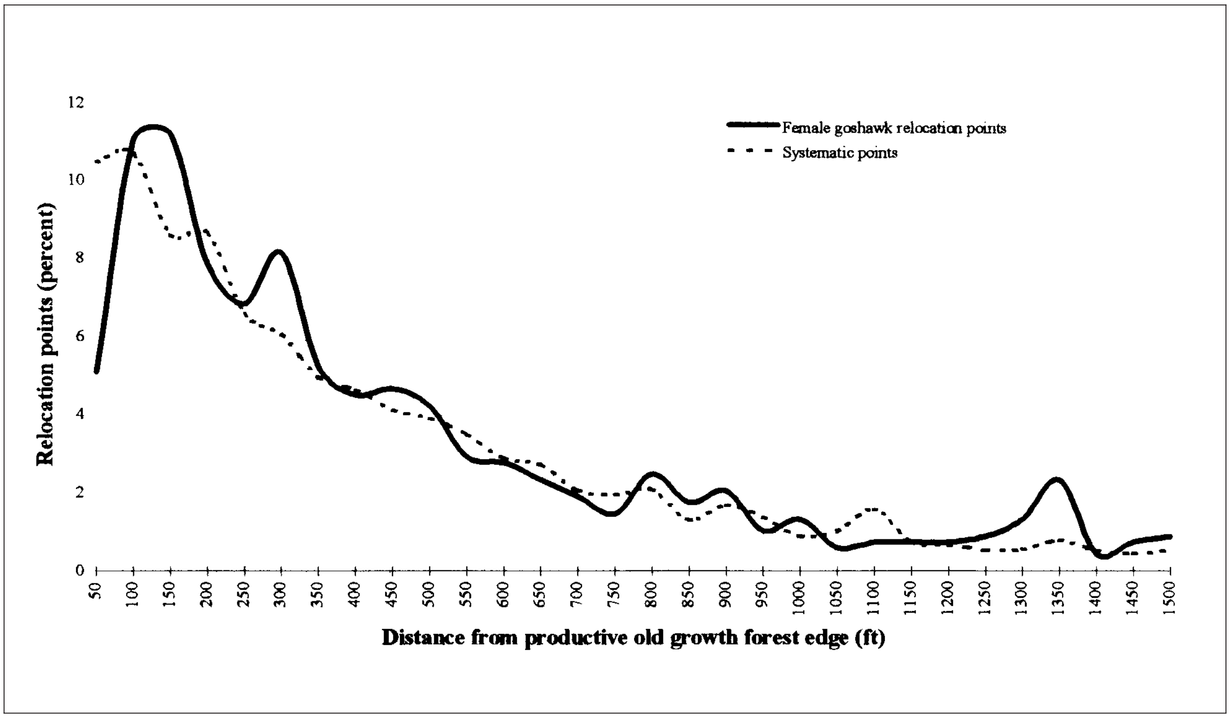

Figure 7—Distance to the edge of productive old-growth forest for female goshawk relocations throughout the year and systematic points within the goshawk minimum convex polygon.

Table 13—Mean point-to-old-growth edge distances for goshawks and systematic points within their minimum convex polygon use areas

Sex	Point type	Mean (geometric)	F (df)[a]	p[b]
		Feet		
F	Goshawk	281.2	2.12 (1,61.3)	0.151
	Systematic	241.4		
M	Goshawk	215.0	2.79 (1,43.9)	0.102
	Systematic	237.5		

[a] F statistic, df = degrees of freedom.
[b] p = probability level.

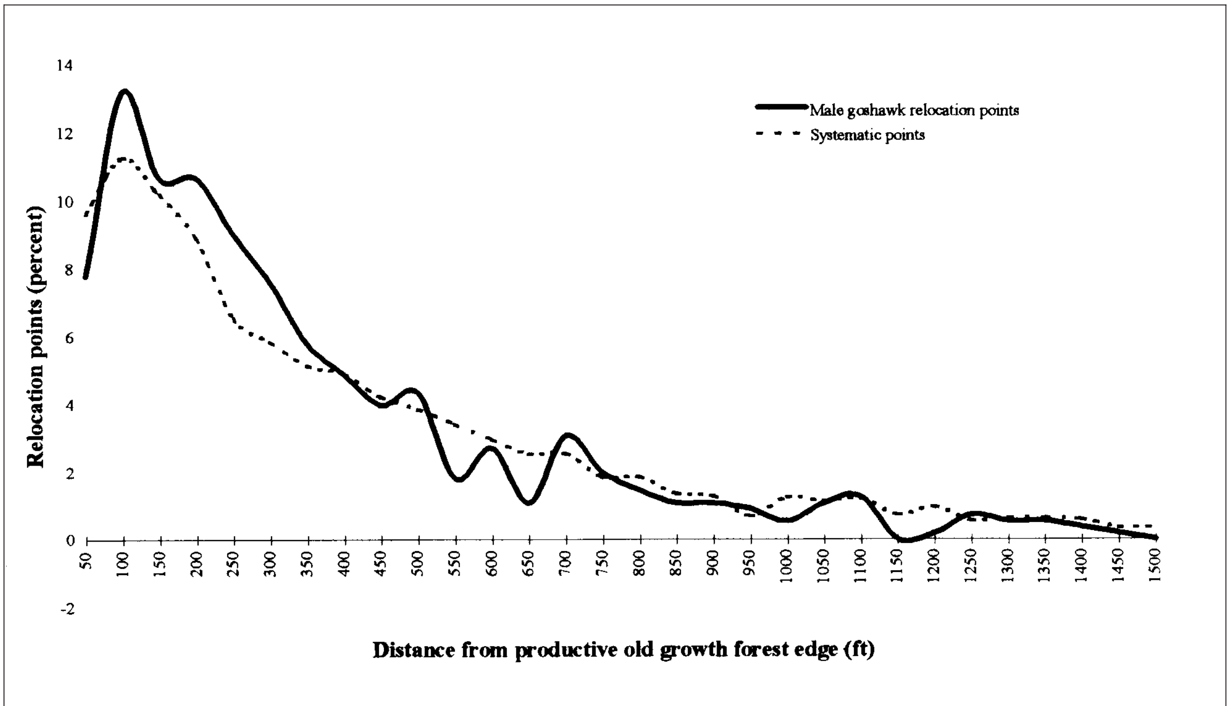

Figure 8—Distance to the edge of productive old-growth forest of male goshawk relocations throughout the year and systematic points within the goshawk minimum convex polygon.

Table 14—Relative use and availability of elevation classes within male and female goshawk minimum convex polygon (MCP) use areas

		Male				Female		
Elevation class	No.[a]	Percent use	Percent available	Test[b]	No.[a]	Percent use	Percent available	Test[b]
Feet		*Mean (SD)*[c]	*Mean (SD)*[c]			*Mean (SD)*[c]	*Mean (SD)*[c]	
0-500	26	40.3 (30.9)	41.2 (26.1)	a b	25	57.3 (32.2)	39.9 (26.6)	a
501-800	26	13.5 (8.9)	11.5 (5.7)	a	25	17.4 (19.2)	14.0 (9.1)	b
801-1200	26	13.4 (8.8)	13.0 (5.8)	a b	25	12.3 (14.2)	14.1 (6.4)	b c
1201-1500	26	7.4 (6.0)	8.2 (4.2)	b	25	4.4 6.1)	9.1 (5.3)	d
1501-2000	26	12.9 (10.4)	11.4 (8.0)	a b	25	4.5 (7.0)	13.2 (10.3)	d
>2000	26	12.6 (16.1)	14.8 (16.3)	a b	25	4.1 (6.0)	9.7 (10.6)	c d

[a] No. = number of goshawk MCP use area polygons included in the anlaysis.
[b] Classes with the same letter do not differ significantly (P > 0.05).
[c] Mean (SD) = mean percent (standard deviation).

Table 15—Relative use and availability of 4 slope classes within goshawk minimum convex polygon (MCP) use areas

Slope class	No.[a]	Percent use	Percent available	Test[b]
Percent		*Mean (SD)*[c]	*Mean (SD)*[c]	
0-35	58	70.3 (24.9)	65.1 (20.6)	a b
36-55	58	20.3 (16.6)	30.2 (16.4)	b c
56-75	58	7.1 (8.9)	4.6 (5.1)	a b
>75	58	2.3 (5.0)	0.1 (0.3)	a

[a] No. = number of goshawk MCP use area polygons included in the anlaysis.
[b] Classes with the same letter do not differ significantly (P > 0.05).
[c] Mean (SD) = mean percent (standard deviation).

Elevation—Most goshawk relocations occurred in lower elevations. Nearly 54 percent of male and 75 percent of female relocations occurred below 800 feet in elevation (table 14), but use of each elevation interval by each sex closely approximated the relative availability. Relative use of elevation intervals differed between sexes (P = 0.047). Females had a stronger pattern of selection for lower elevation classes than did males (table 14). Males generally used all elevation classes relative to availability, possibly due to extensive foraging movements necessary to supply food during the nesting period to nestlings and the adult female. There was no seasonal effect (breeding versus nonbreeding) among females (P = 0.9461) or males (P = 0.5110).

Slope—Most relocation points (70 percent) were on slopes of less than 35 percent (table 15), and use of this slope class was not different relative to availability from the 0- to 35- and 56- to 75-percent classes. The three more gentle slope classes were not significantly different in use compared to availability among the classes. The association with gentle slopes could be related to the goshawk's association with productive old-growth forests. Steeper slopes often have thinner soils and are subject to avalanches, resulting in many stands of smaller, scrubby trees that may be classified as unproductive scrub forest in the GIS. There was no seasonal (breeding vs nonbreeding) effect (P = 0.3811) or sex effect (P = 0.7013). Few relocations were obtained on slopes over 75 percent (2.3 percent), yet this slope class is a relatively rare feature across the landscape and represents less than 1 percent of goshawk use areas.

Aspect—Goshawk use relative to availability of aspects classes within their use areas differed (MANOVA P < 0.0001); east was selected over north and south but not west. Level terrain was the least used aspect (1.8 percent) and selected less (P < 0.05) than all other categories (table 16). Level terrain is generally characterized by poorly drained and deep organic soils with generally lower forest site productivity (see "The Forest Ecosystem and Its Management" above). Eastern exposures had the greatest absolute use (28 percent), but the overall differences among the four cardinal directions were relatively minor. Thus, while differences in aspect use could be detected statistically, the biological significance remains uncertain given the small magnitude of difference in use among all aspects (e.g., all within 7 percent).

Table 16—Relative use and availability of aspects within goshawk minimum convex polygon (MCP) use areas

Aspect	No.[a]	Percent use	Percent available	Test[b]
		Mean (SD)[c]	*Mean (SD)*[c]	
East	59	28.4 (15.1)	25.7 (8.5)	a
South	59	21.2 (15.7)	22.5 (9.1)	b
West	59	26.6 (16.0)	24.7 (7.4)	a b
North	59	22.2 (14.8)	24.4 (9.4)	b
Level	59	1.8 (3.3)	2.8 (4.4)	c

[a] No. = number of goshawk MCP use area polygons included in the anlaysis.
[b] Classes with the same letter do not differ significantly (P > 0.05).
[c] Mean (SD) = mean percent (standard deviation).

Distance to beach—We further examined the relation between goshawk habitat use and the beach fringe zone because use of these areas by goshawks generally exceeded the availability of this landscape region (tables 10, 11). Mean point-to-beach distances were compared between goshawk telemetry relocations and systematically located points within the goshawks MCP use area. Only goshawks with beach in their MCP were included in this analysis. Means were compared by using a mixed-factor analysis of variance appropriate for unequal sample sizes (SAS Type III; Milliken and Johnson 1984). In the analysis, point type (location vs systematic), season (breeding vs nonbreeding), and sex were fixed effects, and individual goshawks were random effects with points nested within goshawk ranges. Because of unequal sample sizes, sums-of-squares and degrees-of-freedom were adjusted by using Satterthwaite's method before conducting tests (Milliken and Johnson 1984). Point-to-beach data were analyzed untransformed and, because of a skewed data set, transformed to natural logarithms.

Results of the analyses for transformed and untransformed data were comparable; only those for the original data are presented. Point-to-beach distances did not differ by season or any interaction terms involving season ($p>0.10$). Point-to-beach distances differed by point type ($F_{1,42.8}=5.40$, $p=0.025$), and there was a type-by-sex interaction ($F_{1,42.7}=5.50$, $p=0.024$) indicating that male and female goshawks were not equally distant from the beach in relation to systematic points in their home ranges. There also were strong individual patterns within the sex classes ($p<0.001$). In separate analyses for each sex, relocations of female goshawks were closer to the

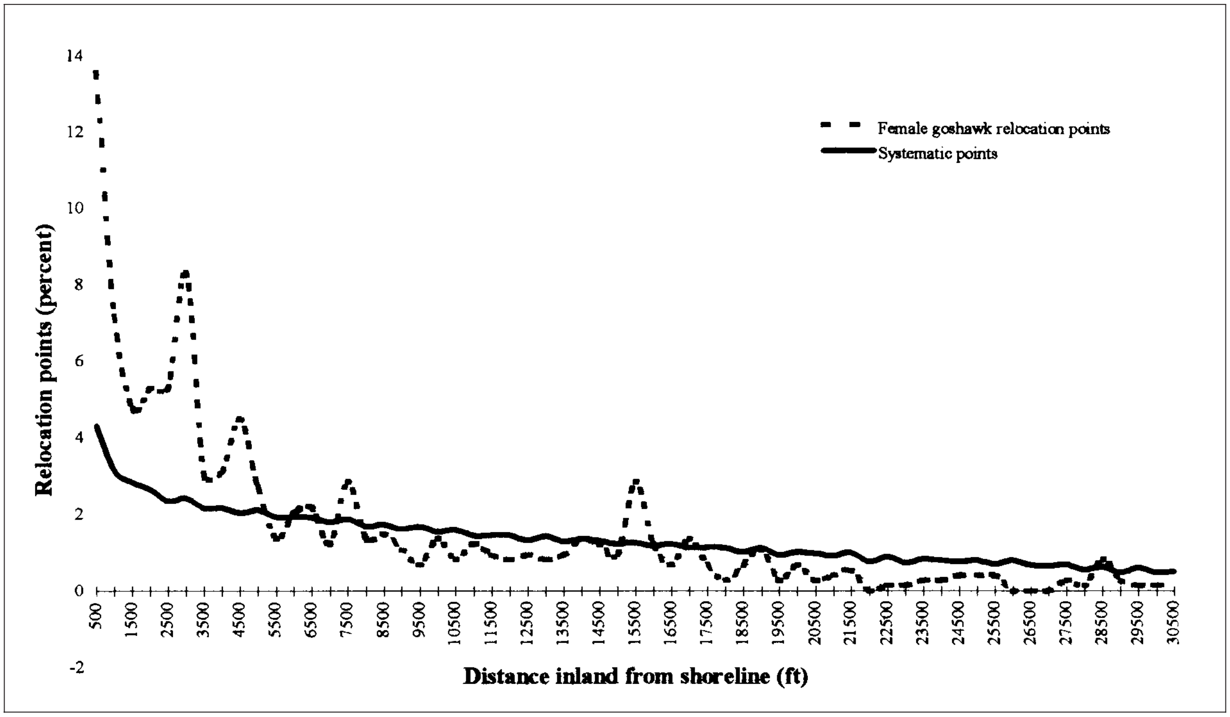

Figure 9—Distance inland from the shoreline for female goshawk relocations throughout the year and for systematic points within the goshawk minimum convex polygon.

beach than were systematic points ($F_{1,22.3}$=6.910, p=0.015) (fig. 9) but there was no difference for males ($F_{1,24.1}$=0.001, p=0.980) (fig. 10) (table 17). Nearly 21 percent of all female relocations and 18 percent of all male goshawk relocations throughout the year occurred within the first 1000 feet from the shoreline. This ecological interface between the marine and terrestrial environment likely supports a greater diversity or abundance of goshawk prey species.

Nest Area Habitat Associations

For birds of prey, nesting areas often differ from the surrounding landscape and are not randomly placed even within otherwise suitable habitat (Newton 1979, Janes 1985). The nesting habitat associations of forest hawks (*Accipitridae* spp.) are difficult to understand because these species have broad distributions and are capable of building nests in many types of forest situations, and their selection of certain nest areas is less obvious. Nest site habitat selection by forest hawks may take place at various scales, from the selection of a tree that has the proper limb geometry for constructing a nest, to the selection of a watershed that provides suitable foraging habitat and adequate prey. Many studies have evaluated the nesting habitat of northern goshawks at the scale of the nest tree and adjacent habitat (e.g., 1 to 20 acres).

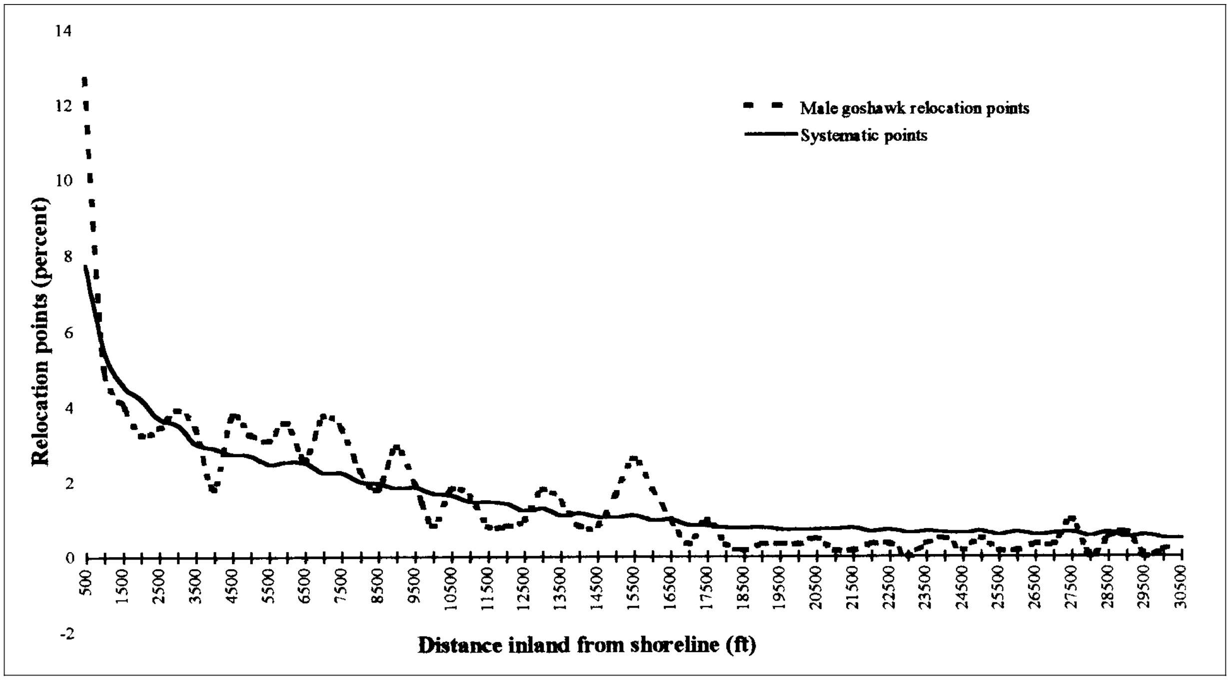

Figure 10—Distance inland from the shoreline for male goshawk relocations throughout the year and for systematic points within the goshawk minimum convex polygon.

Table 17—Mean point-to-beach distances (in feet) for goshawks and systematic points within their minimum convex polygon use area

Sex	Point type	Mean	Standard deviation
		– – – – – – *Feet*	– – – – – –
F	Goshawk	7056	7819
	Systematic	9679	8733
M	Goshawk	8009	7994
	Systematic	8154	7643

Our objective was to determine whether goshawks in southeast Alaska select specific forest stands or habitat cover types for nesting that differ from nearby forested habitats. Goshawk nesting habitat was examined at two scales, 30 and 160 acres surrounding the nest tree, to evaluate whether habitat cover types and location relative to landscape features differed from other nearby forested habitats. Habitat attributes at known goshawk nest locations from southeast Alaska were measured within a 30- and 160-acre plot centered on the nest by analyzing color and black-and-white aerial photographs at scales ranging from 1:15,000 to 1:22,000. A random plot paired with the nest tree plot was selected by moving, in a randomly selected cardinal direction, ~4.5 inches on the aerial photograph from the center of each nest plot. All random points were centered in productive old-growth forest. Variables (tables 18 and 19) were measured by an experienced aerial photograph interpreter who had no prior knowledge of goshawk nests or nesting habitat. Forest stand

Table 18—Habitat cover type of areas surrounding 39 goshawk nest sites[a] and paired random plots as determined by analysis of aerial photographs, Tongass NF

	Nest sites			Random sites			
Variable[b]	Mean	SD[c]	Range	Mean	SD[c]	Range	P-value[d]
	– – – – – – – – Acres – – – – – – – –			– – – – – – – Acres – – – – – – –			
30-acre plots:							
Nonforest	0.70	1.10	0-4.3	2.50	3.8	0-14.0	0.002
Forest	29.30	1.10	25.7-30.0	27.10	4.1	16.0-30.0	0.001
Productive forest	26.10	4.50	13.6-30.0	23.40	6.9	5.8-30.0	0.006
Scrub forest	3.50	4.20	0-16.4	3.70	5.8	0-24.2	0.659
Riparian	1.50	3.10	0-13.7	1.60	2.6	0-8.8	0.833
Beach1	0.02	0.13	0-0.8	0.46	2.6	0-16.0	0.285
Fresh water	0	—	—	0.14	0.7	0-3.9	0.180
Salt water	0	—	—	0.20	1.1	0-7.1	0.180
160-acre plots:		—	—				
Nonforest	7.00	8.90	0-39.9	14.70	16.0	0-58.1	0.010
Forest	149.40	11.60	104.6-160.0	141.30	19.7	82-160.0	0.108
Productive forest	128.10	27.50	47.9-160.0	119.40	38.0	10-160.0	0.192
Scrub forest	21.40	24.80	0-104.5	20.40	27.1	0-119.1	0.827
Riparian	10.40	9.40	0-36.1	10.40	10.1	0-50.4	0.777
Beach1	4.00	11.20	0-155.4	3.20	9.7	0-44.7	0.779
Fresh water	1.20	3.60	0-14.2	1.60	7.6	0-44.2	0.753
Salt water	2.40	7.40	0-29.6	2.40	10.1	0-58.8	0.866

[a] The 39 nest sites occur in 29 nesting areas.
[b] Habitat cover types are further described in table 7.
[c] SD = standard deviation.
[d] P-value based on Wilcoxon matched-pairs signed-ranks test.

openings <3 acres were not counted in the forest cover typing because most Forest Service timber typing does not consider small openings. Most clearcuts were considered as nonforest land except where trees were large and well established (about 30 years of age). Depending on the scale of the photo imagery, from seven to nine subplots were chosen in the 30-acre plot to estimate canopy structure, canopy closure, and species composition. Canopy or crown closure was determined by comparing photo observations with crown density scales graduated in 10-percent classes and interpolated to the nearest 5 percent. Species composition was expressed as a percentage of hemlock. Canopy structure was characterized as being either single story or multistory. Canopy texture was estimated as coarse, medium, or fine. Riparian areas were estimated by applying a 300-foot buffer on class 1 (anadromous fish) and class 2 (resident fish only) streams to both stream banks and calculating the area by using a dot grid. Only perennial streams readily visible on aerial photos were included in this analysis. Wilcoxon-matched pairs sign tests and accompanying *Z*-statistics and *P*-values were used to evaluate differences in distributions between random samples and goshawk nest sites. Additional methodological details are provided in ADF&G (1996).

Table 19—Lengths of ecotones and linear features within 39 goshawk nest sites[a] and paired random plots as determined by analysis of aerial photographs, Tongass NF

	Nest sites			Random sites			
Variable length	Mean	SD[b]	Range	Mean	SD[b]	Range	P-value[c]
	– – – – – – – Feet – – – – – – –			*– – – – – – – Feet – – – – – – –*			
30-acre plots:							
Forest-nonforest edge	400	884	0-4,488	667	872	0-2,957	0.014
Freshwater shoreline	45	162	0-762	39	169	0-760	0.715
Saltwater shoreline	29	12	0-75	36	179	0-1,080	0.285
Stream	339	680	0-2,976	341	556	0-1,920	0.909
Road	53	188	0-794	53	242	0-1,361	0.893
Trail	48	216	0-1,188	39	183	0-1,056	0.593
160-acre plots:							
Forest-nonforest edge	2,674	2,957	0-11,672	3,687	2,670	0-10,428	0.026
Freshwater shoreline	417	1,305	0-5,143	177	634	0-2,661	0.249
Saltwater shoreline	305	960	0-4,338	289	880	0-4,139	0.866
Stream	2,336	2,017	0-7,855	2,066	1,660	0-6,336	0.913
Road	359	876	0-2,956	228	793	0-3,770	0.575
Trail	245	718	0-2,772	229	751	0-2,945	0.892

[a] The 39 nest sites occur in 29 nesting areas.
[b] SD = standard deviation.
[c] P-value based on Wilcoxon matched-pairs signed-ranks test.

The analyses included 39 goshawk nests: 14 in the Chatham, 16 in the Stikine, and 9 in the Ketchikan Administrative Areas of the Tongass NF. Eighty-seven percent of the 39 goshawk nest trees were in productive old-growth forest stands, 2 nests occurring in one nesting area were in mature sawtimber, and 3 nests at two nesting areas were in forest stands with a mixture of productive old-growth and second-growth trees. Goshawk nests in southeast Alaska were mainly identified as a result of searches associated with timber management planning. Of 25 nests (in 22 nest areas) reported by Titus et al. (1994), 83 percent occurred in productive old-growth forest and 17 percent occurred in mature sawtimber, which was over 90 years old and contained some residual old-growth forest structure.

Habitat cover types—Forest cover (98 and 87 percent) and to a lesser extent productive old-growth forest (93 and 80 percent), dominated the area in the 30- and 160-acre plots surrounding goshawk nests, respectively (table 18). There was less variation in the amount of forested area in nest plots of both 30 and 160 acres than in random plots, thereby indicating that few large openings occurred near goshawk nests. Beach and riparian cover types occurred in relatively small amounts in both 30-acre and 160-acre plots (table 18).

There was a greater amount (7.3 percent) of forest area associated with goshawk nest plots than with 30-acre random plots centered on forest (table 18). Mean difference in forested area between nest site versus random plots was 2.2 acres. There also was less variability in the amount of forest area surrounding goshawk nest areas than forested random samples. No goshawk nest site had < 25 acres of forest in the 30-acre plot. The amount of productive old-growth forest land area in the 30-acre plot was significantly higher (2.7 acres or 9 percent) at goshawk nests than a nearby random sample centered on forest (table 18).

At the 160-acre scale, there was no difference in the amount of forest area surrounding goshawk nests versus nearby random samples (table 18). The lack of statistical differences found in the sampling of the 160-acre plots may have been due to a decrease in power associated with higher variability. For example, the coefficient of variation (CV) of area of forest lands for the nest site data increased from 3.7 to 7.8 percent between the 30-acre and 160-acre plots.

Habitat cover types examined may not be directly comparable to other goshawk nest site habitat studies. Those studies used direct measurements of trees and forest stands rather than land cover attributes encompassing a larger area surrounding the nest (e.g., Moore and Henny 1983, Hayward and Escano 1989). In addition, most of these studies did not sample available habitat or make inferences about habitat selection. Falk (1990) used aerial photography to evaluate nest site habitat selection by goshawks within paired 200-acre nest site random plots. She found that goshawks avoided forest openings and that nests were associated with unbroken forest tracts compared with availability. Results from southeast Alaska support the hypothesis that goshawks nest in areas containing more forest when compared with the landscape in general. Yet some Tongass NF goshawk nests are near natural forest openings, perhaps the result of the heterogeneous and patchy forest stands that occur in some portions of the Forest.

Land cover border lengths—Border lengths were considered as indices of cover type heterogeneity. At both the 30- and 160-acre plots, less forest to nonforest edge was measured at goshawk nesting areas compared to random samples (table 19). This likely occurred because of the lack of other habitat cover types at goshawk nest plots. Hence, low cover type heterogeneity was found at goshawk nests compared with randomly selected forested areas. There was no difference in other ecotone variables measured between goshawk nests and randomly selected forest plots (table 19).

Distances to land cover features—No differences were found in the distance from the goshawk nest or plot center to land cover features (e.g., shoreline, roads, trails, and streams) between goshawk nests and random samples (table 20). These results are in contrast to Bosakowski and Speiser (1994) and Falk (1990), who found goshawks nesting farther from forest openings, paved roads, and human habitation than from random samples of forested habitat.

Table 20—Distances of goshawk nests or random plot centers to the nearest land cover feature as determined by analysis of aerial photographs, Tongass NF

	Nest site				Random site				
Feature	No.[a]	Mean	SD[b]	Range	No.[a]	Mean	SD[b]	Range	P-value[c]
		– – – – – – *Feet* – – – – – –				– – – – – – *Feet* – – – – – –			
Forest-nonforest edge	39	1,177	1,190	62-5,984	38	887	1,215	56-7,480	0.230
Freshwater shoreline	30	5,902	4,269	479-16,368	30	6,047	4,389	302-17,952	0.705
Saltwater shoreline	39	11,066	4,269	600-29,040	36	11,258	8,586	352-29,040	0.480
Stream	39	917	528	150-2,426	39	984	798	54-3,184	0.965
Road	28	5,850	7,324	227-36,960	29	5,781	4,247	0-17,952	0.118
Trail	9	5,885	11,824	264-36,960	11	1,932	2,355	0-7,920	0.398
Forest opening	29	4,510	3,143	1161-11,300	28	5,017	4,175	0-13,800	0.409

[a] No. = number of nest sites included in the of the feature.
[b] SD = standard deviation.
[c] P-value based on Wilcoxon matched-pairs signed-ranks test.

Canopy cover and forest composition—Percentage of canopy closure was higher (P = 0.06, Wilcoxon matched-pairs sign-ranked test) in the 30-acre area surrounding goshawk nests (49.6 percent) than in randomly selected forest areas (42.9 percent). Although the canopy cover difference was only 6.7 percent, the analysis was a narrow comparison of forest canopy at and away from goshawk nests. We would not expect great differences in forest canopy cover between goshawk nesting areas and random forested samples unless goshawks were selecting rare features of the habitat that did not occur elsewhere. There is high variability in forested canopy cover across the Tongass NF with goshawks using areas with slightly more cover. The mean percentage of canopy cover value of 50 percent in southeast Alaska was lower than that reported in the literature for this species, which generally ranges from 60 to 95 percent (see “Review of Northern Goshawk Ecology in North America”). In nearly all other studies, however, canopy cover was determined differently from how we estimated it in our study, which evaluated canopy cover across 30 acres and used subsamples and aerial photography. Selection for dense canopy may be more important in warmer climates where denser canopies may provide cooler microclimates for nesting goshawks (Hall 1984, Crocker-Bedford and Chaney 1988, Reynolds et al. 1992).

There was significantly (P = 0.03, Wilcoxon matched-pairs signed-ranks test) more hemlock at goshawk nest sites (81 percent) than paired random sites (75 percent). The difference may have come from goshawk nesting areas being associated with productive old-growth forest and hemlock-spruce cover types, whereas some random samples may have contained a greater component of cedar or spruce only.

Forest stands with multistory canopies occurred in 89 percent of the goshawk nest sites compared to only 84 percent of the random samples. Only 1 of 39 goshawk nesting areas had the majority of nine subsamples defined as a single-canopy layer, thereby supporting the hypothesis that goshawks generally nest in stands with complex structure associated with multiple canopy layers.

Based on the aerial photograph interpretations, 30-acre areas surrounding goshawk nests were, on average, composed of 56 percent medium-grained canopy texture, 24 percent fine-grained canopy texture, 19 percent coarse-grained canopy texture, and 1 percent nonforested. Comparable areas surrounding randomly selected points were composed of 49 percent medium-grained canopy texture, 25 percent fine-grained canopy texture, 17 percent coarse-grained canopy texture, and 9 percent nonforest. Canopy texture may be associated with tree size and canopy heterogeneity. Coarse-grained canopies contain large trees and higher volume old-growth, and medium- and fine-grained canopy textures are either lower volume or younger even-aged stands. In relation to the variation among sample plots, differences between nest plots and random plots were small. The CVs for the average percentage of medium-grained canopy texture was 31 percent for nest plots and 45 percent for random plots.

Only minor differences were detected between goshawk nest sites and random 30- and 160-acre forested sites. These differences were not insignificant, however, given that random sites were constrained to productive old-growth forest. Thus, even when comparing two productive old-growth forest stands, we concluded that goshawks are selecting nesting habitat with specific features. Goshawks select nest sites with a greater proportion of forest cover and productive old-growth forest in the immediate 30-acre nesting area compared to random forest areas and accordingly the forest-nonforest edge was smaller in nest areas. Nesting habitat was generally far from the shoreline (an average of nearly 2 miles), lakes (1 mile), and streams (900 feet).

Landscape Patterns in Vegetation Cover Around Known Goshawk Nests

Field data on habitat use by goshawks in southeast Alaska fit into several broad categories. Point locations of radio-marked birds and nest locations represent two forms of data. Radio telemetry provides an opportunity to estimate the pattern of habitat use by goshawks around their nests and in wintering areas. Logistical problems in obtaining an adequate sample and problems in translating the point samples to estimates of utilization distributions constrain the analyses, however. In contrast, nesting habitat can be identified without the aid of radio telemetry, and the sample of nest sites represents more individual birds than can be obtained to estimate foraging habitat use.

In the case of known nest locations, the functional use of the site is apparent; goshawks produce and rear their young at the site. Choice of the nest site, at scale of the stand, may be driven by features influencing the probability of predation, the thermal environment for the incubating female, the thermal environment for the young, the ease of access to the nest for prey delivery, and the ease of relocating the nest by the adults (e.g., when the male makes prey deliveries). The choice of nest sites also may be driven by characteristics of the surrounding area at a variety of scales (e.g., Sherry and Holmes 1985).

The pattern of habitat surrounding the nest at the scale of hundreds to thousands of acres also may influence the likelihood of predation for adults and young, the thermal environment of the nest, and the availability of prey for the adults and young. Kennedy et al. (1994) drew attention to the potential influence of a large postfledging area (PFA) around the nest on the success of nesting goshawks. Reynolds et al. (1992:13-14) identified a PFA of 300 to 600 acres around the active nest as an important consideration in managing goshawks in the Southwestern United States. Reynolds et al. (1992) implied that forest conditions in the PFA influence goshawk nesting success.

The importance of a 300- to 600-acre area around the nest for goshawks in southeast Alaska is largely undetermined. We therefore examined whether goshawk nests occurred in sites with unique vegetation characteristics at a scale similar to the PFA (Kennedy et al. 1994). Specifically, we tested the null hypothesis that composition of cover types in a circular area corresponding to an area equivalent to the PFA was similar to a random 600-acre circle or to a larger, concentric circle corresponding approximately to the area of the median goshawk MCP for southeast Alaska (10,000 acres). This comparison used a sample of known goshawk nest sites in southeast Alaska to test whether goshawk nests occur in particular 600-acre portions of the landscape relative to the land available within a 10,000-acre circle around the nest.

Sample of nest sites—A total of 34 goshawk nest areas located in southeast Alaska were included in this analysis.[9] Some areas contained several alternate nests, but the analysis was centered over the most recently active nest. Nests located on non-Federal lands (n = 3) with incomplete cover type resource inventories were not included in the analysis. These 34 nest sites represent an ad hoc sample of nest locations from southeast Alaska. Biologists located nests through various methods but did not use a formal sampling scheme to extract a sample from a definable sampling frame or parent population. Many sites were located during nest searches and management activities associated with timber sales. Some nest locations came from reports of goshawk defense behavior provided by persons using recreational trails near centers of human activity. Still other locations resulted from surveys targeted to search for goshawk nests, or from locations of radio-marked goshawks captured the previous year at a different nest site (Titus et al. 1994).

Habitat characterization—Habitat around goshawk nests was characterized by the proportion of the seven vegetation habitat cover types (see table 7) in the vicinity based on the Tongass NF GIS database. Based on this classification, the number of acres of each cover type was determined for 600- and 10,000-acre circular plots centered around each nest. These two geographic scales are referred to as the 600-acre fledging area and the 10,000-acre use area. Because salt water occurs near some goshawk nests, the proportion of the environment occupied by each cover type was determined by dividing the acreage of the habitat cover type by the area of the circular plot, minus salt water. The Tongass GIS database uses a minimum mapping unit (pixel) of 20 acres, which limits the resolution of the analysis. The 600-acre area around the nest chosen as the focus for this analysis corresponds to the PFA and represents a scale effectively characterized by the GIS data.

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[9] Slight differences in nest area samples for different analyses resulted from minor changes in criteria (see table 4).

Table 21—Composition of habitat cover types in 600-acre circles as an estimate of use relative to the composition of cover types in 10,000-acre circles as an estimate of habitat availability[a]

		600-acre circle			10,000-acre circle			
Habitat cover type[b]	No.[c]	Mean	SD[d]	Range	Mean	SD[d]	Range	Test[e]
Very high/high productivity	34	24.0	19.2	0-82.7	21.8	13.4	3.8-58.9	a b
Moderate productivity	34	24.3	15.0	3.1-66.7	19.9	7.5	8.4-36.5	a
Low productivity	34	10.7	11.3	0-41.4	8.5	6.5	0-23.6	b
Scrub forest	34	27.3	17.9	0-65.5	30.0	16.7	6.6-68.5	a b
Mature sawtimber	34	2.7	8.3	0-36.3	0.9	2.4	0-12.4	a b
Clearcut	34	6.6	11.2	0-53.2	9.9	13.2	0-53.3	c
Nonforest	34	4.4	8.0	0-30.0	9.0	12.0	0.1-48.5	c

[a] Circles are centered on nests.
[b] Habitat cover types are further described in table 7.
[c] No. = number of nest sites included in the analysis.
[d] SD = standard deviation.
[e] Cover types with the same letters do not differ significantly ($P > 0.05$) in a test of use (600-acre circle) vs. availability (10,000-acre circle).

The composition of seven cover types (very high/high productivity, moderate productivity, low productivity, scrub forest, mature sawtimber, clearcut, nonforest) was compared between 600-acre circles surrounding a goshawk nest and a randomly located 600-acre circle by using the composition analysis method of Aebischer et al. (1993) described earlier. Similar analyses compared the composition of the 600-acre nest circle to the 10,000-acre use-area circle, also centered on the nest (table 21).

There were no differences ($P=0.631$) in the percentages of the seven habitat types in the 600-acre nest area and random 600-acre circles. Habitat cover types within the 600 acres around goshawk nests did differ, however, from cover types within the 10,000-acre circle centered over the same nests ($P < 0.001$). There was a greater amount of VH/H, M, and L cover types in the 600-acre circle relative to the larger 10,000-acre scale, which suggests a nonrandom selection for greater amounts of very high, high, and moderately productive old-growth forests in the immediate vicinity of the nest stand (table 21). There was also a relatively large component of unproductive forest in both the 600-acre nest circle (27 percent) and in the 10,000-acre circle (30 percent) (table 21) that may result from the naturally heterogeneous character of the conifer forests in southeast Alaska. The proportion of clearcut and nonforest in the 600-acre circle was less than was available in the 10,000-acre use area and were cover types avoided by goshawks (table 21). The amount of mature sawtimber in the 600-acre circle (2.7 percent) was nearly three times greater than its availability (0.9 percent) (table 21). Mature sawtimber is a relatively rare cover type, but these data suggest that it may be selected as nesting habitat cover type relative to low volume old-growth, clearcut, and nonforest cover types.

The distribution of seven habitat cover types at two geographic scales illustrates the degree of variation in habitat among goshawk nest sites. The proportion of productive old-growth forest (sum of very high + high + moderate + low) in the 600-acre circle averaged 59 percent (range 16 to 96 percent). The amount of productive old-growth in the 10,000-acre use area averaged 50 percent (range 22 to 89 percent). The proportion of clearcut ranged from 0 to 53 percent for both the 600- and 10,000-acre areas.

The magnitude of the mean difference in abundance of particular habitat cover types between 600- and 10,000-acre circles was generally small despite statistical significance. For a majority of cover types, the mean difference in abundance was less than 4 percent. These analyses demonstrate, however, that productive old-growth lands were more common near goshawk nests than in the larger use area and goshawks nest sites are not a random subsample of the landscape.

The interpretation of results must consider the characteristics of the sample used in the analyses. The goshawk nests available for analysis represent a potentially biased sample of nests relative to the entire southeast Alaska geographic area. The sample reflects the difficulty biologists encounter in locating goshawk nests, especially an unbiased sample of nests. Patterns observed in these data thus apply specifically to the particular sample obtained. The relation between patterns associated with these nests and patterns of all goshawks throughout southeast Alaska cannot be determined.

Despite the potentially biased sample, the data define the minimum degree of variation around goshawk nests in southeast Alaska. The data also illustrate patterns from a 34-nest sample in the region. As such, these analyses provide valuable insights to local conditions not available from existing literature on goshawk nesting habitat.

To test hypotheses of whether goshawk nests occur in particular landscape conditions, the nature of the test performed and the observational nature of the sample must be considered. A significant difference in habitat between the 600 acres around the nests and a larger 10,000-acre plot does not confirm that goshawks choose nests based on differences in vegetation within 600 acres of the nest, because selection of some other habitat feature correlated with vegetation cover could be involved. Conversely, failure to detect a pattern does not indicate the absence of one; the test may lack sufficient power to detect significant differences.

Goshawk Survival Rates

Survival rates of adult goshawks in southeast Alaska were estimated by using information from goshawks radio marked to study habitat use and movements (Titus et al. 1994). The ADF&G (1996) provides a detailed description of methodology and assumptions used to estimate survival rates. Annual survival rates were estimated for goshawks across southeast Alaska by using the staggered-entry Kaplan-Meier estimator (Pollock et al. 1989). Data were partitioned into monthly periods and for each goshawk; the month when a bird entered the analysis and the fate of the individual through the analysis period were determined. A total of 39 radio-marked adult goshawks were monitored during the analysis period that began in July 1992 and ended in August 1996. Data for males and females were pooled because of small sample sizes. Three possible fates were dead, survived, or censored. Goshawks were considered censored when their fate was unknown, when they lost transmitters and were subsequently recaptured and fitted with a new radio tag, or were not found for over 2 months but subsequently relocated. They were classed as survived from the time of recapture or relocation.

Table 22—Pooled monthly Kaplan-Meier survival estimates for radio-tagged goshawks, Tongass NF, 1992-96

Month	No. at risk	No. of deaths	No. censored	No. added	Survival rate[a]	Variance	Lower CL[a]	Upper CL[a]
June	28	0	0	13	1.00	0.0000	1.00	1.00
July	43	0	0	25	1.00	0.0000	1.00	1.00
August	55	0	0	2	1.00	0.0000	1.00	1.00
September	53	0	0	0	1.00	0.0000	1.00	1.00
October	46	2	2	0	0.96	0.0009	0.90	1.01
November	41	1	1	0	0.93	0.0014	0.86	1.01
December	38	0	0	1	0.93	0.0015	0.86	1.01
January	37	0	0	0	0.93	0.0016	0.86	1.01
February	37	1	1	0	0.91	0.0021	0.82	1.00
March	35	2	4	2	0.86	0.0030	0.75	0.97
April	31	5	5	1	0.72	0.0047	0.58	0.85
May	22	0	0	0	0.72	0.0066	0.56	0.88
Total	466	11	13	44				

[a] The cumulative survival probability from each June (see text).
[b] CL = 95-percent confidence limit.

Thirteen goshawks became censored, and their fates were unknown. Nine adult female goshawks and six adult male goshawks were monitored for > 12 months. On three occasions, adult goshawks became censored and disappeared during winter but were relocated the next spring. Three years of data were pooled into a 1-year period beginning in June (table 22). This increased the number of adult goshawks at risk in any given month and allowed monthly and confidence interval estimations to be made with larger sample sizes than were possible with multiyear analyses. A total of 466 “at-risk months” were available for an estimated annual survival rate of 0.72 (95-percent CI = 0.56-0.88) (fig. 11), given the 11 birds that died during the study. Our results are not readily comparable to other studies because there have been few studies of goshawk survival (DeStefano et al. 1994b).

Patterns in Habitat Use of Principal Goshawk Prey in Southeast Alaska

Habitat associations of principal prey species are important elements in understanding goshawk habitat use patterns (Reynolds et al. 1992). A list of 10 important northern goshawk prey species or species groups was developed based on data from Titus et al. (1994). Each species or species group occurred in prey remains collected at > 2 of 15 northern goshawk nests in southeast Alaska (table 23). Knowledge is limited on the importance of individual prey species to northern goshawks in southeast Alaska. Titus et al. (1994) suggest some limitations to their data:

1. The amount of a given prey species at a nest could not be determined, only its presence.

2. Prey remains were identified by gross characteristics and were not microscopically examined.

3. Prey remains of more colorful species (such as Steller’s jay, *Cyanocitta stelleri*) have a higher probability of being found and identified than the remains of drab species (for instance, murrelets–Alcidae species).

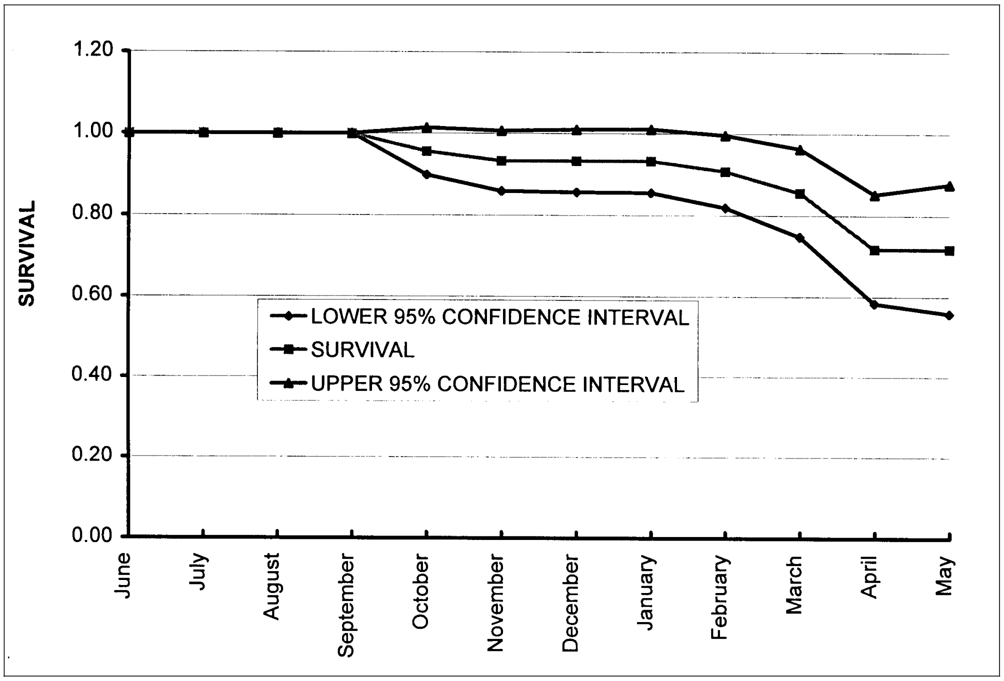

Figure 11—Pooled annual survival rates of adult goshawks, Tongass National Forest, 1992-96.

4. Prey remains were collected only at nest sites and only during the breeding season. Mammals may be underrepresented in prey remains (Boal and Mannan 1994). Furthermore, the importance of particular prey species may not be reflected in their frequency of occurrence. Comparison of prey body mass and relative abundance also may be useful for determining the relative importance of prey species (table 23).

5. Some prey items occur only on some islands and this may confound preference with the geographical availability of prey items.

Knowledge regarding the ecology of northern goshawk prey in southeast Alaska is also relatively limited. Quantified cover type associations, forest structure associations, and density estimates do not exist for most of these species. The importance of habitat edge for these species also is mostly unknown. The northwestern crow (*Corvus caurinus*) inhabits the beach zone and might be considered an edge species. Steller's jays tend to be denser along edges but also occur in interior habitats (Rosenburg and Raphael 1986). In studies outside southeast Alaska, some prey used forest interior habitat more than forest edges: sharp-shinned hawk (*Accipiter striatus*), blue grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*) (Rosenburg and Raphael 1986), and varied thrush (*Ixoreus naevius*). Other species may attain their highest densities in larger forest stands: red squirrels (*Tamiasciurus hudsonicus*) in stands > 30 acres, red breasted sapsuckers (*Sphyrapicus ruber*) in stands > 250 acres, hairy woodpeckers (*Picoides villosus*) in stands > 500 acres, and marbled murrelets in stands > 600 acres (USDA Forest Service 1991).

Table 23—Goshawk prey occurrence obtained from a sample of 15 goshawk nests

Species	Nests (15)	Body mass	Relative abundance in key habitats	
			Summer	Winter
	Percent	*Ounces*		
Steller's jay	100	4-5	Common	Uncommon
Grouse species	73	18-46	Common	Common
Varied thrush	60	3-4	Very common	Rare
Red squirrel	47	7-8	Common	Common
Woodpecker species	40	2-3	Common	Uncommon
Sharp-shinned hawk	27	3-8	Very uncommon	Absent
Alcidae species	20	5-6	Common	Common
Yellowlegs species	13	10-25	Uncommon	Absent
Ptarmigan species	13	11-25	Uncommon	Uncommon
Northwestern crow	13	11-18	Common	Common

Source: Titus et al. 1994.

Little is known about geographic variation in population density for these species within southeast Alaska. Red squirrels are not found on Prince of Wales Island or the islands west of Prince of Wales (MacDonald and Cook 1994). Although grouse are found throughout southeast Alaska, the larger blue grouse is absent from Prince of Wales Island and associated islands; the smaller spruce grouse (*Canachites canadensis*) occurs there but not on the islands to the north.

There is seasonal variation in the abundance of some prey species (table 23). Yellowlegs (*Tringa* sp.) and sharp-shinned hawks are absent or nearly absent from southeast Alaska during winter. Steller's jays, varied thrushes, and woodpeckers are common or very common during summer but rare or uncommon during winter.

All seven species or species groups, which were found at ≥ 20 percent of northern goshawk nests, primarily use forested habitats (table 24). One of the other principal prey species, the northwestern crow, inhabits mostly beach fringe habitats, especially the edge of old-growth forests. Steller's jay, grouse, varied thrush, red squirrel, and woodpeckers appear to be the most important prey species during the breeding season. Each occurred in ≥ 40 percent of the nest site prey examinations, are abundant in southeast Alaska, and are associated primarily with forested habitats (tables 23, 24). Thrushes migrate south for most of the winter, and most jays and woodpeckers appear to leave southeast Alaska (table 23); so Alcidae species, ptarmigan (*Lagopus* sp.), northwestern crow, and other species groups may become more important during winter. In general, the distribution of "H's" in table 24 (highest use of cover type) for principal prey species corresponds to productive old-growth forest, especially for the most important prey species. This distribution also is consistent with the selection for productive old-growth forests by radio-marked goshawks.

Table 24—Association of 10 goshawk prey species or species groups with 11 cover types in southeast Alaska

Species	Cover type[a b] VH	H	M	L	R	B	S	C	MS	A	N
Most important:											
Stellar's jay	M	M	M	H	H	H	H	L	M	L	M
Grouse species	H	H	H	H	H	H	M	L	M	L	M
Varied thrush	H	H	H	H	H	M	M	L	M	L	L
Red squirrel	H	H	H	H	H	H	L	L	M	L	L
Woodpecker species	H	H	H	H	H	H	L	L	L	L	L
Total "high's" (H)	4	4	4	5	5	4	1	0	0	0	0
Less important:											
Sharp-shinned hawk	H	H	H	H	H	H	M	L	H	L	L
Alcidae species	H	H	H	H	H	H	L	L	L	L	L
Yellowlegs species	L	L	L	L	L	L	M	L	L	L	H
Ptarmigan species	L	L	L	L	L	L	L	L	L	H	M
Northwestern crow	L	L	L	L	L	H	L	L	L	L	L
Total "high's" (H)	2	2	2	2	2	3	0	0	1	1	1

[a] VH = very high, H = high, M = moderate, L = low, R = riparian, B = beach, S = scrub forest, C = clearcut, MS = mature sawtimber, A = alpine, and N = nonforest. Cover types are further described in table 7.
[b] L = little or no use, M = moderate use, and H = highest use of a cover type for that species or species group.

Goshawk Relations With Other Predators

In addition to goshawks, other large raptors that occur in southeast Alaska include the peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), red-tailed hawk, and great horned owl. There are probably 100 to 200 pairs of peregrine falcons in southeast Alaska (Ambrose et al. 1988), but they occur primarily on the outer coast facing the open Pacific Ocean and likely have little interaction with goshawks. The bald eagle population in southeast Alaska is estimated to be 13,340 (Jacobson and Hodges 1993) and may exclude goshawks from some coastal areas. Goshawk nest site records show only limited use of beach areas. This may be due to competition or direct aggression by bald eagles.

Red-tailed hawks occur sporadically across the Tongass NF and are associated mainly with open habitats, such as low-elevation scrub forests and early successional stages after timber harvest. Great horned owls occur widely throughout the forests of southeast Alaska but are thought to be rarer on the islands than in mainland forests, perhaps due to more abundant mammalian prey on the mainland. Both red-tailed hawks and great horned owls have been documented as predators of goshawks and their nestlings (Boal and Mannan 1994, Woodbridge and Detrich 1994) and may occupy a large proportion of goshawk nests after logging (Crocker-Bedford 1990, Patla 1990). There is no evidence suggesting that either owls or red-tailed hawks have an adverse effect on goshawks in southeast Alaska. Where other raptor populations are dense, they also may compete with goshawks for limited resources such as prey or nest sites.

Conservation Status of Northern Goshawks in Southeast Alaska

Conservation status refers to the demographic condition of a species as it relates to the likelihood of local and regional persistence of that species over the long term. The conservation status of goshawks in southeast Alaska is examined relative to the information already presented in this assessment.

Given incomplete knowledge about goshawk ecology in southeast Alaska, the status of goshawks can be evaluated by asking a series of critical questions about its biology and habitat. This approach has been used elsewhere (Murphy and Noon 1992, Verner et al. 1992, Hayward and Verner 1994). The available information is evaluated to distinguish among three broad conclusions relative to long-term conservation status of goshawks in southeast Alaska: (1) populations of goshawks are secure and likely will remain so given current land management practices, (2) populations of goshawks are in peril (declining or experiencing some demographic trauma) or likely will be in peril in the future given current management practices, or (3) there is insufficient evidence to determine or predict the conservation status of the species. Goshawk populations differ in biology and ecology depending on geographic setting. Therefore, when answering the critical questions, we first relied on evidence from studies in southeast Alaska and secondarily on information from elsewhere in North America and Europe. Few references are presented here because literature was reviewed earlier.

1. Do habitats differ in their capacity to support the principal prey species used by goshawks?

Our review of the limited literature available does indicate that habitats in southeast Alaska differ in their capacity to support prey populations. Productive old-growth forests support a wider range of important prey than do other habitat cover types. Except for ptarmigan, Steller's jay, and yellowlegs, the principal prey species generally occur in higher densities in productive old-growth forest than other habitats. Ptarmigan occur most in alpine and subalpine areas; Steller's jays seem most common near forest edges, and yellowlegs use peatlands, beaches, and estuaries.

Timber harvest may reduce populations of primary goshawk prey species owing to the association of these prey species with productive old-growth forests where timber management occurs. Our understanding of the habitat associations of principal prey populations and forest dynamics suggests that clearcut, even-aged, short-rotation management reduces habitat quality for these species. The loss of habitat begins immediately after harvest and continues over many decades. Furthermore, partial cutting likely has less adverse impact on prey abundance per acre than does clearcutting. Forest features in leave-tree patches will influence the quality of the site for prey species. Landscapes with partial cuts that retain patches of old trees will provide a greater diversity of forest structure that likely will support larger prey populations than will landscapes with uniform even-aged forest structure.

Management activities other than timber harvest also can influence the abundance of principal goshawk prey species. For instance, forest roads remove vegetation, initiate secondary succession, and affect vegetation in plant communities along roadways and in adjacent stands.

Key prey species are not evenly distributed across southeast Alaska. Red squirrels are absent from Prince of Wales Island and islands west of it. On these same islands spruce grouse are present, replacing the blue grouse that are common throughout most of the remainder of southeast Alaska. Further, marten (*Martes americana*) and red squirrels may have been introduced on several islands and may have altered the natural ecological systems. Even though marten diets may overlap goshawk diets in this region, the consequences of possible marten introductions on principal goshawk prey are unknown. Introduction of the red squirrel, however, has likely increased prey availability for goshawks.

2. Do habitats differ in their capacity to support goshawk populations or to support particular functional activities? What are the characteristics of those habitats? Are these habitats limiting goshawk populations? How does forest management influence habitat quality for goshawks?

Observations of goshawk habitat use in southeast Alaska demonstrate selection for specific habitat cover types and locations. Although the available data do not confirm differences in goshawk fitness among habitats or directly show that goshawks obtain more prey in any particular habitat, data on nonrandom habitat use provide indirect evidence that habitat quality differs among habitat cover types.

Characteristics of habitat within 600 acres around the nest—Our sample suggested that goshawk nests occur in a subset of available forest habitats. Documented nests occur below 1,000 feet in elevation in productive old-growth forest stands but not in beach fringe or estuary forests. Nests have not been discovered in scrub forest or early seral stages after clearcutting despite the high visibility such nests would have had in these open habitats. Although nests have not been found in scrub forests, nests have been found in small stands (less than 10 acres) of productive old-growth forest generally surrounded by scrub forest.

Literature on goshawk nesting behavior (e.g., Crocker-Bedford 1990, Woodbridge and Detrich 1994, Reynolds et al. 1994) demonstrates that goshawks show strong, but variable, nest site fidelity. This behavior is thought to indicate that selected sites have unique characteristics associated with increased goshawk fitness. Newton (1986) showed that sites differ in quality for sparrowhawk (*Accipiter nicus*), and quality is associated with nesting success. If we consider the landscape context of nest site locations, our sample of goshawk nests occurred in areas that differ from the surrounding landscape. Studies in southeast Alaska show that goshawks chose nest sites with an average of 9 to 11 percent more productive old-growth forest around the nest than in the surrounding 10,000-acre plot, respectively. Even in this respect, however, goshawk nest areas showed broad variation. Cover of productive old-growth forest ranged from 16 to 96 percent within 600 acres of the site; some portion of this variation may be an artifact of circles not representing the concentrated goshawk use areas.

Forest management influence on goshawk nesting habitat—Given the strong association of nest sites with productive old-growth forest in southeast Alaska and the lower probability of reoccupancy of small nest stands observed elsewhere (Woodbridge and Detrich 1994), nesting by goshawks is likely to be lower in areas with fewer acres of productive old-growth forest, whether due to natural conditions or as a result of timber harvest. Reduction in the size of suitable nest stands or in the total extent of productive old-growth forest will reduce goshawk nesting habitat, especially in areas where productive old-growth forests are less common.

Selection and characteristics of other habitats—Without intensive observations of goshawk behavior, investigators cannot distinguish among habitats used for different functions; e.g., foraging, roosting, and loafing habitats or habitats used for other diurnal activities. No data are available on nocturnal activities. (Throughout this discussion, we have assumed that goshawk radio-telemetry locations represent suitable foraging habitat.) During the diurnal period in southeast Alaska, 57 percent of female and 41 percent of male goshawk relocations occurred below 500 feet in elevation; 74 percent of females and 54 percent of males occurred below 900 feet in elevation. Goshawks were relocated in productive old-growth forest 67 percent of the time and half of that occurred in the very high or high volume class strata. About 20 percent of goshawk relocations occurred in the narrow 1,000-foot beach fringe and 24 percent occurred in narrow riparian buffers. These observations indicate that goshawks are using a nonrandom subset of the environment.

The amount and distribution of productive old-growth forest (especially the moderate to very high volume components), mature sawtimber, and riparian and beach zones are likely to set a limit on goshawk distribution and abundance. Clearcuts reduce the amount of productive old-growth forest and thus the area frequently used by goshawks. Although scrub forests are used occasionally by goshawks (19 percent), this was not a selected cover type relative to availability (28 percent, table 10). Also, this cover type is relatively abundant (27.6 percent of the landscape) and not threatened by management; consequently, changes in the abundance of scrub forest are not likely to play a key role in goshawk population change in southeast Alaska. Goshawk relocations in scrub forest areas frequently occurred in patches of productive old-growth forest too small (e.g., < 5-10 acres) to be mapped in the GIS database. Thus the use of scrub forest types may depend on the amount of inclusions of productive old-growth forest patches within them.

Goshawks occur in a variety of habitats at the landscape scale (e.g., thousands of acres); some occur in landscapes dominated by productive old-growth forest, and others use landscapes dominated by scrub forest or clearcut lands. The goshawks we observed in each of these situations reproduced successfully and may demonstrate their adaptability to a variety of landscapes. We have no data, however, to indicate relative abundance or fitness of nesting goshawks among these varied landscapes, which would serve as an indirect measure of relative habitat quality.

The geographic extent of goshawk use areas also differed dramatically; breeding season use areas of adult males averaged 17,000 acres (range 6,800 to 48,185 acres) and for females averaged 35,076 acres (range 492 to 203,391 acres). Differences in the number of sample relocations accounted for much of the variation in the size of the use areas; however, there is likely variation in use-area size among individuals that exploits the variety of landscape compositions. Goshawk use areas documented in southeast Alaska are exceptionally large relative to other regions and may be related to low prey diversity or abundance. Kenward (1982) suggests that home ranges in his study area were of a size to encompass an adequate amount of key foraging habitat.

Data from southeast Alaska demonstrate differential use of cover types and topographical locations by radio-marked goshawks. A definitive assessment of the relative value of different combinations of cover types to goshawk fitness would require information for landscapes on the relative density of goshawks, reproductive success, mortality rates for adults and juveniles, and prey habitat relations and abundance.

Forest management influence on foraging habitat—Natural disturbance in the coastal, temperate rain forest of southeast Alaska generally occurs in small patches (0.1 to 0.2 acre) as a result of small-scale windthrow. Because of the cool, moist, maritime climate, fire does not produce the disturbance patterns characteristic of many other conifer forest types in other regions. Catastrophic windthrow events generally affect much larger areas, up to 1,000 acres, but much more infrequently, an average of only 0.3 percent of the productive old-growth forest is affected within a landscape per decade (Nowacki and Kramer, in prep.).

Past timber harvest in southeast Alaska has emphasized even-aged clearcut silviculture that differs from natural disturbance processes and has long-term consequences on forest structure and goshawk habitat. Clearcutting removes high-quality goshawk habitat (i.e., productive old-growth forest) and creates low-quality habitat (i.e., clearcut and early seral conifer stands). Clearcut stands likely remain poor quality goshawk habitat for over 100 years, through the stand initiation and stem exclusion stages of forest succession (fig.2). The rate of habitat recovery after clearcutting depends on site productivity, the amount of stand structure remaining after timber harvest, the forest types that regenerate on the site, and many, site-specific, chance events that influence secondary succession. Evaluating the extent of habitat decline resulting from clearcutting is further complicated because productive old-growth forest sites probably differ in their value to goshawks according to prey density and forest structure, which facilitate goshawk flight and prey capture (Moore and Henny 1983, Fisher 1986, Spieser and Busakowski 1987, Widen 1989, Crocker-Bedford 1990, Reynolds et al. 1992).

Evaluating the influence of forest management becomes especially complex in a landscape context. The effects of clearcutting on habitat quality depend on the amount and distribution of cover types (especially productive old-growth forest) present before and after harvest. For instance, harvest of 1,000 acres of productive old-growth forest from a 10,000-acre watershed likely will have different consequences if, before harvest, productive old-growth forest occupied 2,000 acres or 9,000 acres. The geographic dispersion of various cover types before and after harvest also likely influence the impact of clearcut harvest on goshawks. Despite wide variation in the size and habitat composition of goshawk use areas, 23 and 28 percent was the minimum proportion of productive old growth present in any breeding season use area for adult males and females, respectively. We do not know the consequences to goshawk nesting if landscapes are managed below these levels. We also do not know the relation between the amount of productive old-growth forest and either goshawk fitness or relative abundance. As selected habitat components decline at the landscape scale, home range size may increase (Kenward 1982), and population density may decrease. Goodman (1987) suggests that any management that reduces habitat quality to near minimum conditions will substantially increase the probability of extinction resulting from chance environmental events or catastrophes.

3. Do the life history and ecology of the goshawk suggest that populations are vulnerable to habitat change?

Several aspects of goshawk life history suggest that the species may be vulnerable to habitat changes. Goshawks are long-lived birds, have a low reproductive rate, occur in low densities, and at least in southeast Alaska do not migrate. As such, goshawk life history parallels that of other large avian predators, such as the bald eagle and spotted owl (*Strix occidentalis*). Demographic sensitivity analysis of the life history strategy for these species shows that population growth rates are most sensitive to changes in adult survival rates (Noon and Biles 1990). Habitat changes that decrease adult survival would decrease the probability of persistence. In particular, reductions in prey populations or prey availability as a consequence of forest management could increase goshawk mortality, especially during periods of stress. Goshawks in other regions exhibit dramatic movement patterns in response to winter prey shortages (Doyle and Smith 1994), suggesting the potential for food stress during winter.

Habitat change also could influence adult and juvenile survival rates by changing the vulnerability of goshawks to predation or interactions with competitors. Elsewhere, great horned owls prey on goshawks, and red-tailed hawks may compete with goshawks. Although both great horned owls and red-tailed hawks are associated with openings in other conifer forests, neither species would likely benefit from clearcuts for a long period in southeast Alaska, owing to low structural diversity and prey productivity of the stem exclusion stage of secondary forest succession.

The very large areas used by goshawks in southeast Alaska may lead to high energy expenditure during daily movements. Hirons (1985) has shown that, for the tawny owl (*S. aluco*), clutch size is limited by energy available to the female prior to laying. Palmer (1988) emphasizes the importance of late winter and early spring habitat in determining the breeding condition of female raptors. In this context, the large areas used by goshawks are a conservation issue for two reasons: (1) populations of individuals requiring large ranges may be energetically stressed, have lower reproductive success, and be less resilient to further stress; and (2) land management must provide habitat within large areas to meet individual as well as population needs. Reductions in productive old-growth forest that reduce prey populations likely would further stress individual goshawks, especially in landscapes with relatively low prey populations. Goshawks occupy an upper trophic level in a broad food web; they rely on the integrity of trophic levels two to three lower levels. This food web is poorly understood; however, changes in habitat that negatively influence prey populations likely would reduce the probability of persistence for goshawks.

The influence of habitat change on successful dispersal of young goshawks, or on movements of adult goshawks, is unknown. Likewise, the influence of habitat change on other demographic characteristics of goshawks in southeast Alaska is not understood. Several authors have provided deductive arguments, and some empirical data, indicating reduced nest occupancy or reduced reproduction per occupied nest following timber harvest (see “Species response to forest harvest” in “Review of Northern Goshawk Ecology in North America,” above).

4. Given that goshawks select particular habitats, are these habitats declining or at risk under current management?

Nearly 900,000 acres of productive old-growth forests have been converted to early seral forests within the temperate rain forest ecosystem in southeast Alaska. The amount of habitats used and selected by goshawks for nesting and foraging, and most likely important habitats for principal prey species, have declined in the past and continue to decline under current management. Clearcut stands represent one of the least-used cover types by goshawks. Most clearcut stands are currently less than 40 years old and provide poor habitat for goshawks and will continue to provide poor habitat for another 60 to 100 years. Evaluating the risk of further reductions in the extent and quality of goshawk habitat depends on several aspects of future management direction. We can conclude, however, that the projected harvest of an additional estimated 1.5 million acres of productive old-growth forest planned under the current Tongass Land Management Plan (USDA 1979) can only further adversely affect the conservation status of the goshawk. The distribution of timber harvest, the silvicultural prescriptions used, and the overall timber volume harvested will all influence risk as discussed further in "Management Considerations"(below).

5. Is evidence available that goshawk distribution or abundance is declining in all or part of southeast Alaska?

Data on goshawk density, survival, reproduction, and dispersal in southeast Alaska are too limited to directly determine the trend in any demographic characteristic for the population. Due to the lack of historical information, direct estimates of status and trend will be difficult for the near future. Preliminary data and literature review suggest that adult goshawk survival in southeast Alaska might be within the range judged necessary for population stability. The annual estimated survival of adult goshawks averaged 72 percent (56 to 88 percent for the 95-percent confidence interval), not too different from the minimum 80- to 86-percent adult survival calculated by McGuire and Call (Arizona Game & Fish 1993) and believed necessary for stability in goshawk populations.

Although demographic data are not available to determine population trends, patterns may be inferred based on trends in habitat, if it is assumed that habitat or a process related to habitat abundance and quality is limiting goshawk populations. Considerable amounts of the most productive old-growth forest habitats selected by goshawks have been removed in southeast Alaska, and the decline will continue under the current Tongass land management plan. It is likely that productive old-growth forest that has been harvested once supported goshawks and their prey at densities comparable to those currently observed in unharvested areas. Although goshawk abundance is not likely linearly related to the proportion of productive old-growth forest, goshawks likely require some unknown abundance of productive old-growth forest at large spatial scales (e.g., >10,000 acres), and that below that level goshawk abundance declines. Reducing the amount of productive old-growth forest to a level still above this critical amount may or may not have a significant effect.

Despite the lack of direct data on current population size or trend, where habitat abundance and quality has been reduced, relative goshawk density will likely also be lower. Therefore, based on significant reductions in the amount of highly productive old-growth forest habitat, goshawk abundance has likely declined during the past period of intensive timber harvest. Data are, however, insufficient to estimate the magnitude of decline or the likelihood of long-term goshawk persistence.

6. What is the current conservation status of the goshawk in southeast Alaska?

The current conservation status of goshawks in southeast Alaska cannot be precisely defined and this situation is not unique. Sound estimates of persistence probabilities are not available for many more intensively studied species (e.g., goshawks in other areas or the northern spotted owl). Principal barriers include insufficient information about important population parameters. In particular, population growth rates for species with life histories similar to goshawks are most sensitive to changes in adult survival rates. Available ecological information on goshawk habitat use, trends in habitat condition for goshawks and their prey, life history characteristics of the goshawk, and characteristics of its prey together form the basis for making inferences to assess the conservation status of the goshawk in southeast Alaska.

Based on the information presented in this document and summarized earlier in this section, we can draw three main conclusions. The first is that **the probability of persistence for goshawks throughout southeast Alaska has declined since the middle of the 20th century.** Secondly, although persistence may be in immediate peril in specific areas with highly modified landscapes (see “Management Considerations,” “Risk Assessment,” below) **goshawks in most ecological provinces with limited or no habitat modification are likely not in immediate peril**. Thirdly, we concluded that **a sound habitat management strategy is important to maintain long-term, well-distributed populations**. These three conclusions are based on the following points:

- Habitats selected by goshawks remain abundant in many portions of southeast Alaska, especially in wilderness areas. Some habitats used for activities other than nesting are not significantly altered by current management practices (e.g., scrub forests with inclusions of large trees).
- Goshawks studied in southeast Alaska produce numbers of young similar to goshawks elsewhere, however they likely exist in lower nesting densities in southeast Alaska.
- Goshawks in southeast Alaska appear to use a variety of landscape conditions and to prey on a variety of vertebrates occurring in several cover types, thereby suggesting the species may be resilient to some degree of change. Use of a particular habitat (e.g., scrub or nonforest) does not, however, necessarily imply a positive contribution to fitness (Van Horne 1983). Nonetheless, the productive old-growth forest component on the landscape is selected by goshawks, and some of these forests are at risk of habitat loss because of current forest management direction.
- Evidence suggests that goshawks in southeast Alaska are not migratory. They would therefore not be placed at increased risk due to loss of wintering habitat outside the region or be faced with potential increased mortality during migratory movements. Correspondingly, however, habitat within the region must be adequate to support goshawks throughout the year.
- Goshawks in southeast Alaska move extensively within the region. This movement suggests that the probability of recolonizing areas that have experienced local extirpations would be high once habitat quality was restored; but given forest succession rates, this response may take several decades or centuries to occur.

- Goshawks in southeast Alaska exhibit color and morphological features suggesting distinct genetic characteristics. These features imply that the group of goshawks in the region have not been a sink population, at least in the past. The different morphology furthermore suggests that a population with minimal demographic support from outside populations has remained viable and distinct within the region for a relatively long period.
- Risks to long-term (e.g., 100 years or more) and short-term persistence of goshawks in specific areas are management challenges for the immediate future. These challenges were identified from available information on goshawk habitat use and nest area habitat, the dynamics of those habitats, the consequences of current forest management, and goshawk life history. Specifically:
  - Goshawks have been identified as a species of viability concern by several agencies because they occur at low densities, have low reproductive rates, and use habitats for nesting and other activities that have been reduced or markedly altered by timber management. These population characteristics have been associated with a decreased probability of persistence for other vertebrates (Pimm et al. 1988, Shaffer 1981).
  - Habitat associated with goshawk nest areas has been reduced in southeast Alaska during the latter half of the 20th century owing to timber harvest. Goshawks have not been found nesting in clearcuts or early seral stage forests. If goshawks are limited to mature and productive old-growth habitat, then extensive clearcut harvest likely will result in a reduction in the number of breeding goshawks, breeding goshawks no longer occurring in particular areas, and reduced abundance of goshawks in selected watersheds. Contractions in the range of a species decrease the probability of persistence owing to chance environmental events (implied by Goodman 1987, Pimm et al. 1988).
  - Harvest of productive old-growth forest reduces habitat quality for 8 of the 10 goshawk principal prey species and may negatively affect forest structure for foraging goshawks. Productive old-growth forest habitats are selected by goshawks when away from the nest, and the principal prey species are probably most abundant and accessible in productive old-growth stands. Although goshawks in this region appear to forage in a variety of habitats, reductions in prey abundance and accessibility likely will lead to a lower abundance of goshawks, to reduced goshawk survival, and to reduced productivity.
  - The large use areas exhibited by goshawks in southeast Alaska suggest that the population may be more sensitive to reduction in habitat quality than populations elsewhere. There is some indication that goshawk use areas in southeast Alaska are even larger in the more modified landscapes (e.g., North Prince of Wales Island Province); however, this speculation is confounded by lower prey species richness in these same areas.
  - Some biologists have suggested that goshawks are rarely seen, and their nests rarely found, in landscapes with the most clearcutting. However, substantial surveys in landscapes where timber harvest has not occurred also have failed to detect nesting goshawks (Schempf et al. 1996).

- The degree to which population growth is density dependent, especially at low population densities, is important to carefully consider in assessing goshawk demography and the potential consequences of habitat change. The extent that goshawk population growth is density dependent is specifically unknown, and we do not know whether goshawks are likely to experience an Allee effect (negative density dependence at low populations size; Allee 1931) at modest population sizes. A strong Allee effect could result if goshawks experience difficulty in locating mates at low population densities, or if low population densities are associated with large use areas, which affect energy needs and subject the birds to more predation and competition.

In general, then, trends in habitat condition throughout the region suggest that the probability of persistence for goshawks in southeast Alaska has decreased relative to conditions prior to or earlier in the 20th century. The actual degree to which the probability of persistence has been reduced is unknown. Under the management direction of the current Tongass National Forest Plan (USDA Forest Service 1979) the probability of persistence will continue to decline.

Management Considerations

Management considerations are developed and presented as a framework for goshawk conservation in southeast Alaska. They represent an integration of the available literature, results of research and surveys conducted in southeast Alaska, past and planned forest management practices relative to the ecology of the temperate rain forest, and conclusions regarding the conservation status of goshawks in southeast Alaska, elements described in earlier sections. Statements made here also represent management hypotheses that need to be tested through research, rigorous monitoring, and adaptive management.

Goshawk Response to Forest Disturbance

Response to forest change at the stand scale—We examined a variety of silvicultural systems to assess the impact of fine-scale habitat change on goshawk habitat use. Goshawks disproportionately select productive old-growth forest habitats among all available habitat types. Clearcutting of productive old-growth stands initiates secondary forest succession which results in fundamental changes to forest structure avoided by goshawks. Thus, the dual effects of clearcutting—eliminating a selected habitat type and creating an avoided habitat type at the stand scale—serve to focus management considerations on the productive old-growth forest component of the landscape. For purposes of this discussion, we consider a “stand” to be a relatively homogeneous forest in structure and composition in the size range of 20 to 100 acres.

Five stand structures that result from a range of silvicultural treatments were evaluated by integrating our knowledge of forest dynamics and goshawk ecology to estimate relative habitat suitability for nesting and foraging use by goshawks (table 25). Old-growth forest was used as a basis for comparison. Value assignments for foraging were based on our prediction of prey abundance within stands and whether stands would facilitate goshawk hunting behavior. The general assumption was made that goshawk habitat use not related to the immediate nesting habitat is either directly or indirectly related to foraging activities.

Table 25—Estimated value of forest stands with different structures for goshawk nesting and foraging habitat, southeast Alaska[a]

Forest structure	Estimated value for nesting	Estimated value for foraging
Old growth (>250-300 years old)	H	H
Mature sawtimber (75-250 years old)	M	M
Uneven-aged management prescription:		
Single-tree selection (300-year "rotation")	H	H
Group selection (1- to 2-acre openings) (300-year "rotation")	M+	H-
Even-aged management prescription:		
Shelterwood with reserves	L-	M-
Clearcut	L-	L

[a] All cases evaluate stands on sites that can support productive old-growth forest. Ratings: L = low value, M = medium value, H = high value; + and - provide finer resolution among categories.

Goshawks likely have adapted to forest processes of gap dynamics and catastrophic windthrow and the resulting fine- and coarse-scale seral stand mosaic, as evidenced by their apparent long-term presence in southeast Alaska. Thus, the assumption is made that the more closely active forest management emulates the size, frequency, and intensity of natural forest dynamic processes in time and space, the more suitable the resulting combination of stand structures will be to sustain goshawks. However, any application of silvicultural treatments likely is additive to "residual" (e.g., natural) forest disturbance processes already occurring, possibly resulting in more frequent and intense disturbances.

Old-growth forest is rated highest for nesting and foraging because goshawks select it for nesting and nonnesting activities and it provides a greater diversity and abundance of prey. Old-growth forest stand structure also provides the canopy closure and relatively open understory suitable for foraging.

Uneven-aged silviculture—Group selection resulting in up to 2-acre openings occurring at different stages of succession may emulate aspects of the gap-dynamic, shifting-mosaic characteristic of temperate rain forests. To employ both a time and space control, we assumed that no more than 3.3 percent of the stand is removed in any decade (approximating a 300-year rotation) and that some groups of trees that are at least 300 years old will always remain.

Group selection sites may not provide nesting habitat equivalent to old-growth forest because of the degree of increased patchiness (over residual gap processes) that will result over time; however, the value for nesting likely would remain adequate over the entire area throughout the rotation. Light, single-tree selection is expected to retain high-value nesting habitat as long as large, old trees remain on the site through time. Group or single-tree selection also maintains relatively high-value foraging habitat throughout the management cycle (table 25). Thus, uneven-aged silviculture that emulates natural disturbance patterns will have a high likelihood of sustaining suitable goshawk habitat (Reynolds et al. 1992).

Even-aged silviculture—Shelterwood is a clearcut-type harvest that leaves scattered residual trees after the initial harvest of most (e.g., 80 percent) of the trees on a site. In the “shelterwood with reserves” system (table 25), retained trees are never harvested. Even with reserve trees, shelterwood treatment is considered among the least valuable treatments for nesting or foraging owing to inadequate forest structure remaining in the stand. Compared to clearcut sites, residual large trees and snags retained on shelterwood sites likely would contribute to increased structural complexity with at least two canopy layers. They also would function as a source of future recruitment of snags and downed woody material leading to accelerated development of stand structure for nesting and foraging habitat, especially during the period from about 100 to 150 years. The more windfirm residual structure retained in a shelterwood harvest, the higher the habitat suitability for goshawks and prey species, especially 1 to 2 centuries after the shelterwood harvest.

Clearcut refers to a complete removal of all trees within a stand to restart secondary forest succession at the stand initiation stage. This even-aged seral condition resulting from clearcutting persists for at least 100 years (current TLMP rotation length) and up to 150 years through the stem exclusion stage of forest succession. The value of clearcut stands (20 to 100 acres) for goshawk nesting or foraging is initially very low because nearly all vertical structure is removed at harvest, but suitability changes as the stand matures. During the stand initiation phase (about 0 to 25 years after harvest), the stand provides no nesting habitat but may provide some minimal foraging habitat, depending on seral conditions, opening size, and the landscape context of the stands. During the stem exclusion phase (30 to 150 years), nesting habitat is generally absent until late in this period of stand development. The dense forest provides little flight space and goshawk foraging is unlikely. During understory reinitiation (starting at about 150 years) and as the stand continues to mature, the foraging habitat quality will gradually improve as conditions increase for a variety of prey species, and the more open stand provides necessary flight space. Nesting also becomes more likely as tree size increases and the stand becomes more open.

Intermediate treatments—Intermediate silvicultural treatments such as precommercial and commercial thinnings that open the canopy, could theoretically enhance stand suitability for goshawk habitat use. The greatest benefits would not be in direct habitat improvement, but rather in reducing the time to develop stand structural characteristics necessary to provide suitable goshawk nesting and foraging habitat (e.g., 120 years instead of 150 years on an average site). Opening the canopy could theoretically enhance understory development of herbaceous vegetation to enhance habitat for prey species, but the vegetative responses would likely be very slow (Alaback 1982), and known prey species apparently do not respond to precommercial thinning in southeast Alaska (DellaSalla et al. 1994). To the extent that these silvicultural treatments increase natural disturbances that further alter stand structure, such as additional windthrow, the consequences for goshawks are less certain.

Response to forest change at the landscape scale—When the consequences of implementing stand-scale treatments across large landscapes and over long periods are considered, then several considerations emerge concerning goshawk response to forest management. Applying various silvicultural treatments to a landscape over time creates a mosaic of stand structures. Characteristics of the mosaic and resulting consequences to goshawk habitat suitability depend on the type and combination of silvicultural treatments applied (e.g., single-tree selection versus clearcut); the intensity, frequency, and size of these silvicultural treatments; the existing landscape composition and structure; and interactions with natural disturbance events. In theory, forest management through uneven-aged silviculture approximating the size, scale, and intensity of natural disturbance processes should provide continuous moderate- to high-quality habitat when applied across the landscape, if treated stands retain some old trees with complex forest structure. An uneven-aged management framework has no actual rotation age; however, the choice of patches and scheduling of harvest determines the mix of structures present in the forest.

The size of seral stands created by various silvicultural treatments impacts goshawk habitat. Goshawks in southeast Alaska preferentially select against use of clearcuts. These data are, however, based on relatively large clearcuts (e.g., generally 20 to 100 acres); the likely impact of small clearcuts or group selection harvests are much less known and will depend, in part, on patch size. Prey availability for goshawks may increase if average treatment openings are smaller, because (1) prey within harvested patchs will all be closer to the edge (where hawks can perch), and (2) any prey species favoring edge habitat will have more edge habitat relative to clearcut area. The tradeoffs between group selection and clearcutting, then, may depend on the proportion of the landscape in early seral stages and the habitat value of edge areas to goshawks. Regardless of the silvicultural system used (even vs uneven aged), the total amount of early seral forest stand structure (cover types avoided by goshawks) within a landscape strongly influences habitat quality.

We do not suggest that goshawks require extensive tracts of productive old-growth forest on the Tongass NF, but rather that landscapes with large proportions of early seral forest reduce the cumulative habitat quality for goshawks across the landscape. When productive old-growth forest stands are clearcut in a landscape having a large scrub forest component, the landscape will retain some foraging habitat quality because goshawks use scrub forests (especially their inclusions of small patches of productive old-growth forest) but avoid clearcuts. The use and contribution of the scrub forest component and the variability in its abundance across the landscape is a likely cause for the high variability in the amounts of productive old-growth forest within goshawk use areas. The overall habitat capability and probable goshawk persistence are likely to be most reduced when landscapes dominated by productive old-growth forests are converted to predominantly early seral habitats and contain little scrub in the resulting mosaic that may provide compensatory foraging habitat.

Rotation length—Because productive old-growth forests provide important nesting habitat for goshawks and habitat for their prey, the effective rotation period for a stand (the maximum age before each stand is harvested again) has a significant influence on the value of habitats to goshawk conservation after silvicultural treatment.

Under a theoretical 200-year rotation for all current old growth, about half of the forest is maintained at all times in either the stand initiation or stem exclusion stages (less than 100 years) and half in the understory reinitiation stage (100 to 200 years). A 200-year rotation may double the effective landscape goshawk habitat capability over a comparable 100-year rotation, with nearly half of the landscape in a mature sawtimber cover type. Because 100- to 200-year-old stands are currently uncommon in the Tongass NF, data are insufficient to accurately assess their habitat value to goshawks. However, based on likely stand structure, forest successional pathways, and goshawk foraging behavior, these stands would provide at least intermediate quality goshawk habitat (see table 26), and they represent the mature sawtimber component used by goshawks in greater proportion than its relative availability. When 200-year-old stands begin to exhibit increased structural complexity through development of gap dynamic processes that lead to the initial expression of some old-growth characteristics under a 200-year rotation, they are harvested and set back to the stand initiation stage. We cannot judge if all prey species niches are present within stands managed under 200-year rotations. There would be no old-growth forest component under this scenario.

By contrast, a 300-year rotation for all old growth provides up to 10 decades for development of late successional forest stand structure (stand age 200 to 300 years) for use by goshawks. Under a 300-year rotation, at least one-third of a landscape would be productive old-growth forest with associated niches to support diverse prey populations. A second third of the landscape would be in the intermediate-valued mature sawtimber stage. The remaining landscape would be in the least valuable 0- to 100-year-old conifer stand structure. Extended rotations with time controls (e.g., 3.3 percent of productive old-growth forest harvested per decade) and area controls (e.g., Value Comparison Units averaging 15,000 acres) present an opportunity to both harvest timber and provide habitat likely to sustain goshawk populations.

Data from southeast Alaska suggest that goshawks can successfully produce young in landscapes with moderate amounts of early seral forest stand structure. This relation is not unexpected because large-scale windthrow, an occasional disturbance event, creates essentially even-aged stands that may occupy hundreds of acres, and goshawks have either adapted to or can tolerate this disturbance regime. Use of a 300-year rotation that maintains nearly two-thirds of the landscape in either understory reinitiation (moderate value) or old-growth forest (high value) development stages is consistent with the habitat use patterns exhibited by goshawks (see "Analysis of Northern Goshawk Ecology in Southeast Alaska," above) where 70.5 percent of goshawk habitat use occurred in mature sawtimber or productive old-growth forest.

Further support that a 300-year rotation would provide this theoretical dynamic landscape composition of seral age classes was developed from observed variation in goshawk use of landscapes. Productive old-growth forests within individual goshawk breeding season use areas ranged from 23 to 88 percent of the area. The mean of this distribution is about 48 percent productive old-growth (standard deviation is 15 percent). Thus, even though some birds occurred in landscapes with as low as a 24 percent component of productive old-growth forest, they represent a small proportion of the sample population. If the management objective is that 48 percent of the landscape should be composed of late seral or old-growth forest, then habitat

Table 26—Goshawk risk assessment at the biogeographic province scale for the Tongass NF showing the percentage of the productive old-growth forest harvested in 1995 and the potential harvest in 2055 with continued implementation of the current Tongass NF land management plan[a] [b]

	Productive old growth harvested	
Biogeographic province	1995	2055
	Percent	
East Chichagof Island	8.6	38.6[c]
West Chichagof Island	0.0	6.0
East Baranof Island	8.0	37.0[c]
West Baranof Island	4.5	22.5
Admiralty Island	0.0	3.0
Lynn Canal	3.0	26.2
North Coast Range	0.4	32.0
Kupreanof Island and Mitkof Island	9.1	47.3[c]
Kuiu Island	7.2	37.0[c]
Central Coast Range	2.3	25.6
Etolin Island and vicinity	11.7	49.2[c]
North Prince of Wales Island	20.8[d]	66.9[c]
Revilla and Cleveland Peninsula	4.8	35.5[c]
Southern outer islands	11.6	36.3[c]
Dall Island and vicinity	1.1	55.7[c]
South Prince of Wales Island	1.9	34.3[c]
North Misty Fiords	0.4	3.8
South Misty Fiords	0.0	0.0
Ice fields	2.4	6.3
Tongass National Forest	6.5	31.4

[a] The Yakutat area is excluded from the analysis.
[b] Harvest rates exceeding 13 percent (1995) and 33 percent (2055) represent increased risk to long-term goshawk persistence.
[c] Province harvest rates exceed 33-percent threshold; 300-year rotation harvest rate.
[d] Province harvest rates exceed 13-percent threshold; 300-year rotation harvest rate.

needs of, at best, only 50 percent of the population will be met. Thus, some proportion of the population above the mean may be a prudent management objective, perhaps 1 standard deviation. This level would approximate the 60- to 70-percent range demonstrated by the proportion of goshawk relocations that occurred in productive old-growth forest. This analysis assumes that the proportion of a selected habitat component used by goshawks equates to the proportion of that habitat type needed within the landscape to have a high probability of sustaining goshawks.

We conclude that timber harvest management regimes with longer effective rotations will provide a higher probability of goshawk population persistence than shorter rotations. One possibly goshawk conservation strategy is to manage 66 percent of the productive forest in equal proportions of mature sawtimber and productive old-growth forest habitat cover types with the remaining one-third managed under an even-aged, short rotation design. These conclusions are consistent with previously published recommendations for goshawks (Crocker-Bedford 1990, Reynolds et al. 1992).

Risk Assessment

A risk assessment was conducted under the assumption that a 300-year-rotation timber management regime applied to all productive forests would provide a relatively high probability of long-term goshawk persistence throughout their current range in southeast Alaska. This assumption implies that the probability of goshawk persistence increases if less than one-third of the forested landscape is in early successional stand structure (e.g., 100 years), nearly one-third is in a understory reinitiation stage of secondary succession (e.g., 100- to 200-year-old mature sawtimber) and more than one-third is in stands 200 years or older and containing the full complement of old-growth forest characteristics.

The risk analysis was conducted at three spatial scales (described below) and at two points in time: (1) the current situation after four decades of timber harvest beginning on an extensive scale in 1955; and (2) projecting another six-plus decades assuming full implementation of current TLMP (USDA Forest Service 1979) using a 100-year rotation. From these analyses, two thresholds of early seral (e.g., less than 100 years) forest composition present on the Tongass were developed: 13 percent (the current situation—four decades divided by 30 decades), and 33 percent (the end of the first 100-year rotation—10 decades divided by 30 decades). Areas with less than 13 percent (1995 situation) or 33 percent (2055 situation) of the productive old-growth forest harvested were consistent with the habitat capability of a 300-year rotation schedule and were judged as having a relatively high probability of sustaining goshawks. Areas exceeding these thresholds presented a higher risk of not providing the amount and distribution of habitat necessary to sustain goshawks.

A risk assessment could also examine a theoretical 200-year rotation where one-half of all forests managed in 0 to 100 age classes and one-half in 100 to 200 age classes with commensurate thresholds of 20 percent (current) and 70 percent in 2055 of the landscape in productive old-growth forest. This scenario was not examined in detail, however, because this rotation length is unlikely to regenerate much old-growth stand structure known to be selected by goshawks. Furthermore, the relative value of 100- to 200-year-old regenerating forest stands to goshawks is unclear, because it is a relatively rare feature across the landscape and goshawk habitat relations are not well tested. It is doubtful that this stand structure, without an accompanying old-growth forest component, could sustain goshawks across all landscapes.

This risk assessment should be placed within the following context and assumptions:

1. Goshawks are not entirely dependent on productive old-growth forests included in the timber base. Productive old-growth forests not suitable or available for timber harvest (e.g., wilderness and riparian buffers) provide significant amounts of habitat. The abundance of these habitats that are not suitable or available for timber harvest differs among landscapes. Specifically, 46 percent of goshawk habitat use occurred in riparian buffers and other areas of productive old-growth forest stands unsuitable for timber harvest during the 100-year planning horizon under the current TLMP. These unsuitable timber management acres of productive old-growth forest remain a permanent contribution to the old-growth habitat component across the landscape.

2. Forest lands will be managed under the current TLMP for the next 100 years at the projected maximum average annual harvest of 450 million board feet, with no amendments occurring to change that level.

3. Relative risk is a function of prey richness and availability as determined by the percentage of productive old-growth forest lands harvested.

4. This analysis includes only Tongass NF lands; non-Federal lands are not included in this analysis. Trees on over 50 percent of the 700,000 acres of forests on non-Federal lands in southeast Alaska have been harvested (USDA Forest Service 1991). Given this level of habitat change, ecological risks to goshawks are higher for areas with significant amounts of non-Federal forests that have been harvested.

5. The analysis assumes that all productive old-growth forests are of equal value to goshawks.

Southeast Alaska regional scale—At the scale of the entire Tongass NF (excluding Yakutat), 6.5 percent of the productive old-growth forest has been harvested since 1955 (table 26). Under the current TLMP, an estimated 32.1 percent of the productive old-growth forest land will be harvested by 2055. Thus, at the regional scale, management is currently consistent with a 300-year scheduling regime in terms of goshawk habitat capability and should remain consistent in 2055. However, this broad scale of analysis fails to consider distribution of habitats throughout southeast Alaska.

Biogeographic province scale—The Tongass NF has been stratified into 21 biogeographic provinces representing ecologically distinct landscapes (e.g., Admiralty Island, Kuiu Island, West Baranof Island, etc.) (USDA Forest Service 1991). Of the 20 provinces corresponding to the regional area used above (i.e., Yakutat excluded), only the North Central Prince of Wales Province currently exceeds the 13-percent threshold level (table 26). Under the current TLMP, 10 of 20 provinces would exceed the 33-percent threshold by 2055, including all island provinces within the Stikine and Ketchikan Administrative Areas of the Tongass (table 26, fig. 12).

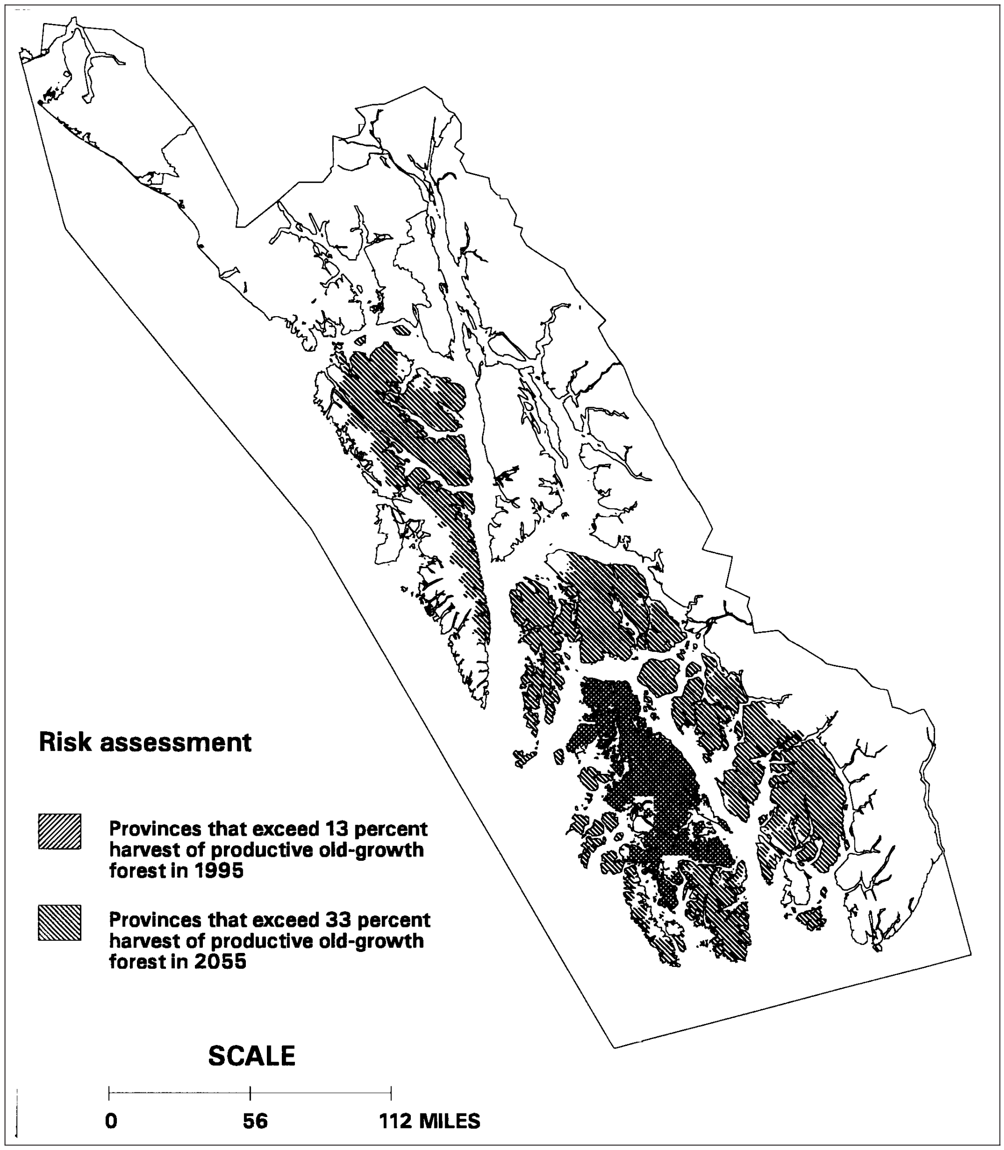

Figure 12—Goshawk risk assessment at the biogeographic province scale. Figure shows distribution of the productive old-growth forest harvested in 1995 and the potential harvest in 2055 with continual implementation of the current Tongass NF land management plan.

Table 27—Tongass NF management areas, exceeding a 300-year timber harvest schedule[a]

Administrative location	Management Areas exceeding 13% harvest level in 1995[b]	Management Areas exceeding 33% harvest level in 2055[b]
Chatham	C44 (13.5), C41 (14.1), C27 (15.0), C30 (15.1), C37 (18.4), C32 (12.3)	C07 (37.5), C29 (40.3), C43 (40.3), C10 (42.5), C18 (42.8), C40 (43.1), C39 (43.1), C44 (43.3), C25 (45.5), C15 (47.9), C03 (48.1), C27 (48.1), C21 (49.2), C34 (51.3), C32 (53.5), C28 (55.0), C13 (56.2), C30 (56.8), C37 (57.0), C14 (60.1), C19 (60.3), C41 (61.6), C31 (65.5)
Ketchikan	K32 (14.1), K15 (14.5), K08 (17.7), K10 (23.4), K04 (23.6), K01 (24.9), K17 (28.7), K03 (29.3), K09 (35.5), K07 (38.6), K11 (38.7), K05 (44.6)	K44 (35.7), K13 (39.8), K28 (50.7), K39 (53.3), K19 (54.1), K34 (56.0), K30 (57.5), K24 (57.9), K22 (58.8), K25 (60.4), K32 (60.6), K21 (62.8), K35 (63.1), K10 (64.4), K04 (66.0), K14 (66.2), K17 (66.6), K20 (66.7), K29 (67.0), K18 (67.1), K01 (76.0), K08 (77.0), K03 (78.4), K15 (81.3), K07 (81.6), K09 (83.5), K11 (84.0), K05(86.7)
Stikine	S35 (12.9), S11 (13.4), S29 (14.4), S22 (15.7), S17 (16.8), S04 (17.8), S19 (19.5), S21 (31.5), S18 (41.8)	S29 (36.2), S20 (44.2), S26 (45.8), S07 (46.3), S33 (48.6), S16 (49.9), S22 (51.1), S35 (51.5), S23 (52.1), S13 (54.1), S25 (54.3), S21 (55.3), S08 (56.4), S14 (57.1), S18 (57.5), S17 (57.8), S09 (58.7), S01 (59.2), S10 (61.0), S04 (62.7), S19 (66.0), S11 (58.7)

[a] Based on a 3.3-percent harvest rate per decade (1955 base). Potential harvest levels in 2055 were predicted by using the current Tongass NF land management plan.
[b] Management area identifier is followed by the percentage of harvested old growth (in parentheses).

Management area scale—Management areas represent 140 land divisions used in the current TLMP to identify landscapes on the order of tens to hundreds of thousands of acres. In the Chatham Administrative Area, 6 of 54 management areas currently exceed the 13-percent harvest threshold, and 23 management areas are expected to exceed the 33-percent harvest threshold by 2055; in the Stikine Administrative Area, 9 of 37 management areas currently exceed the 13-percent harvest threshold and 22 management areas are expected to exceed the 33-percent harvest threshold by 2055; and in the Ketchikan Administrative Area, 12 of 48 management areas currently exceed the 13-percent threshold and 28 management areas are expected to exceed the 33-percent threshold by 2055 (table 27, fig. 13).

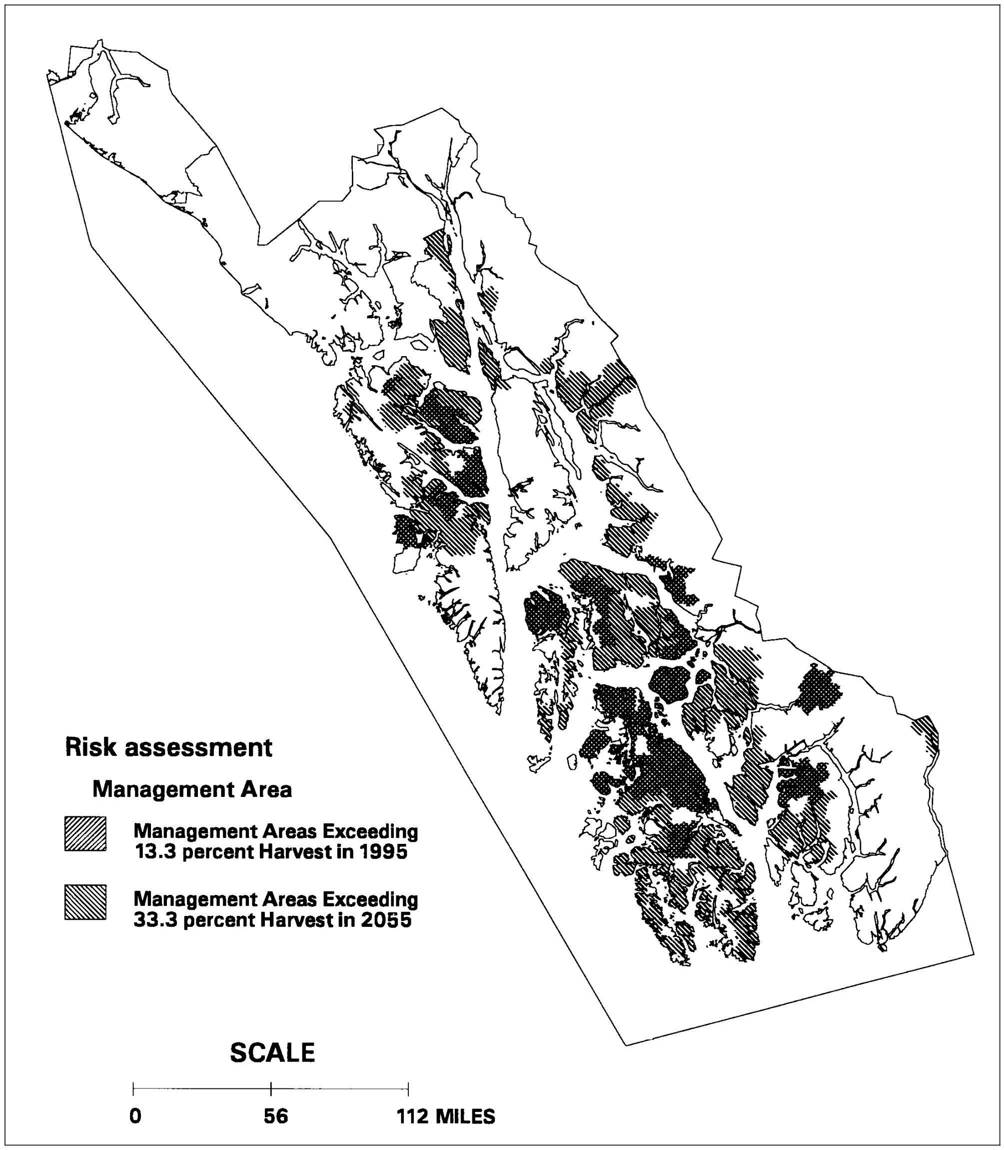

Figure 13—Goshawk risk assessment at the management area scale. Figure shows distribution of the productive old-growth forest harvested in 1995 and the potential harvest in 2055 with continual implementation of the current Tongass NF land management plan.

Goshawk Conservation Strategies

Our knowledge and understanding of goshawk ecology is insufficient to fully address all specific components of a strategy for sustaining goshawks throughout southeast Alaska. We do not know how many goshawks occurred in the past or the original habitat capability. We do know that over 900,000 acres (including State, private, and National Forest lands) of productive old-growth forest habitat, a cover type preferentially selected by goshawks, has been replaced by early seral stages avoided by goshawks. Short silvicultural rotations, currently applied on Federal, State, and private lands, are unlikely to regenerate forest stand structures suitable for goshawk use. Gross estimates of this habitat change range from 15 to 20 percent of the entire area within the temperate rain forest ecosystem in southeast Alaska. This range represents a crude estimate of current habitat capability reduction.

We do not know how many goshawks currently exist in this region. Goshawks likely exist in lower densities in southeast Alaska than elsewhere within their range, especially because of relatively low prey diversity and abundance. Relatively low goshawk densities, combined with a small subspecific range, suggest a relatively low absolute population size. Populations with low numbers are more susceptible to local extirpation than larger populations.

We do not know how many goshawks are necessary, or in what spatial distribution they need to occur, to assure their long-term persistence in southeast Alaska. Data are insufficient to craft robust population dynamics or habitat capability models that could be used to provide a spatially explicit habitat conservation strategy to sustain goshawk populations throughout southeast Alaska.

Given these unknowns, spatial scale is a critical parameter on which to design and implement a goshawk conservation strategy in southeast Alaska. Management strategies applied at too broad a scale (e.g., a management area or province), or that rely solely on landscapes currently in a permanent reserve status (e.g. wilderness and other congressionally legislated Land Use Designation II lands in the Tongass NF) may present significant management risks. Habitats capable of sustaining goshawks will likely be clumped, resulting in significant gaps in area-wide distribution that could leave insufficient intervening habitat suitable to support a well-distributed population. Gaps in distribution jeopardize population interaction and thus long-term persistence.

Management risks likely would be reduced if all landscapes were managed to sustain goshawks in their current distribution throughout southeast Alaska, though not necessarily in the same relative density. The probability of persistence would most likely remain relatively high if habitat capable of sustaining goshawks was distributed across the landscape at a scale consistent with known goshawk use areas (for instance, 10,000 to 20,000 acres, or the scale of TLMP Value Comparison Units). Sustaining goshawk habitat at such a scale across the landscape would enhance the interaction between individuals within the population.

Two principal landscape approaches to conserving species at the landscape scale dominate the conservation biology literature: a static reserve design and a dynamic landscape equilibrium. These two approaches were examined for their potential to assure goshawk persistence in southeast Alaska. For comparative purposes, it is assumed that the total harvest of timber from southeast Alaska remains the same for both alternatives. Under that assumption, if stands are not harvested in one area, then a commensurate volume would need to be harvested from some other area.

Static habitat reserves—The concept of habitat conservation areas (HCAs), or reserves of protected habitat distributed across the landscape, is a management approach with a long history in wildlife conservation (Diamond 1975, 1976; Harris 1984; Noss and Harris 1986; Thomas et al. 1990), and has been recommended once for goshawk management in southeast Alaska (Crocker-Bedford 1993). In addition to reserve design criteria, the utility of habitat reserves depends on the relation between the habitat needs of the species and the factors influencing the availability of quality habitat. If a species' fitness depends on the abundance of a habitat that would become rare as a result of human land uses, then reserves form a necessary part of a conservation strategy. Alternatively, when land uses do not place important habitat in jeopardy, then reserves may not be necessary or warranted.

Evidence suggests that goshawks in southeast Alaska use and successfully reproduce in mosaics of forested habitat cover types occurring across the landscape. Productive old-growth forest provides important nesting habitat, but the acreage of productive old-growth forest needed for nesting is relatively small compared to the large areas used by goshawks. Goshawk use areas encompass a mosaic of forested habitat cover types (primarily productive old-growth and scrub forests) that likely provide foraging habitat, because landscapes with high amounts of natural edge are not selectively avoided. These patterns suggest that goshawks use some habitats not at risk from silvicultural treatments (e.g., productive old-growth forest in protected riparian corridors, scrub forest, etc.), because about 46 percent of goshawk use of old-growth forest occurs in productive old growth not suitable for timber harvest. Secondly, the mixture of habitats within a goshawk use area may influence the relative value of productive old-growth forest to goshawks. In landscapes with lower quality alternative habitats (e.g., rock and ice, clearcuts), any reduction of productive old-growth forest may have greater relative effects than in landscapes with higher quality alternative foraging habitat (e.g., scrub forests containing a fine-scale mosaic of productive old-growth). Thus, the extent of productive old-growth forest necessary for individual goshawks likely varies across the landscape. Given observed landscape patterns, if spatially static reserves are a component of landscape conservation strategy (although habitat composition of reserves is not static but rather very dynamic because of natural forest processes discussed earlier), then goshawk persistence likely will benefit from more and larger reserves in landscapes that have a greater proportion of the forested land base in early seral stand conditions.

Disturbance ecology-based matrix management—Habitat needs for a species may be strongly linked to specific structural features. When natural disturbance processes are considered, conservation may dictate reliance on an extensive area of constant habitat change (e.g., a dynamic landscape equilibrium), such as the conservation strategy for the California spotted owl (Verner et al. 1992) or northern goshawk in the Southwest (Crocker-Bedford 1990, Reynolds et al. 1992), rather than a static reserve design.

In the most general sense, we hypothesize that management strategies that do not employ reserves, but rather provide suitable habitat throughout a larger area such as all lands available for timber harvest, will lead to higher persistence probabilities than a reserve-based approach. This conclusion assumes that our hypotheses about non-clearcut silviculture are correct, and also stems from our current inability, due to lack of knowledge, to accurately define the size and composition of a reserve system adequate to sustain a well distributed goshawk population. However, in landscapes (management areas or Value Comparison Units) where past timber harvest has removed over one-third of the productive old-growth forest component, reserves may be an important complementary component of a conservation strategy designed to protect sufficient productive old-growth forest necessary to achieve a dynamic equilibrium mosaic (e.g., 300-year rotation on all productive old-growth forests).

Goshawk conservation strategies and landscape risk—A goshawk conservation strategy, then, will consider two basic questions: (1) What does a habitat reserve strategy provide for this species and its prey (and what are the tradeoffs in alternative size and placement)? and (2) Is there an alternative landscape conservation approach other than reserves that also would meet conservation objectives? Throughout this assessment, we have emphasized that productive old-growth forest is a critical component of goshawk habitat use, and that the amount of this cover type needed likely depends on the landscape context—what occurred naturally in the past and currently exists. Owing to the high variability in landscapes across the Tongass, a specific approach providing the highest long-term probability of persistence in one landscape may not be the most effective approach in another landscape. Thus, judicious use of both reserves and dynamic landscape strategies depends on local landscape conditions and habitat cover type composition.

Based on landscape context, then, a management approach across the Tongass emphasizing reserves in areas with high levels of past or currently projected extensive timber harvest (e.g., Value Comparison Unit-sized units currently exceeding 13 percent of productive old-growth forest land or planned harvest exceeding 33 percent by 2055), and long rotation or uneven-aged management schemes elsewhere, likely will provide the highest persistence probability. This hypothesis assumes that reserve placements and silvicultural prescriptions consider both goshawk habitat needs within the context of existing conditions and the desired long-term landscape habitat pattern. This hypothesis also assumes a hierarchy of landscapes (or ecosystems), with larger scales predominating, and that landscapes judged necessary to be managed as reserves are not subject to any further timber management. If our judgments regarding stand-scale uneven-aged management treatments are correct, then they may be used to sustain important structural characteristics to support goshawk use within the matrix among reserves, and in other landscapes where reserves are not needed.

Where a reserve strategy is used, the size, habitat composition, and geographic distribution of reserves must be prescribed. Currently, local Tongass data are insufficient to develop an optimum design, and therefore a combination of the available data and the concepts discussed here are necessary to guide application of reserve design. In areas of extensive past timber harvest (i.e., exceeding the 13-percent threshold shown in tables 26, 27), larger reserves that encompass considerable productive old-growth forest should most effectively increase goshawk persistence. In areas where the extent of past timber management is low to moderate, and the availability of suitable alternative foraging habitats in diverse landscapes and with a variety of vegetation types is relatively high, smaller reserves may provide persistence probabilities similar to large area reserve systems over the long term. These hypothesis are based on the following assumptions and observations:

1. Goshawks will obtain some resources from habitats outside reserves when those outside areas include foraging habitats such as scrub forest (with small inclusions of productive old-growth forest) and productive old-growth forests not available for timber harvest.

2. Goshawks will move among reserves dispersed across the landscape when habitat is not available within the matrix between reserves.

3. In areas with extensive past timber harvest, much of the landscape is now poor quality habitat for goshawks, and potential sites for reserves (i.e., productive old-growth forest) are concentrated in large blocks.

One of the most important criterion for selecting a landscape approach to conserve goshawk habitat is the estimated risk to long-term goshawk persistence. It is important to consider how potential changes in the way productive old-growth forests are harvested today may influence choices available for future goshawk management strategies. If Forest Service management continues even-aged, short-rotation silviculture, then options for a habitat conservation strategy of uneven-aged management and long-rotation, even-aged management diminish. As these options become less feasible, the reserve approach becomes an increasingly important management approach.

Reserves and long timber harvest rotations have complementary roles in minimizing risk. Reserves provide the means to increase the probability of persistence by providing high-quality habitats, especially in landscapes where options for long-rotation silviculture have been lost. The degree to which a reserve network reduces risk depends on placement, size, and composition, as discussed above. Long rotations minimize the local intensity of timber harvest and provide a forest age class distribution of stands more favorable to the goshawk. Long rotations maintain the majority (e.g., over 66 percent) of a landscape in a marginal or suitable habitat cover type for goshawk habitat use well distributed across a landscape and precludes the need to explicitly quantify, with insufficient information, the size, spacing and composition of reserves. However, both strategies can provide opportunities to apply adaptive management concepts and to learn more about goshawk habitat relations.

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Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.305 meter
1 acre = 0.405 hectare
1 mile = 1.609 kilometers
1 square mile = 2.59 square kilometers
424 board feet = 1 cubic meter
1 cubic foot = 0.028 cubic meter
1 ounce = 28.35 grams

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Appendix 1

Table 28—Breeding season percentage use (u) of cover types by goshawks and percentage availability (a) of cover types within the minimum convex polygon use area

Adult female	Habitat cover types[a]													
goshawk-ID	VH/H		M		L		S		MS		C		N	
	u	a	u	a	u	a	u	a	u	a	u	a	u	a
BBF1_99B	0.11	0.14	0.22	0.39	0.00	0.01	0.23	0.27	0.43	0.14	0.00	0.03	0.02	0.01
BJF1_93B	0.00	0.05	0.62	0.39	0.23	0.13	0.15	0.39	0.00	0.00	0.00	0.00	0.00	0.03
BJF1_94B	0.67	0.60	0.17	0.13	0.11	0.15	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.02
CCF1_94B	0.44	0.20	0.33	0.19	0.22	0.14	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.07
ECF1_99B	0.12	0.16	0.47	0.23	0.00	0.02	0.37	0.38	0.00	0.01	0.00	0.00	0.03	0.20
MCF1_94B	0.26	0.28	0.16	0.17	0.05	0.02	0.47	0.40	0.00	0.00	0.05	0.06	0.00	0.06
MPF1_94B	0.17	0.05	0.28	0.10	0.28	0.13	0.28	0.70	0.00	0.00	0.00	0.00	0.00	0.02
NCF1_99B	0.28	0.15	0.16	0.18	0.00	0.00	0.25	0.17	0.22	0.10	0.06	0.17	0.03	0.23
PBF1_94B	0.21	0.10	0.42	0.22	0.05	0.01	0.16	0.19	0.05	0.02	0.00	0.01	0.11	0.44
PRF1_95B	0.13	0.10	0.20	0.21	0.33	0.21	0.20	0.26	0.00	0.00	0.07	0.09	0.07	0.13
RNF1_93B	0.75	0.39	0.17	0.16	0.00	0.11	0.00	0.16	0.00	0.00	0.08	0.05	0.00	0.13
RRF1_95B	0.32	0.20	0.36	0.18	0.08	0.10	0.12	0.28	0.00	0.00	0.12	0.21	0.00	0.03
SLF1_92B	0.21	0.07	0.53	0.16	0.16	0.20	0.05	0.46	0.00	0.00	0.05	0.06	0.00	0.04
SLF1_94B	0.18	0.30	0.55	0.17	0.09	0.07	0.09	0.17	0.00	0.00	0.09	0.23	0.00	0.04
TRF1_95B	0.55	0.30	0.23	0.13	0.05	0.03	0.11	0.32	0.00	0.00	0.00	0.09	0.07	0.13
WPF1_95B	0.78	0.46	0.11	0.15	0.11	0.06	0.00	0.10	0.00	0.00	0.00	0.19	0.00	0.03

Adult male	Habitat cover types[a]													
goshawk-ID	VH/H		M		L		S		MS		C		N	
	u	a	u	a	u	a	u	a	u	a	u	a	u	a
BBM1_99B	0.11	0.12	0.37	0.26	0.02	0.00	0.27	0.39	0.10	0.02	0.00	0.00	0.14	0.19
BJM1_93B	0.19	0.12	0.41	0.19	0.15	0.18	0.26	0.45	0.00	0.00	0.00	0.04	0.00	0.01
BPM1_99B	0.67	0.58	0.14	0.16	0.14	0.11	0.05	0.06	0.00	0.00	0.00	0.06	0.00	0.02
ECM1_99B	0.30	0.24	0.30	0.32	0.03	0.03	0.20	0.24	0.03	0.00	0.03	0.03	0.10	0.14
FCM1_99B	0.16	0.13	0.16	0.19	0.00	0.01	0.42	0.36	0.00	0.00	0.00	0.00	0.26	0.30
HCM1_94B	0.18	0.16	0.00	0.10	0.05	0.01	0.05	0.07	0.00	0.00	0.68	0.64	0.05	0.00
LRM1_99B	0.11	0.06	0.24	0.17	0.03	0.00	0.45	0.22	0.00	0.00	0.00	0.00	0.18	0.53
MCM1_95B	0.42	0.20	0.25	0.18	0.08	0.06	0.25	0.40	0.00	0.00	0.00	0.16	0.00	0.00
MIM1_94B	0.08	0.10	0.17	0.13	0.33	0.16	0.42	0.48	0.00	0.00	0.00	0.11	0.00	0.03
MPM1_94B	0.16	0.13	0.21	0.09	0.26	0.14	0.37	0.39	0.00	0.00	0.00	0.01	0.00	0.24
NCM1_99B	0.28	0.11	0.13	0.20	0.02	0.04	0.16	0.15	0.13	0.06	0.10	0.07	0.18	0.37
RNM1_99B	0.39	0.41	0.29	0.15	0.06	0.04	0.13	0.17	0.03	0.00	0.10	0.10	0.00	0.14
RRM1_95B	0.45	0.20	0.17	0.16	0.03	0.11	0.31	0.46	0.00	0.00	0.03	0.05	0.00	0.02
SLM1_92B	0.44	0.33	0.31	0.14	0.14	0.08	0.03	0.04	0.03	0.00	0.06	0.40	0.00	0.01
TRM1_95B	0.28	0.24	0.24	0.13	0.00	0.03	0.32	0.36	0.00	0.00	0.04	0.09	0.12	0.15

[a]VH/H = very high and high volume class.
M = medium volume class.
L = low volume class.
S = scrub forest.
MS = mature sawtimber.
C = clearcut.
N = nonforest.
Cover types are further described in table 7.

Appendix 2

Table 29—Winter season percentage use (u) of cover types by goshawks and percentage availability (a) of cover types within the minimum convex polygon use area

Winter female goshawk-ID	Habitat cover type[a]													
	VH/H		M		L		S		MS		C		N	
	u	a	u	a	u	a	u	a	u	a	u	a	u	a
BBF1_99W	0.26	0.17	0.52	0.22	0.02	0.00	0.07	0.19	0.02	0.04	0.00	0.01	0.10	0.37
BJF1_99W	0.58	0.39	0.20	0.19	0.05	0.07	0.10	0.17	0.00	0.00	0.00	0.00	0.08	0.18
ECF1_99W	0.40	0.19	0.26	0.22	0.00	0.01	0.20	0.34	0.03	0.00	0.00	0.00	0.11	0.22
MCF1_99W	0.38	0.24	0.33	0.15	0.00	0.03	0.29	0.49	0.00	0.00	0.00	0.00	0.00	0.09
MPF1_99W	0.34	0.23	0.34	0.16	0.14	0.06	0.17	0.43	0.00	0.00	0.00	0.07	0.00	0.05
NCF1_99W	0.37	0.09	0.26	0.21	0.00	0.02	0.11	0.15	0.05	0.09	0.16	0.16	0.05	0.29
PBF1_99W	0.14	0.18	0.43	0.23	0.00	0.01	0.21	0.18	0.14	0.04	0.00	0.02	0.07	0.34
PRF1_95W	0.10	0.19	0.10	0.22	0.40	0.18	0.40	0.22	0.00	0.00	0.00	0.11	0.00	0.09
RNF1_99W	0.51	0.45	0.26	0.18	0.11	0.08	0.04	0.13	0.00	0.00	0.03	0.11	0.04	0.06
RRF1_95W	0.59	0.19	0.19	0.18	0.04	0.11	0.15	0.27	0.00	0.00	0.04	0.22	0.00	0.03
SLF1_9W	0.72	0.34	0.61	0.34	0.21	0.23	0.19	0.57	0.06	0.01	0.18	0.47	0.03	0.03
TRF1_99W	0.52	0.33	0.23	0.13	0.03	0.02	0.17	0.34	0.00	0.00	0.00	0.08	0.05	0.10
WPF1_95W	0.50	0.51	0.31	0.23	0.06	0.03	0.00	0.11	0.00	0.00	0.00	0.09	0.13	0.02

Winter male goshawk-ID	Habitat cover type[a]													
	VH/H		M		L		S		MS		C		N	
	u	a	u	a	u	a	u	a	u	a	u	a	u	a
BBM1_99W	0.23	0.18	0.38	0.30	0.00	0.01	0.21	0.25	0.08	0.07	0.03	0.02	0.08	0.17
BJM1_99W	0.21	0.14	0.42	0.20	0.05	0.14	0.30	0.47	0.00	0.00	0.02	0.03	0.00	0.03
BPM1_99W	0.56	0.57	0.15	0.17	0.03	0.08	0.18	0.10	0.00	0.00	0.09	0.06	0.00	0.02
ECM1_99W	0.28	0.22	0.39	0.30	0.00	0.02	0.06	0.21	0.00	0.07	0.06	0.05	0.22	0.13
FCM1_99W	0.37	0.12	0.26	0.21	0.00	0.02	0.32	0.37	0.00	0.00	0.00	0.00	0.05	0.27
LJM1_99W	0.06	0.16	0.28	0.20	0.33	0.11	0.06	0.14	0.00	0.00	0.16	0.34	0.11	0.04
LRM1_99W	0.24	0.05	0.12	0.17	0.12	0.00	0.47	0.24	0.00	0.00	0.00	0.00	0.05	0.52
MCM1_95W	0.32	0.23	0.18	0.17	0.23	0.03	0.27	0.44	0.00	0.00	0.00	0.12	0.00	0.00
MPM1_99W	0.29	0.24	0.04	0.07	0.36	0.14	0.14	0.30	0.00	0.00	0.00	0.02	0.17	0.23
NCM1_99W	0.08	0.04	0.17	0.13	0.00	0.00	0.21	0.11	0.04	0.04	0.00	0.04	0.50	0.65
PBM1_99W	0.55	0.40	0.18	0.34	0.00	0.02	0.09	0.12	0.09	0.04	0.00	0.03	0.09	0.06
RNM1_99W	0.42	0.41	0.21	0.16	0.09	0.06	0.16	0.16	0.02	0.00	0.02	0.10	0.07	0.11
RRM1_95W	0.38	0.24	0.17	0.16	0.04	0.08	0.42	0.37	0.00	0.00	0.00	0.10	0.00	0.04
SLM1_99W	0.53	0.28	0.41	0.16	0.06	0.10	0.00	0.14	0.00	0.00	0.00	0.30	0.00	0.02
TRM1_95W	0.20	0.25	0.24	0.14	0.12	0.02	0.32	0.38	0.00	0.00	0.00	0.05	0.12	0.15

[a]VH/H = Very high and High volume class.
M = medium volume class.
L = low volume class.
S = scrub forest.
MS = mature sawtimber.
C = clearcut.
N = nonforest.
Cover types are further described in table 7.

Appendix 3

Table 30—Breeding season use (u) of landscape positions by goshawks and availability (a) of positions within the MCP use area

Breeding Female Goshawk-ID	Landscape Position									
	B1		B2		R		A		G	
	u	a	u	a	u	a	u	a	u	a
BBF1_99B	0.02	0.07	0.08	0.09	0.12	0.07	0.00	0.00	0.78	0.76
BJF1_93B	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	1.00	0.74
BJF1_94B	0.22	0.05	0.06	0.08	0.11	0.29	0.00	0.04	0.61	0.54
CCF1_94B	0.00	0.00	0.00	0.00	0.67	0.26	0.00	0.06	0.33	0.67
ECF1_99B	0.00	0.00	0.00	0.00	0.05	0.10	0.17	0.29	0.78	0.60
MCF1_94B	0.00	0.00	0.00	0.00	0.16	0.15	0.05	0.12	0.79	0.74
MPF1_94B	0.39	0.03	0.06	0.03	0.28	0.28	0.00	0.00	0.28	0.65
NCF1_99B	0.00	0.00	0.00	0.00	0.06	0.14	0.00	0.00	0.94	0.86
PBF1_94B	0.00	0.18	0.21	0.17	0.11	0.11	0.05	0.12	0.63	0.42
PRF1_95B	0.07	0.00	0.07	0.03	0.20	0.28	0.00	0.00	0.67	0.69
RNF1_93B	0.42	0.06	0.00	0.04	0.17	0.31	0.00	0.09	0.42	0.49
RRF1_95B	0.24	0.02	0.16	0.02	0.28	0.27	0.00	0.04	0.32	0.65
SLF1_92B	0.42	0.07	0.26	0.07	0.05	0.27	0.00	0.00	0.26	0.59
SLF1_94B	0.27	0.08	0.00	0.08	0.55	0.30	0.00	0.03	0.18	0.51
TRF1_95B	0.00	0.00	0.00	0.00	0.18	0.24	0.14	0.30	0.68	0.46
WPF1_95B	0.00	0.02	0.00	0.02	0.33	0.22	0.00	0.00	0.67	0.74

Breeding Male Goshawk-ID	Landscape position									
	B1		B2		R		A		G	
	u	a	u	a	u	a	u	a	u	a
BBM1_99B	0.00	0.00	0.02	0.00	0.13	0.08	0.08	0.27	0.78	0.65
BJM1_93B	0.00	0.00	0.04	0.00	0.44	0.19	0.00	0.00	0.52	0.81
BPM1_99B	0.10	0.14	0.14	0.13	0.29	0.10	0.00	0.00	0.48	0.62
ECM1_99B	0.00	0.03	0.00	0.05	0.20	0.09	0.07	0.13	0.73	0.70
FCM1_99B	0.00	0.00	0.00	0.00	0.07	0.12	0.40	0.38	0.53	0.50
HCM1_94B	0.05	0.08	0.00	0.07	0.09	0.20	0.00	0.00	0.86	0.65
LRM1_99B	0.00	0.13	0.05	0.11	0.08	0.11	0.26	0.32	0.61	0.33
MCM1_95B	0.00	0.00	0.00	0.00	0.25	0.20	0.00	0.00	0.75	0.80
MIM1_94B	0.00	0.10	0.08	0.07	0.08	0.12	0.00	0.00	0.83	0.71
MPM1_94B	0.05	0.11	0.11	0.11	0.42	0.17	0.00	0.00	0.42	0.62
NCM1_99B	0.00	0.00	0.00	0.00	0.18	0.15	0.21	0.26	0.61	0.59
RNM1_99B	0.06	0.02	0.03	0.02	0.52	0.34	0.00	0.07	0.39	0.56
RRM1_95B	0.00	0.00	0.00	0.00	0.21	0.33	0.03	0.01	0.76	0.65
SLM1_92B	0.50	0.20	0.17	0.16	0.06	0.22	0.00	0.00	0.28	0.41
TRM1_95B	0.00	0.00	0.00	0.00	0.08	0.22	0.40	0.26	0.52	0.52

B1 = Beach :0-500 feet
B2 = Beach 500-1000 feet
R = Riparian stream buffers
A = Alpine
G = General upland forest

Cover types are further described in table 7.

Appendix 4

Table 31—Winter season use (u) of landscape positions by goshawks and availability (a) of positions within the MCP use area

Winter Female Goshawk-ID	Landscape position									
	B1		B2		R		A		G	
	u	a	u	a	u	a	u	a	u	a
BBF1_99W	0.02	0.03	0.02	0.03	0.17	0.10	0.05	0.26	0.74	0.58
BJF1_99W	0.10	0.08	0.10	0.06	0.28	0.24	0.03	0.17	0.50	0.46
ECF1_99W	0.03	0.01	0.03	0.01	0.20	0.10	0.11	0.31	0.63	0.57
MCF1_99W	0.00	0.00	0.00	0.00	0.52	0.24	0.00	0.00	0.48	0.76
MPF1_99W	0.14	0.03	0.06	0.02	0.31	0.13	0.00	0.07	0.49	0.74
NCF1_99W	0.00	0.00	0.00	0.03	0.32	0.13	0.00	0.00	0.68	0.83
PBF1_99W	0.07	0.04	0.07	0.03	0.07	0.15	0.14	0.27	0.64	0.50
PRF1_95W	0.00	0.00	0.00	0.00	0.60	0.29	0.00	0.00	0.40	0.71
RNF1_99W	0.22	0.07	0.09	0.05	0.38	0.22	0.00	0.03	0.31	0.63
RRF1_95W	0.04	0.02	0.04	0.02	0.63	0.26	0.00	0.04	0.30	0.66
SLF1_9W	0.59	0.27	0.36	0.20	0.41	0.36	0.00	0.03	0.64	1.15
TRF1_99W	0.00	0.00	0.00	0.00	0.17	0.21	0.14	0.27	0.69	0.50
WPF1_95W	0.25	0.02	0.13	0.02	0.31	0.18	0.00	0.00	0.31	0.78

Winter Male Goshawk-ID	Landscape position									
	B1		B2		R		A		G	
	u	a	u	a	u	a	u	a	u	a
BBM1_99W	0.03	0.04	0.08	0.05	0.23	0.09	0.10	0.14	0.56	0.67
BJM1_99W	0.02	0.03	0.02	0.02	0.35	0.15	0.00	0.01	0.61	0.78
BPM1_99W	0.24	0.08	0.06	0.07	0.15	0.16	0.00	0.00	0.56	0.69
ECM1_99W	0.00	0.02	0.00	0.02	0.28	0.16	0.06	0.11	0.67	0.68
FCM1_99W	0.00	0.00	0.00	0.00	0.21	0.11	0.05	0.35	0.74	0.53
LJM1_99W	0.00	0.00	0.00	0.00	0.33	0.30	0.00	0.00	0.67	0.70
LRM1_99W	0.12	0.10	0.00	0.09	0.12	0.12	0.18	0.40	0.59	0.30
MCM1_95W	0.00	0.00	0.00	0.00	0.59	0.18	0.05	0.02	0.36	0.79
MPM1_99W	0.21	0.11	0.18	0.09	0.07	0.10	0.00	0.00	0.54	0.70
NCM1_99W	0.00	0.00	0.00	0.00	0.04	0.14	0.38	0.47	0.58	0.38
PBM1_99W	0.09	0.06	0.18	0.06	0.09	0.15	0.00	0.05	0.64	0.68
RNM1_99W	0.28	0.04	0.05	0.03	0.26	0.27	0.09	0.07	0.33	0.58
RRM1_95W	0.00	0.00	0.00	0.00	0.50	0.30	0.04	0.03	0.46	0.67
SLM1_99W	0.35	0.21	0.18	0.16	0.06	0.18	0.00	0.00	0.41	0.44
TRM1_95W	0.00	0.00	0.00	0.00	0.24	0.19	0.32	0.28	0.44	0.53

B1 = Beach 0-500 feet
B2 = Beach 500-1000 feet
R = Riparian stream buffers
A = Alpine
G = General upland forest
Cover types are further described in table 7.

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The conservation status of northern goshawks in southeast Alaska is examined through developing an understanding of goshawk ecology in relation to past, present, and potential future habitat conditions in the region under the current Tongass land management plan. The probability of persistence of goshawks has declined over the past 50 years owing to habitat loss and likely will continue to decline under current management plan regimes; however, the goshawk population likely is not in immediate peril. Reserves are most likely critical if extensive clearcut logging continues.

Keywords: Northern goshawk, *Accipiter gentilis laingi*, habitat, conservation, assessment, management.

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