Appendix AAI

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Research Progress Report

Goshawk Ecology and Habitat Relationships on the Tongass National Forest:

Selected Analyses and 1995 Field Season Progress Report

Kim Titus
Craig Flatten
Richard Lowell

Richard E Lowell

Grant SE-4-2
July 1996

STATE OF ALASKA
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DEPARTMENT OF FISH AND GAME
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GOSHAWK ECOLOGY AND HABITAT RELATIONSHIPS ON THE TONGASS NATIONAL FOREST

SELECTED ANALYSES AND 1995 FIELD SEASON PROGRESS REPORT

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Prepared by

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
DOUGLAS AND KETCHIKAN

GOSHAWK ECOLOGY AND HABITAT RELATIONSHIPS ON THE TONGASS NATIONAL FOREST

Selected Analyses and 1995 Field Season Progress Report

Kim Titus
Craig Flatten
Richard Lowell

July 1996

RESEARCH PROGRESS REPORT

STATE: Alaska **STUDY:** SE-4-2

COOPERATORS: US Forest Service, Alaska Region, Tongass National Forest, Pacific Northwest Forest and Range Experiment Station – Juneau Forest Sciences Laboratory, US Fish and Wildlife Service, Alaska Region.

STUDY TITLE: Goshawk Ecology and Habitat Relationships on the Tongass National Forest: Selected Analyses and 1995 Field Season Progress Report

AUTHORS: Kim Titus, Craig Flatten, and Richard Lowell

PERIOD: 15 March 1995–August 31, 1995

SUMMARY

In 1991 the Alaska Department of Fish and Game (ADF&G) and the USDA Forest Service (USFS) initiated a study of northern goshawk (*Accipiter gentilis*) ecology and habitat relationships on the Tongass National Forest in Southeast Alaska. In 1995 ADF&G, USFS, and US Fish and Wildlife Service (FWS) personnel completed the fourth field season of interagency goshawk nest searches on the Tongass. To date, 36 goshawk nesting areas have been identified in Southeast Alaska, and between 1991 and 1994 33 nesting areas were identified. Goshawk survey efforts increased annually during this period and, as a result, the documented number of active nests and cumulative nest areas also increased annually. This trend ended when the number of documented active nests declined from a high of 21 in 1994 to just 10 in 1995. Despite substantial efforts to locate nests in 1995, only 3 new nest sites were identified. Based on our search efforts, only 7 (23%) of 30 previously documented nest areas examined this year contained an active nest. These results support speculation that goshawk nesting densities and nest area reoccupancy rates are low on the Tongass National Forest. In 1995 10 documented nesting attempts produced 20 young with a mean productivity of 2.0 young per nest. Between 1991 and 1995 46 documented nesting attempts produced a total of 97 young at 33 nest areas with a mean productivity of 2.1 young per attempt (range = 0–3).

In 1995 ADF&G personnel captured and banded 22 goshawks (15 adults, 6 juveniles, 1 immature). Since 1992, 72 goshawks (35 adults, 32 juveniles, 5 immatures) have been captured and banded in Southeast Alaska. Of the 72 captured goshawks, 67 were fitted with radio transmitters (35 adults, 29 juveniles, 3 immatures). Using fixed-wing aircraft and standard aerial radiotracking techniques, 2333 goshawk relocation points were collected between June 17, 1992 and January 1, 1996, including 716 relocations collected during 1995. We analyzed 1210 relocation points from 52 goshawks (27 adults, 22 juveniles, 3 immatures) radiotagged at 19 Southeast Alaska nest sites between June 17, 1992 and January 1, 1995 for goshawk habitat selection and movement patterns. Field relocation data from 26 adult goshawks radiotagged at 17 nest sites in Southeast Alaska between 1992 and 1994 demonstrate that *A. g. laingi* does not exhibit long-range annual migration. Adult goshawks exhibited 2 separate patterns of seasonal movements. Some adults used winter and breeding season areas that overlapped extensively, while others used spatially separated winter and breeding season areas with little or no overlap.

For the larger area around nest sites, we described nesting habitat at 39 goshawk nests at 29 nest areas and tested whether land covertypes at 2 scales (30 acre and 160 acre) differed from other nearby forested habitats by analyzing plots on color and black-and-white aerial photographs.

We used aerial radiotelemetry relocations of adult goshawks to test patterns of habitat selection in pristine versus clearcut portions of the Tongass National Forest. We monitored 24 adult goshawks during the nesting (15 March–15 August) and winter seasons, representing 32 sampling units for log-ratio compositional analyses of habitat selection. Our analyses compared point estimates of habitat use with estimates of the seasonal use area of a bird as determined by the minimum convex polygon home range estimate. We used USFS timber and land-type maps within a geographic information system (GIS) to determine habitat covertypes, discern old-growth forest blocks, and buffer edges for interior old-growth versus edge old-growth habitat selection. During the nesting season 67% of all relocations were in productive upland old-growth forest or forested riparian ecotones according to GIS analysis. There was selection against early succession and clearcut covertypes. Based on a log-ratio compositional analysis, goshawks strongly selected for old-growth forest covertypes, compared to the availability of this habitat in goshawk use areas. We found similar selection for coarse-grained canopy (usually higher volume, old-growth forests) forests during the winter. We tested for differences in selection comparing 'nonproductive' forest, 'productive' forest <100 m from edge and 'productive' forest >100 m from edge. In both the nesting and winter seasons, we found strong selection for productive forest, but we were unable to demonstrate differences in selection for forest edges versus forest interior patches.

Using data collected from June 1992 through May 1995, we estimated the annual survival rates for 27 adult goshawks (15 males, 12 females) radiotagged across the Tongass National Forest using the staggered-entry design Kaplan-Meier estimator. The annual survival rate for 27 adult goshawks was 0.76 when pooling across years and sexes. Estimates of juvenile survival rates were not possible due to the large number of censored birds.

Key Words: *Accipiter gentilis, Accipitridae*, forest management, northern goshawk, raptor, Tongass National Forest.

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PART 1

1995 Field Season Report

INTRODUCTION

The northern goshawk is a species often associated with mature forests across its Holarctic range. In Southeast Alaska the goshawk is most often associated with old-growth coniferous forests, the most common forest type currently available in this region. Yet, forest structure, size, and composition vary widely across Southeast Alaska, and these habitats are believed to be of unequal value to goshawks. Prey availability, distribution, and density also vary widely, with some prey absent from portions of the forest. Forest management may also influence goshawks, largely in association with past and ongoing timber harvest that converts 10,000–15,000 acres of old-growth forest annually to a younger seral stage. Because factors of prey, habitat, and forest management affect goshawk populations, understanding these relationships is useful to ensure that a viable and well-distributed population is maintained across the Tongass National Forest. Our objective in this report is to summarize 1995 field season activities and other progress associated with ongoing ecological studies through 1996. We also report on adult goshawk survival rates, patterns of habitat selection within home ranges of radiotagged goshawks, and habitat associated with nesting areas based on aerial photography. These results are of interest for resource management.

OBJECTIVES

This progress report summarizes interagency northern goshawk fieldwork conducted between March 15 and August 31, 1995 and other progress associated with ongoing ecological studies. Specifically addressed are Jobs 1, 2, 3, 4, 6, and 7 of the Study Plan (ADF&G, 1993), as modified in subsequent years.

- Job 1 Locate additional goshawk nest sites and inventory known and suspected goshawk nesting areas annually.
- Job 2 Capture and radiotag goshawks.
- Job 3 Collect and analyze nest site habitat data.
- Job 4 Determine home range, patch size, and habitat associations of the goshawk.
- Job 5 Evaluate the diet of goshawks during the nesting period.
- Job 6 Determine the short-term dispersal distances and survival rates of juvenile goshawks.
- Job 7 Collect blood samples and morphometric samples from goshawks for analysis of subspecific variation.
- Job 8 Prepare goshawk habitat management considerations.

NESTING ACTIVITY

We define the nesting area as a forested stand and general area (e.g., approximately 20 ha) that may contain ≥1 known nest tree. Areas with aggressive adult behavior or the presence of fledglings also constitute a nesting area. Vague descriptions, repeated adult goshawk sightings in a specific local, or the presence of stick nests without additional evidence of nesting activity were not included in our criteria of a goshawk nesting area. We defined a nest site as a known goshawk nest tree and a 1-hectare area surrounding the tree (*cf.* Mosher et al. 1987).

Of the 36 goshawk nest areas documented on the Tongass National Forest since 1992, 21 (58%) were located during activities associated with timber sale preparation, and 15 (42%) were located as a result of searches unrelated to timber harvest. Survey efforts included nest searches in proposed timber harvest units as part of pre-sale goshawk inventories, searches at previously identified nest areas, searches at new locations where goshawks or evidence of nesting were observed or reported, and searches at randomly selected forested plots. Still other nests were located by tracking radiotagged adult goshawks to nesting areas that differed from that of the previous year.

Between 1991 and 1994, field activities and record reviews documented 33 northern goshawk nest areas in Southeast Alaska. With the discovery of 3 new nest areas in 1995, the cumulative number of documented nest areas increased to 36 (Table 1-1). In the Ketchikan, Stikine, and Chatham Areas of the Tongass National Forest, 9, 14, and 13 nest areas, respectively, have now been identified. At least 1 nest has been located at 34 (94%) of the 36 documented nesting areas. Nests were not located at 2 nest areas (Dewey Lake Trail, Skagway, and Game Creek, Chichagof Island); however, nesting activity was implied by aggressive behavior of adult goshawks and/or the presence of fledglings. Two potential nests areas (Falls Creek, Mitkof Island 1992 and Phocena Bay, Gravina Island 1994) were excluded from the list because, despite the presence of a single fledgling at each area late in the breeding season, no additional evidence indicated a nest site in these vicinities. Unsubstantiated reports of active nests at 2 additional sites that were subsequently clearcut have also been excluded from the list of known nest areas (Kake, Kupreanof Island 1989 and Cabin Creek, Mitkof Island 1980).

Despite substantial efforts to locate nests in 1995, we found only 10 active nest areas. These include 7 nests at previously documented nest areas and 3 nests at newly discovered nest areas. Nest searches, ranging from 1 visit lasting several hours to 10 or more visits over the course of the breeding season, were conducted at 30 of 33 previously identified nest areas, and only 7 (23%) contained active nests. Goshawk activity (e.g., responses, sightings) was detected at 7 other known nest areas where active nests were not found. Of the 10 active nest areas located in 1995, we found 4 by tracking radiotagged adult females to nests within previously identified nest areas, 3 by searching known nest areas, and 3 were new nest areas located this year. Of the 6 nests located without the aid of telemetry, we found 3 by adult responses to broadcast calls, 1 by unsolicited adult vocalizations, 1 by unsolicited juvenile food-begging vocalizations, and 1 by checking a nest that had been active the preceding year.

Goshawk survey efforts increased annually on the Tongass National Forest from 1990 to 1994. As a result, both the number of active nests found and the cumulative number of documented nest areas increased annually during this period. This trend ended when the number of documented active nests declined from a high of 21 in 1994 to just 10 in 1995 (Figure 1-1). Although the reason for this decline is unclear, the 1994 completion of timber harvest pre-sale work in some project areas probably resulted in an overall reduction in survey effort during 1995. As a result, fewer incidental goshawk observations and active nest sites were reported to ADF&G and Forest Service staff. While the completion of timber pre-sale work in some project areas may have reduced the number of active nest sites found, it is also possible that other factors, such as weather or fluctuations in prey abundance, adversely influenced goshawk reproduction, causing fewer nesting attempts in 1995.

In 1995 FWS staff conducted a separate but related series of surveys to assess the relative abundance of nesting goshawks on a portion of the Tongass National Forest. Using broadcast conspecific calls, FWS researchers surveyed 724 points in 62 plots, covering approximately 67km^2 of Land Use Designation (LUD) I wilderness and LUD II roadless areas in southern Southeast Alaska. Multiple goshawk responses were detected from a single adult at 4 stations in 1 plot for a basic detection rate of 1.6 percent. Although results were inconclusive, these researchers found that goshawk nests were rare in the LUD I and II lands surveyed in 1995, and they suggested there was no evidence these areas provide a significant reservoir of hawks to buffer potential losses in forests intensively managed for timber products (P. Schempf, et al. unpubl. rep.). These results further support speculation that goshawk-nesting densities are low on the Tongass National Forest.

NEST AREA REOCCUPANCY RATES

The difficulties associated with locating nests and accurately determining the activity status of known nest areas in the temperate rainforest environment characteristic of Southeast Alaska have been previously discussed (Titus et al. 1994). Goshawks often have several alternative nests located within territories, and the spacing and distribution of alternate nests varies widely among territories (Woodbridge and Detrich 1994). In the absence of intensive searches using systematic surveys covering broad areas, estimates of reoccupancy rates beyond the vicinity of known nest sites and nest areas are not currently possible. Preliminary data collected between 1992–1995 indicate that goshawk nest site and nest area reoccupancy rates in Southeast Alaska are low compared to those documented elsewhere.

ADF&G and Forest Service biologists documented 46 nesting attempts at 33 nest areas in Southeast Alaska between 1991 and 1995. Forty-two nesting attempts were documented at 29 nest areas that were checked for reoccupancy. Researchers disregarded 2 nest areas with no documented activity during this period, 1 area identified in 1994 but not checked in 1995, 1 site with 2 nests but no documented nest attempts, and 3 new areas located in 1995. Based on our search efforts, 13 (31%) of 42 attempts represented nest area reoccupancies. In a study conducted on the Kaibab Plateau in northern Arizona, 34 (92%) of 37 documented goshawk nest areas were reoccupied in a 2-year period from 1991 to 1992 (Reynolds et al. 1994). In northern California, Woodbridge and Detrich (1994) monitored 141 territory years at 28 goshawk territories and observed breeding attempts in 89 (63%).

In Southeast Alaska only 1 documented nest area had an active nest during each of 3 consecutive years (Blueberry Hill, Douglas Island 1993–95). The occupancy rate of individual nest trees was low. In only 1 of 13 consecutive year nest area reoccupancies was the same nest occupied both years (Duffield Peninsula, Barinof Island 1994 and 1995).

Goshawks have been radiotracked to nest sites ranging from ~100 meters to 43 km (26.9 mi) from that of the previous year. To determine if large-scale annual movements between alternate nest sites caused us to underestimate nest area reoccupancy rates, we compared consecutive year occupancy rates of nest areas where at least 1 member of a pair was radiotagged with nest areas where neither member of a pair was radiotagged. Twenty-six nesting attempts, each involving at least 1 radiotagged adult, were documented at 18 nest areas checked during consecutive years. Eight (31%) of these 26 nesting attempts were consecutive year nest area reoccupancies. Fifteen nesting attempts, involving adults not radiotagged, were documented at 13 nest areas that were checked during consecutive years. Five (33%) of these 15 nesting attempts were consecutive year nest area reoccupancies. Similar reoccupancy rates for radiotagged (31%) and non-radiotagged (33%) goshawks indicate that reoccupancy rates have not been grossly underestimated due to annual movements of nonradiotagged goshawks to alternate nest areas within territories. This also suggests that capturing and radiotagging goshawks have no detectable influence on pair bonding or movements between nesting areas.

In northern California, Woodbridge et al. (1994) found that goshawks typically have several alternative nests located within territories, with most having from 3 to 9. The mean distance between alternate nests in 65 nesting attempts was 273 m (SE = 68.6, range = 30–2066 m). In Southeast Alaska, however, the largest number of alternate nests documented at any of the 35 nest areas visited by ADF&G and Forest Service biologists was 4 (Port Refugio, Suemez Island).

NEST SITE PRODUCTIVITY

We calculated mean nest productivity by totaling the number of young (fledglings or nestlings) observed minus known mortalities and divided by the total number of active nests. Productivity estimates were confounded by the fact that visits to nest sites, and counts of young produced, were conducted during different stages in the nesting chronology. Some nest sites were visited on multiple occasions during both nestling and fledgling periods, while others were visited only during the nestling period. When possible, the number of surviving fledglings was used to calculate productivity rather than the number of nestlings observed in order to account for nestling and fledgling mortalities.

In 1995 10 documented nesting attempts produced 20 young with a mean productivity of 2.0 young/nest (Table 1–2). Nest productivity was calculated based on the observation of 17 fledglings at 8 nest sites and 3 nestlings at 2 nest sites. Because most nests located without the aid of radiotelemetry are discovered during the nestling or fledgling dependency periods, nest success and productivity are probably overestimated because nesting attempts that fail before the nestling stage and mortalities occurring after fledging are less likely to be detected (Woodbridge and Detrich 1994). One fledgling mortality and 2 nestling mortalities were documented during the 1995 field season.

Annual nest productivity in Southeast Alaska was relatively consistent from 1991 to 1995, with a 5-year mean of 2.0 young/nest (range = 1.8–2.3). During this period 46 documented nesting attempts produced 97 young (either fledglings or nestlings) at 33 nest areas for a mean productivity of 2.1 young per attempt (range = 0–3). Ninety-eight percent of observed nesting attempts were successful. One nest failure during the egg-laying or incubation period was documented at Port Refugio, Suemez Island (1994). Goshawk nest productivity figures for Southeast Alaska are comparable to those reported for other regions: Interior Alaska, 2.0 young/nest (McGowan 1975); Oregon, 1.7 young/nest (Reynolds and Wright 1978); California, 1.7 young/nest (Bloom et al 1986); Nevada, 2.2 young/nest (Younk and Bechard 1994); California, 1.9 young/nest (Woodbridge and Detrich 1994).

Birds Captured

In 1995 ADF&G personnel captured, radiotagged, and/or banded 22 goshawks in Southeast Alaska, including 15 adults and 6 juveniles captured at 9 nest sites and 1 immature female captured during winter while raiding domestic fowl. Fifteen of these 22 goshawks were first time captures (8 adults, 6 juveniles, 1 immature) and 7 were adults (4 females, 3 males) captured on at least 1 previous occasion (Table 1–3). Radio transmitters were attached to 14 of the 15 goshawks captured for the first time and were replaced on the 7 recaptured adults.

Since 1992 ADF&G personnel have captured and banded 72 goshawks in Southeast Alaska, including 35 adults, 32 juveniles, and 5 immatures. Of these, 67 were fitted with radio transmitters (35 adults, 29 juveniles, and 3 immatures) including 61 (33 adults, 28 juveniles) captured at nest sites, and 6 (2 adults, 1 juvenile, 3 immatures) captured away from nest sites.

Nest and Nest Site Habitat Data

Job 3 of the study plan requires the development and application of a protocol for describing the vegetative and topographic attributes at goshawk nests and nest sites in Southeast Alaska. In 1995 a protocol was developed using standard field techniques (e.g., Mosher et al. 1987, Bonham 1989) for collecting data on nest and nest site habitat attributes. Data was collected from 10 nest sites at 7 nest areas located in the Ketchikan and Stikine Areas of the Tongass National Forest. Data collection will continue and an analysis of nest site habitat attributes will be conducted when we have sampled an adequate number of nest sites.

A preliminary analysis of 35 of the 36 documented nest areas in Southeast Alaska reveals that 33 (94 %) occur in productive old-growth forest while 2 (6 %) occur in mature second-growth forest >90 years of age. One of the 2 nest areas located in mature second growth (Blueberry Hill, Douglas Island) contains a residual old-growth component.

FWS GOSHAWK SURVEYS IN LUD I AND LUD II AREAS

One principal criticism of the current cooperative goshawk study has been the potentially biased manner in which many of the goshawk nest sites under study have been located. Twenty-one (58%) of 36 documented nest areas in Southeast Alaska were located during activities associated with timber management, while 15 (42%) were located as a result of searches unrelated to timber management. During the 1995 breeding season, the FWS, in response to this criticism, conducted systematic surveys for goshawks in wilderness and roadless lands on the Tongass National Forest. In an effort to determine representative detection rates for goshawks in the coastal forests of Southeast Alaska, researchers used broadcast tape-recorded conspecific calls and standardized survey methods to locate goshawks and their nests. In conjunction with the taped-broadcast surveys, attempts were made to quantify goshawk prey species and habitat characteristics at each broadcast point.

GENETIC ANALYSIS

Ornithologists generally recognize that the Northern Goshawk is comprised of 3 subspecies in North America. Whaley and White's (1994) recent analysis of goshawk morphological measurements support designation of these 3 subspecies. Taverner (1940) originally described *A. g. laingi* as a distinct subspecies with the type specimen collected at Massett, Queen Charlotte Islands, British Columbia. After examining goshawks collected in Southeast Alaska, Webster (1988) reported that, based on the dark coloration of these specimens, the range of *A. g. laingi* extends north from the Queen Charlotte Islands as far north as Baranof Island and Taku Inlet. The U.S. Department of Interior's Habitat Management Series for Unique or Endangered Species Report Nr. 17 (Jones 1981) shows the range of *A. g. laingi* extending north to Prince William Sound. Although sample sizes were limited, a preliminary ADF&G analysis of morphological measurements and plumage characteristics from 35 goshawks captured at nesting sites across Southeast Alaska also supports designation of *A. g. laingi* as a distinct subspecies (Titus et al. 1994).

In addition to morphological measurements, since 1992 ADF&G biologists have collected blood samples from >60 goshawks captured at nest sites in Southeast Alaska. These include 11 blood samples collected in 1995. Through a cooperative effort with the U.S. Fish and Wildlife Service, ADF&G staff also obtained morphological measurements and 3 blood samples from 5 immature goshawks captured in Southcentral Alaska during

1995. These samples will be useful for comparing the morphology and genetic makeup of goshawks from Southeast Alaska to those from other regions.

Forty-nine blood samples from Southeast Alaska goshawks were sent to Drs. Thomas A. Gavin and Bernie May of Cornell University who analyzed DNA from goshawk populations across North America to assess genetic variation and taxonomy of *Accipiter gentilis* in North America. These researchers used a number of different molecular techniques to assay genetic variation in goshawks including allozymes, random amplified polymorphic DNA (RAPDs), restriction fragment length polymorphism (RFLPs) of monomorphic RAPD-generated bands, and microsatellites.

In a report to Arizona Department of Game and Fish, these researchers concluded that based on DNA analysis *A. gentilis* does not exhibit or does not have as much genetic variation as most other birds studied. It is not known whether this low level of variation is typical of hawks in general or of the genus *Accipiter* or only of this particular species. They caution, however, that allozymes would have provided a better assay than any of the DNA techniques tried, but because of logistical constraints in the field, this technique is not practical. While it is possible for 2 or more conspecific populations to be significantly different genetically, the difference may not be detected because of a lack of suitable genetic markers. Therefore, these researchers caution that their conclusions should be considered as tentative and conservative (Gavin and May 1996).

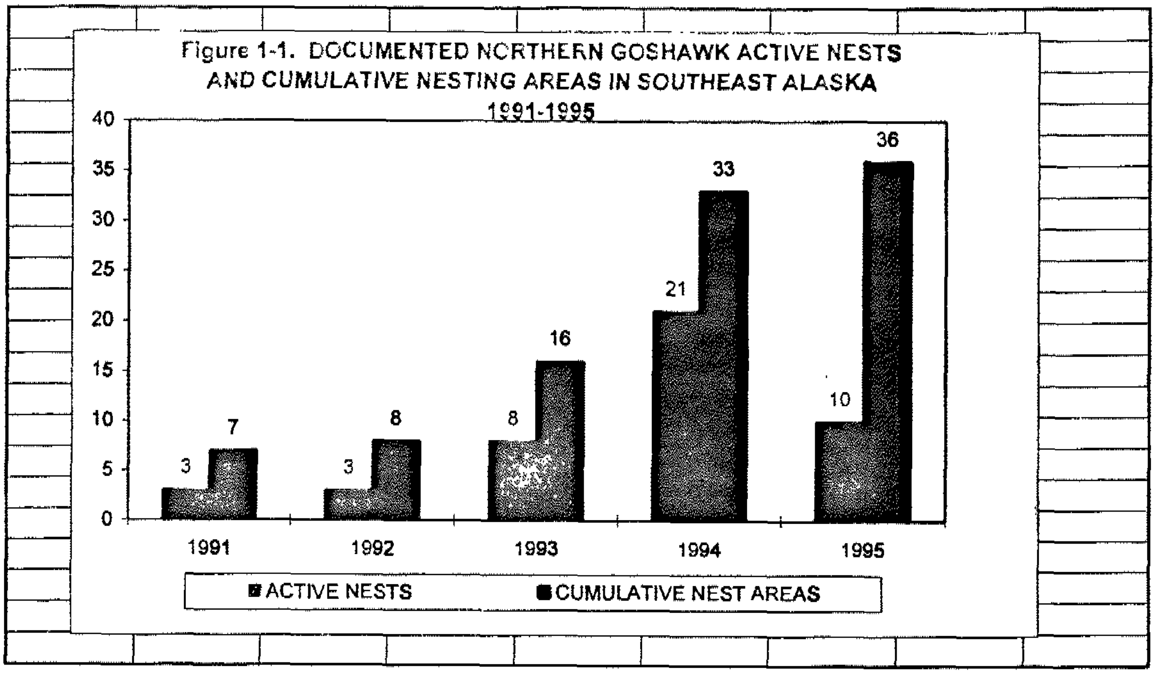

Fig 1-1. Documented northern goshawk active nests and cumulative nesting areas in Southeast Alaska, 1991–1995.

Table 1-1. 1995 Status of known northern goshawk nest sites in Southeast Alaska.

A. Ketchikan Area

Nest Area	Status
Port Refugio, Suemez Island	Site visited on March 27, July 18, and August 16, 1995. 1994 and 1989 nests inactive. Two units adjacent to 1994 nest were clearcut in February and March, 1995. No activity observed.
Sarheen, Prince of Wales Island	Site visited on June 7, July 20 and 26, August 1 and 9, 1995. No activity observed.
Sarkar Lake, Prince of Wales Island	Site visited on May 23, July 20 and 28, 1995. 1992 nest inactive. No activity observed.
Logjam Creek, Prince of Wales Island	Site visited on May 2, 22, and 23, and July 18 and 28, 1995. 1993 nest inactive. No activity observed.
Butterball Lake, Heceta Island	Site visited on July 27, 1995. 1994 nest inactive. Remains of 1994 tagged adult female (1992 Sarkar Lake adult) recovered on Heceta Island on March 13, 1995. Last radio signal for 1994 adult male was on Heceta Island on August 31, 1994.
Traitors Creek, Revillagigedo Island	1995 nest located on April 24, ~100m from 1994 nest by tracking tagged adult female. Adult male tagged and adult female tag replaced on June 27. Female fledgling tagged on August 11. 2 fledglings observed.
Convenient Cove, Hassler Island	Site visited on April 4, 13 and 26, June 28, 29, and 30, and July 18, 19, and 28, 1995. 1994 nest inactive. Adult goshawk observed in flight at site on April 26, 1995. Recent Stellers's jay pluck found in nest stand. No other activity observed.
Margaret Lake, Revillagigedo Island	Site visited on April 5 and 18, May 22 and 23, June 26, 27, and 28, July 17, 20, and 27, and August 16, 1995. 1994 nest inactive. Goshawk observed chasing ravens over site on April 5, 1995. Red-tailed hawks observed in vicinity on several dates in spring and summer. Second inactive nest located in 1994 nest stand on April 18, 1995. No other activity observed.
Rio Roberts Creek, Prince of Wales Island	New site in 1995. Active nest located on June 14 after adult female wail call was heard during songbird point count survey. Adult female and male tagged on June 29. Three nestlings present. Remains of 1 nestling found below nest on July 21. Female and male fledglings tagged on August 8.

Table 1-1. Continued

B. Stikine Area

Nest Area	Status
Big John Creek, Kupreanof Island	Site visited on June 16, 1995. 1992 and 1993 nests inactive. No activity observed.
Rowan Creek, Kuiu Island	Site visited on May 18 and 19, 1995. 1993 nest inactive. Unmarked adult male flew in silently in response to playback recording on May 18. Remains of adult male tagged at this site in 1993 were recovered ~4.5 km. from the nest site May 18.
Mossman Inlet, Etolin Island	1986 nest area inactive in 1992 and 1993. Not checked in 1994 or 1995.
Starfish, Etolin Island	Site visited on June 24, 1995. 1991 nest inactive. No activity observed.
Upper Totem Creek, Kupreanof Island	Site visited on June 20, 1995. Two inactive nests located in 1993 were also inactive during 1994 and 1995.
Mitchell Creek, Kupreanof Island	1995 nest located on June 29, ~200m from 1994 nest after adults responded to playback calls. Unmarked adult male tagged on July 9, 1995 (1994 adult male was not tagged). Adult female was not captured in 1995 (she was tagged at this site in 1994, but dropped tail-mounted transmitter). Two nestlings observed. Remains of 1 nestling found below nest tree on September 12. Fledging status of other young unknown.
Mountain Point, Kupreanof Island	Site visited on June 15, 1995. 1994 nest inactive. Adult female tagged at this site in 1994 died and was recovered on May 9, ~4 km. from 1994 nest. Radio signal from the adult male tagged with a tail-mounted transmitter in 1994 was static October 5 - November 28, 1994 on a ridge above the site. This transmitter presumably failed before it could be recovered.
Duncan Creek, Kupreanof Island	Site visited on June 14 and July 11, 1995. 1994 nest inactive. No activity observed.
Totem Camp, Kupreanof Island	Site visited June 19, 1995. 1994 nest inactive. No activity observed.
East Site, Bay of Pillars, Kuiu Island	1995 nest located on May 19, ~125m from 1994 nest by tracking tagged adult female to nest (1993 Rowan Creek adult). Adult male and female radios replaced on July 6. Both birds nested at this site in 1994. Three nestlings observed. All fledged on July 6.
West Site, Bay of Pillars, Kuiu Island	1995 nest located on July 7, ~150m from 1994 nest after unmarked adult female responded to playback recording. Radio signal from the 1994 adult female (1993 Big John Creek adult) last heard on October 7, 1994 at Bay of Pillars. New 1995 adult female tagged on July 8. Unmarked adult male was tagged on July 9 (1994 adult male was not tagged). One nestling observed; fledging status unknown.
Cat Creek, Cape Fanshaw	Site visited on June 1, 1995. 1994 nest inactive. No indication of recent activity.
Negro Creek, Port Houghton	Site visited on May 31, 1995. Adult female wail calls heard as an adult male departing the reported 1994 nest stand. No additional signs of nesting activity observed. Located reported 1994 nest tree, however, no nest visible. Site occupied in 95 but nesting status uncertain.
Sanborn Canal, Port Houghton	Site visited on June 3, and 5, 1995. 1994 nest inactive. No indication of recent activity.

Table 1-1. Continued

C. Chatham Area

Nest Area	Status
Dewey Lake Trail, Skagway	Active in 1985. Site not checked in 1995. Recent status unknown..
Ready Bullion Creek, Douglas Island	Site visited on July 8 and August 8, 1995. Possible response to broadcast calls on July 8. Separate unconfirmed reports of adult and fledgling observations in 1995. 1991 and 1992 nests inactive.
Blueberry Hill, Douglas Island	Site active for 3consecutive years. Active nest found on April 18, after walking in on radiotagged adult female. Pair reoccupied 1993 nest in 1995. Adult radios changed on June 29. Pair successfully fledged two juveniles in early July but they disappeared soon after.
Nugget Creek, Mendenhall Glacier	Site visited and intensively searched on May 7, and July 10. 1993 and 1994 nests inactive. Radiotagged adult female died during February, 1995. Radiotagged adult male frequented the 1993-94 nest stand during the early 95 breeding season, however, no signs of breeding activity were detected.
Point Bridget, Echo Cove	Site visited and intensively searched on June 24, July 11, 13, and 14. An adult male responded to broadcast calls at inactive 92 nest on June 24. Adult vocal response to broadcast calls between 92 and 93 nests on July 13. Jays mimicking (unsolicited) goshawk alarm and wail calls. Adult goshawk breast feather and numerous thrush and grouse plucks on trail. Site occupied in 95 but nesting status uncertain.
Eagle Creek, Douglas Island	Site visited on April 26, June 14, and July 17, 1995. 1993 nest inactive. Radiotagged adult female moved to Fish Creek site in 1994. Adult males' radio failed in January 1995. No sign of activity in 95.
Fish Creek, Douglas Island	Active nest found on April 19 after walking in on radiotagged adult female. 1995 nest located ~125m south of 94 nest. Adults radios changed on July 3. Pair successfully fledged 2 young. One fledgling found dead near base of nest tree and second juvenile (female) captured and radiotagged on August 1.
Mud Bay River, Chichagof Island	Site visited on July 10, 1995. 1993 nest inactive. Adults and fledglings observed in June and July of 1994 but nest was never located. No activity observed in 1995.
Lace River, Berners Bay	Site visited on May 23,1995. 1994 nest inactive. Signal from adult female last heard in October 1994. Radiotagged adult male frequented the 1994 nest stand early in 95 breeding season, however, no active nest found was found.
Distin Lake Trail, Admiralty Is.	Active nest in 1994. Site not checked in 1995.
Duffield Peninsula (Rodman Creek), Baranof Island	Site visited on July 29, 1995. 1994 nest occupied again in 1995. Two nestlings observed in nest.
Pavlov River, Chichagof Island	New site located on July 26, 1995 after adult and fledglings responded to broadcast calls. Active nest located on July 27. Three fledglings observed. Fledgling female tagged on July 27. Adult female tagged on July 28.
Game Creek, Chichagof Island	New site located on July 27, 1995 after adult female was observed perched along roadway and juveniles were heard foodbegging nearby. Nest not located but adults and three fledglings observed in vicinity repeatedly over 3 week period in July-August. Fledgling female tagged on August 4. Adult female tagged on August 16.

Table 1-2. Northern goshawk productivity at Southeast Alaska nest sites in 1995.

USFS Area	Nest Site	# of Young[1]	Comment
Ketchikan	Traitors Creek, Revillagigedo Island	2	2 nestlings; both fledged
	Rio Roberts, Prince of Wales Island	2	3 nestlings; 1 died, 2 fledged
Stikine	East Bay of Pillars, Kuiu Island	3	3 nestlings; all fledged
	West Bay of Pillars, Kuiu Island	1	1 nestlings; fledging status unkn.
	Mitchell Creek, Kupreanof Island	1	2 nestlings; 1 died, 1 fledged
Chatham	Blueberry Hill, Douglas Island	2	2 nestlings; both fledged
	Fish Creek, Douglas Island	1	2 nestlings; both fledged, 1 died
	Duffield Peninsula (Rodman Creek), Baranof Island	2	2 nestlings; fledging status unkn.
	Pavlov River, Chichagof Island	3	3 fledglings observed
	Whitestone, Chichagof Island	3	3 fledglings observed
Total number of surviving young observed at 10 nests[1]		**20**	**Includes 17 fledglings and 3 nestlings**
Mean number of young/nest		**2.0**	

[1] Number of young equals number of fledglings minus known mortalities, otherwise, number of young equals number of nestlings minus known mortalities.

Table 1-3. Northern goshawks captured in Southeast Alaska in 1995.

A. Ketchikan Area

Nest Site	Age/Sex	Date	USFWS Band #/Leg	Previously Banded/Tagged?
Vallener Point, Gravina Island	immatue female	2/03/95	1807-57801 right	no
Traitors Creek, Revillagigedo Island	adult female	6/27/95	1387-64200 right	Traitors Creek 7/28/94
Traitors Creek, Revillagigedo Island	adult male	6/27/95	1807-41975 left	no
Traitors Creek, Revillagigedo Island	juvenile female	8/11/95	1807-57801 right	no
Rio Roberts Creek, Prince of Wales Island	adult female	6/29/95	1387-64205 right	no
Rio Roberts Creek, Prince of Wales Island	adult male	6/29/95	1807-41984 left	no
Rio Roberts Creek, Prince of Wales Island	juvenile female	8/08/95	1387-84701 left	no
Rio Roberts Creek. Prince of Wales Island	juvenile male	8/08/95	1807-41987 right	no

B. Stikine Area

Nest Site	Age/Sex	Date	USFWS Band#/Leg	Previously Banded/Tagged?
East Bay of Pillars, Kuiu Island	adult female	7/06/95	1387-64183 left	Rowan Creek 7/28/93
East Bay of Pillars, Kuiu Island	adult male	7/6/95	1807-41973 right	East Bay of Pillars 7/1/94
West Bay of Pillars, Kuiu Island	adult female	7/8/95	1387-64206 right	no
West Bay of Pillars, Kuiu Island	adult male	7/9/95	1807-41985 left	no
Mitchell Creek, Kupreanof Island	adult male	7/9/95	1807-41986 left	no

Table 1-3. Continued

C. Chatham Area

Nest Site	Age/Sex	Date	USFWS Band#/Leg	Previously Banded/Tagged?
Blueberry Hill, Douglas Island	adult female	6/29/95	1387-64177 left	Blueberry Hill 6/29/93, 6/23/94
Blueberry Hill, Douglas Island	adult male	6/29/95	1807-41956 right	Blueberry Hill 6/29/93, 6/23/94
Fish Creek, Douglas Island	adult female	7/3/95	1387-64182 left	Eagle Creek 7/23/93, Fish Creek 6/24/94
Fish Creek, Douglas Island	adult male	7/3/95	1807-41971 right	Fish Creek 6/24/94
Fish Creek, Douglas Island	juvenile female	8/1/95	1387-84717 right	no
Pavlov River, Chichagof Island	adult female	7/28/95	1387-84716 right	no
Pavlov River, Chichagof Island	juvenile female	7/27/95	1387-64191 right	no
Whitestone, Chichagof Island	adult female	8/16/95	1387-84719 right	no
Whitestone, Chichagof Island	juvenile female	8/4/95	1387-84718 right	no

PART 2

Goshawk Breeding Phenology

We estimated goshawk-nesting phenology in Southeast Alaska by backdating from estimated dispersal dates for 21 juveniles radiotagged at 15 nest sites between 1992 and 1994. Juvenile goshawks were considered to have dispersed when they moved >1.5 km (0.9 mi) from the nest without returning (Kenward, et al. 1993). Dispersal dates were estimated by averaging the date of the first relocation >1.5 km from the nest with the date of the last relocation <1.5 km from the nest. Age at dispersal was estimated by comparing observed morphological development of 14 juvenile goshawks at 9 nest sites with age-specific characteristics (McGowan 1975, Titus et al. 1994).

Mean estimated age at dispersal for 14 juveniles radiotagged at 9 nest sites in 1992 and 1993 was 82 days for females and 75 days for males (Titus et al. 1994). These are consistent with the 65–90 day range for juvenile goshawk dispersal age reported by Kenward et al. (1993). Fledging dates for Southeast Alaska juveniles were calculated using nestling periods of 36 days for males and 42 days for females. These are consistent with the 35–42 day range reported for the goshawk nestling period (McGowan 1975, Reynolds and Wright 1978, Newton 1979, Johnsgard 1990, Kenward et al. 1993, and Boal 1994). To determine the date of egg laying, we used an incubation period of 30 days (Beebe 1974, McGowan 1975, Reynolds and Wright 1978).

Relocation data from radiotagged Southeast Alaska goshawks indicate that adults begin to frequent nest stands in late February and early March. Pairs engage in courtship flight displays before and during nest repair (Beebe 1974). During the current Southeast Alaska study only 1 goshawk flight display has been documented. This flight display, involving an adult male, occurred on June 15, 1994 following a failed nesting attempt at a nest site near Port Refugio on Suemez Island.

For 21 juvenile goshawks radiotagged at 15 nest sites in Southeast Alaska between 1992 and 1994, mean estimated date of egg laying was May 4, ranging from April 12 to May 24. The mean estimated hatching date was June 3, ranging from May 12 to June 23. Mean estimated fledging date was July 13, ranging from June 23 to August 4. Mean estimated dispersal date for these 21 juveniles was August 21, ranging from August 2 to September 13 (Table2-1).

Table 2-1. Estimated northern goshawk breeding phenology in Southeast.[1]

Egg Laying	(12 April to 24 May)	Mean: 4 May
Hatching	(12 May to 23 June)	Mean: 3 June
Fledging	(23 June to 4 Aug)	Mean: 13 July
Dispersal	(2 Aug to 13 Sept)	Mean: 21 Aug

[1] Determined by backdating from estimated dispersal dates of 21 juveniles radiotagged at 15 sites between 1992 and 1994 using: incubation period (30 days); fledging (males 36 days, females 42 days); dispersal (males 75 days, females 82 days).

PART 3

Goshawk Movement Patterns

Before the current cooperative study, no information was available concerning the annual and seasonal movement patterns of goshawks inhabiting the Tongass. Between 1992 and 1994 ADF&G biologists radiotagged 52 goshawks in Southeast Alaska, including 27 adults and 22 juveniles captured at 19 nest sites and 3 immatures captured away from nests. Using fixed-wing aircraft and standard aerial radiotracking techniques (Kenward 1987), we collected 1617 radiotelemetry relocation points between June 17, 1992 and January 1, 1995. In contrast to ground-based tracking techniques, aerial tracking minimizes the number of occasions when radiotagged goshawks cannot be relocated due to long-range movements or restricted observer access. As a result of the current study, information is now available concerning annual and seasonal movement patterns of adult goshawks and movements of juvenile goshawks away from nests in Southeast Alaska.

ANNUAL MOVEMENTS

Several ornithologists have speculated about the migratory status of the Queen Charlotte goshawk (*A. g. laingi*) (Taverner 1940, Beebe 1974, Jones 1979, Webster 1988). Field relocation data from 26 adult goshawks radiotagged at 17 nest sites in Southeast Alaska between 1992 and 1994 demonstrate that (*A. g. laingi*) does not exhibit long-range annual migration. Some adults were monitored for >1 year for a combined total of 38 bird years. Of the 38 documented bird years, 28 involved birds successfully monitored throughout the winter which were nonmigratory. Of the remaining birds, 2 died in the fall, 6 were lost during fall or early winter (migratory status unknown), and 2 either dropped tail-mount radio tags or died (ADF&G unpubl. data). Two of the 6 adult goshawks whose radio signals were lost during fall or early winter were subsequently relocated the following spring with functioning radio transmitters. We could not determine if these 2 individuals moved outside Alaska, or if they remained in Alaska but moved beyond the range of aerial tracking flights.

Radiotelemetry data from adult goshawks captured and radiotagged at nest sites in Southeast Alaska confirm that the majority do not undergo long-range seasonal migration. Researchers studying goshawks elsewhere, however, have noted that migration is often tied to regional fluctuations in prey; winter irruptions sometimes occur due to reductions in prey availability (Mueller and Berger 1967, 1968, Beebe 1974, McGowan 1975, Doyle and Smith 1994).

SEASONAL MOVEMENTS

Adult goshawks radiotagged at nest sites in Southeast Alaska exhibited 2 separate patterns of seasonal movement. Some adults had winter and breeding season use areas that overlapped extensively, while others had spatially separated winter and breeding season areas with little or no overlap. Eleven (7 males, 4 females) of 15 adults radiotagged in 1992 and 1993 and monitored through the winter had breeding season and winter use areas which overlapped extensively. These birds merely extended the size of breeding season use areas during the nonbreeding season while maintaining a loose association with 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 8 adult males (75%) radiotagged at nest sites and monitored throughout the winter maintained loose year-round associations with their respective breeding season use areas. The 2 adult males with the largest documented winter movements away from breeding sites (94.5 km [58.7 mi] and 42.9 km [26.8 mi]) had both been deserted by females that selected new mates at different nesting territories. During the breeding season immediately following the desertion of their mates, these 2 males maintained use areas similar to those documented the preceding year but became nomadic during the ensuing winter. Despite intensive surveys of known nest areas, we could not determine if these 2 males successfully replaced deserting females or attempted to nest during the breeding season immediately following the desertion of their mates.

Radiotagged adult females exhibited both patterns of seasonal movement but had a greater tendency to be nomadic than did adult males. Four of 7 adult females (57%) radiotagged at nest sites in 1992 and 1993 and monitored throughout the winter had seasonal use areas that overlapped extensively. Three others (43%) had spatially separated winter and breeding season areas with little or no overlap. Adult females that used spatially separated seasonal use areas began movements from breeding areas to winter areas during or immediately following the fledgling dependency period. The maximum documented distance from the nest recorded for an adult female was 53.9 km (33.5 mi).

NEST SITE ABANDONMENT

Between 1992 and 1995 we documented 3 instances in which adult females abandoned nest sites during the fledgling dependency period. Following abandonment of nests, the adult females began movements toward winter use areas spatially separated from breeding season use areas. In all instances adult males continued to provide for fledglings until dispersal. Similar behavior has been documented in Cooper's hawks and may be associated with females in poor condition (Kelly and Kennedy 1993).

MATE AND SITE FIDELITY

Between 1992 and 1995 we documented 13 consecutive year nest area reoccupancies in Southeast Alaska. Both members of the previous years' nesting pair were present at 5 of 13 same-stand reoccupancies. At 2 of 13 same-stand reoccupancies, the identity of 1 adult was unknown. At 6 of 13 same-stand reoccupancies, the identity of both adults was known. During the same period we documented 4 instances in which individual birds nested in successive years but at different territories each year. All 4 instances involved radiotagged adult females that had spatially separated seasonal use areas. These females selected new mates and established breeding territories located within previously documented winter use areas. Distances between sequential year nests for these 4 females ranged from 3.2 km (2.0 mi) to 43 km (26.9 mi). Radiotagged adult males displayed greater site tenacity than did adult females. To date, no documentation shows an adult male's moving to a new breeding territory.

Our records of adult goshawk movements indicate a complex pattern of nomadism and site tenacity that differs between the sexes. In boreal owls (*Aegolius funereus*), pressures of food stress favor nomadism and nest site scarcity favors site tenacity resulting in different movement patterns for males and females: females exhibited nomadism while males exhibited greater site tenacity (Lundberg 1979, Lofgren et al. 1986).

JUVENILE MOVEMENTS AWAY FROM NESTS

In 1995, 6 fledgling goshawks (1 male and 5 females) were radiotagged at 5 nest sites in Southeast Alaska. Since 1992 ADF&G biologists have captured and banded 32 fledgling goshawks (10 males, 22 females) at 21 nest areas in Southeast Alaska. Radio transmitters were attached to 28 fledglings (8 males and 20 females) at 19 nest sites to gather information on habitat selection, short-term postfledging movements, and juvenile survival rates. Using fixed-wing aircraft, we monitored juvenile goshawks at irregular intervals throughout the winter or until signals were lost, tail feather radio packages were shed, or juveniles died. Weather and the availability of funding for aircraft charter dictated the timing, duration, and frequency of tracking flights. Dispersal was initiated when juveniles moved >1.5 km (0.9 mi.) from the nest and did not return for at least 2 days (Kenward, et al. 1993).

Twenty-three (5 males, 18 females) of 28 radiotagged juveniles had documented movements greater than 1.5 km from the nest. Of the remaining 5 juveniles, 4 could not be located after dispersing from nest sites, and 1 died during the fledgling dependency period. The maximum documented dispersal distance for each radiotagged juvenile was calculated by GIS as a straight line distance between the nest and the most distant relocation. The mean maximum distance from the nest for 23 juveniles relocated after dispersing from nest sites was 62.4 km (38.8 mi.) with a range of 11.6 km (7.2 mi.) to 162.4 km (101.0 mi.). Both the monitoring period and the number of relocations per juvenile varied greatly. The monitoring period for 23 juveniles successfully relocated after dispersing from nest sites ranged from 9 days to 319 days (mean 126 days). Mean and maximum distances from the nest are likely underestimated because transmitter failure or long-range movements beyond the range of aerial tracking flights probably prevented documentation of longer dispersal distances. Following initial nomadic movements away from the nest, juveniles often established use areas in late fall and winter where they could be consistently relocated until radio tags failed, were shed, or the juveniles died.

Of the 28 juveniles radiotagged between 1992 and 1995, 7 (25 %) were confirmed mortalities. The fates of the remaining 21 juveniles were not determined because 18 (64 %) either could not be relocated or were lost, while 4 (14 %) others either dropped tail-mounted transmitter packages or had transmitter packages that became stationary in remote, inaccessible locations. Because such a large percentage of juveniles had unknown fates, an accurate estimate of survival rates was not possible.

PART 4

Land Cover Habitat Associations of Northern Goshawk Nest Areas as Determined by Aerial Photography

INTRODUCTION

Suitable nesting areas are critical in the reproductive biology of all avian species. Birds of prey often select nesting sites in specific locations that provide security from weather and predators while being near suitable foraging areas. For birds of prey, these nesting areas often differ from the surrounding landscape and are not randomly placed even within otherwise suitable habitat (Newton 1979, Janes 1985). Examples of species with very specific nesting habitat associations include the peregrine falcon (*Falco peregrinus*) that uses cliff habitat with appropriate ledges and the bald eagle (*Haliaeetus leucocephalus*) whose nest areas are often in the largest available trees near water.

The nesting habitat associations of forest hawks (*Accipitridae*) are more difficult to understand because these species have broad distributions and are capable of building nests in many forest conditions and their selection for certain nest areas are less obvious. Nest site habitat selection by forest hawks may take place at a variety of 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 (*Accipiter gentilis*) at the scale of the nest tree and associated nearby habitat (e.g., Hennesey 1978, Reynolds et al. 1982, Hall 1984, Moore and Henny 1983, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Hayward and Escano 1989). Few studies evaluated goshawk nesting habitat at a broader scale and with comparisons of available habitat to make inferences about habitat selection. In the eastern deciduous forest biome microhabitat features are important parameters in nest site selection of goshawks when compared with random sites (Speiser and Bosakowski 1987). Falk (1990) found goshawks selecting nesting areas in relatively contiguous tracts of forested land and away from forest openings and human activity, compared to random samples of the landscape.

Suitable nesting habitat is critical in the reproductive biology of goshawks. Nest areas are occupied by breeding goshawks from early March until September, and nest areas are the focus of all movements and activities associated with nesting (Reynolds 1983). Nest areas are often used >1 year, and some are used intermittently for decades (Reynolds 1983, Crocker-Bedford 1990, Detrich and Woodbridge 1994). The size and shape of nest areas depend on topography and the availability of patches of dense, large trees (Reynolds 1983).

We described northern goshawk nesting habitat and tested whether land covertypes at two scales (30 acre and 160 acre) differed from other nearby forested habitats. Our objective was to determine if goshawks on the Tongass National Forest were selecting specific forest stands or land covertypes for nesting that differed from nearby forested habitats and to identify the types of land cover associations that differed most from those measured. Because forest management activities can result in the loss of nesting habitat by altering the structure of existing nest stands or the early developmental stage in potential nesting stands (Crocker-Bedford and Chaney 1988), this information may have implications for forest management. Suitable nesting habitat is important in the reproductive biology of goshawks; however, protecting nesting habitat alone may not be sufficient for maintaining goshawk populations.

Goshawks are uncommon or rare on the Tongass National Forest, and locating their nests is expensive, labor intensive, and time-consuming. This information may be useful to determine if goshawk nesting areas can be predicted as an aid in their location. It is also useful for estimating the relative abundance of suitable goshawk nesting habitat. Ultimately this information may help in establishing the degree of protection necessary to adequately protect goshawk nest sites from forest management activities.

STUDY AREA

Rugged mountains, old-growth rainforest, and thousands of kilometers of marine shoreline (Schoen et al. 1988) characterize Southeast Alaska. The area includes the islands of the Alexander Archipelago. Forests of Southeast Alaska include old growth composed primarily of western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*). Eighty-seven percent of 39 goshawk nest trees were located in old-growth forest stands, 2 nests in 1 nesting area were located in second-growth, and 3 nests at 2 nesting areas were located in a forest stand with a mixture of old-growth and second-growth trees. Our analyses include a total of 39 goshawk nests including 14 on the Chatham, 16 on the Stikine, and 9 on the Ketchikan administrative areas of the Tongass National Forest.

METHODS

We collected habitat association data at an *ad hoc* sample of nest locations from Southeast Alaska. Most nest sites were located during activities associated with timber sale preparation and administration. Some nests were located as a result of taped-broadcast surveys (Kennedy and Stahlecker 1993) in areas that may be subject to future timber harvest and in pristine wilderness areas. Other nests were located after investigating reports of goshawk nest defense behavior and by tracking radiotagged adult goshawks to nesting areas that differed from those of previous years. We were unable to determine if the sample of nests located with the aid of radiotelemetry were unbiased with respect to describing goshawk nesting habitat across the Tongass National Forest.

We collected habitat attributes at 2 separate landscape scales (30 acre and 160 acre) by analyzing plots on color and black-and-white aerial photographs at scales varying from 1:15,000 to 1:22,000. Because scale varied from photo to photo with changes in elevation, adjustments in scale were made if the elevation changed more than 500 feet. Plots were paired with 1 plot being centered on the nest tree. The other plot was determined by moving in a randomly selected cardinal direction ~4.5 inches on the aerial photograph (4 radius lengths) from the center of each nest plot. Throughout North America goshawks typically nest in mature or old-growth coniferous or deciduous stands having relatively dense canopies and a high-density of large trees (McGowan 1975, Hennessy 1978, Shuster 1980, Reynolds et al. 1982, Moore and Henny 1983, Hall 1984, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Hayward and Escano 1989); therefore, all random points were centered in productive forest. Random points that did not fall in productive forest (i.e., muskeg or other nonforested area) were rejected and another point was selected. The reasons for selecting random points that were centered on forest were that goshawks do not nest in muskegs or other nonforested areas and we wanted a comparison focusing on differences between forest cover at nests and away from nests.

Variable Measurement

Variables were measured by aerial photograph interpreter R. C. Smith (USFS retired) who had no prior knowledge of goshawk nests or nesting habitat. Variable groups included area, length, and distance measurements in 30- and 160-acre circular plots, and canopy and position on slope measures at the 30-acre plot. Areas of covertype were estimated using a dot grid with 64 dots/in^2. Distances and lengths were measured on aerial photographs using a map wheel or straight edge, except when distances were >3500 ft in which case distances were approximated with the aid of topographic maps.

Forest stand openings <3 acres were not counted in the forest cover typing because most Forest Service timber typing does not consider small openings. Freshwater ponds or lakes <3 acres were not typed. Most clearcuts were considered as nonforestland except where trees were large and well established (approx. 30 years of age). In instances where timber harvest or road construction had occurred since the available photography, other supplementary information was used to update the photography.

Depending on the scale of the photo imagery, from 7 to 9 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 percent hemlock. Canopy structure was characterized as being either single or multistory. Canopy texture was estimated as either coarse, medium, or fine.

Riparian areas were estimated by applying a 300-ft buffer (standard for Tongass Land Management Plan database) to both stream banks and calculating the area using a dot grid. Only perennial streams that were readily visible on aerial photos were included in this analysis. Small ephemeral streams were often obscured beneath forest canopies, making them difficult or impossible to detect on aerial photos.

Statistical Analysis

We used Wilcoxon-matched pairs sign tests and accompanying Z-statistics and P-values to evaluate differences in distributions between random samples and goshawk nest sites.

RESULTS AND DISCUSSION

Land Cover Areas

There was significantly more forested area associated with goshawk nest plots than with 30-acre random plots centered on forest (Table 4-1). Mean difference in forested area between nest site versus random plots was 2.2 acres. The most noticeable difference was that there was little variability in the amount of forest area surrounding goshawk nest areas and that forested random samples had a larger range. No goshawk nest site had <25 acres of forest in the 30-acre plot. We found no difference in the amount of forest area surrounding goshawk nests versus nearby random samples at the 160-acre scale. 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 productive forestlands for the nest site data increased from 3.7 to 7.8% between the 30-acre and 160-acre plots.

We also found the amount of productive forestland area in the 30-acre plot was significantly higher at goshawk nests than a nearby random sample centered on forest. The area of productive forest was positively correlated ($r = 0.55$, $r = 0.52$; $n = 78$, $P < 0.001$) with the total area of forest for both the 30-acre and 160-acre plots, respectively. The lack of a very high correlation was due to the fact that total forest area may contain areas of forest that contained small trees not of commercial quality and, therefore, not defined as productive forest.

Forest cover, and to a lesser extent productive forestland, dominated the area in the 30-acre plot. There was little range in the amount of forested area in the 30-acre plot, indicating that few large openings were near goshawk nests. We found negative correlations between the amount of forest area and the area of nonforest in the 30-acre and 160-acre plots, respectively ($r = -0.95$, $r = -0.79$, $n = 78$; $P < 0.001$).

Beach and riparian covertypes occurred in relatively small amounts in both 30-acre and 160-acre plots. Freshwater lakes and saltwater covertypes were not within the 30-acre nest plots and were usually absent in the 160-acre samples. This was indicated by the mean or median zero values.

Most of our land cover attributes could not be compared with other goshawk nest site habitat studies. These 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) evaluated nest site habitat selection by goshawks using aerial photography and 80 ha (197 acres) nest and random plots. She found that goshawks avoided forest openings and that nests were associated with unbroken forest tracts compared with availability.

LAND COVER BORDER LENGTHS

We considered border lengths to be indices of covertype heterogeneity. At both the 30-acre and 160-acre plots, we found less forest to nonforest edge at goshawk nesting areas than at random samples (Table 4-2). This probably occurred because of the lack of other forest covertypes at goshawk nest plots. Therefore, we found low covertype heterogeneity at goshawk nests compared to other randomly selected, forested areas.

Distances to Land Cover Features

We found no differences in the distance to land cover features between goshawk nests and random samples (Table 4-3). The data set was incomplete for the variable distance to trail, largely because the aerial photography interpreter experienced difficulty when attempting to identify forest trails beneath the canopy. Our inability to detect differences in distance measures between nest plots and random plots differed from the patterns found by others. (Bosakowski and Speiser 1994, Falk 1990) found goshawks nesting farther from forest openings, paved roads, and human habitation than random samples of forested habitat.

CANOPY COVER AND STRUCTURE

Canopy cover was significantly higher in the 30-acre area surrounding goshawk nests than in other nearby forest areas (Table 4-4). Although the difference was only 6.7%, this 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 samples unless goshawks were selecting rare features of the habitat that did not occur elsewhere. Such differences would be unlikely on the highly fragmented and patchy Tongass National Forest.

The mean percent canopy cover value of 50% was lower than reported in the literature for this species. Based on a literature review, Siders and Kennedy (1994) found that nest site canopy cover varied from 59.8 to 95% for goshawks. In nearly all of these studies, canopy cover was measured differently from our study that evaluated canopy cover across 30-acres and by using subsamples and aerial photography. Siders and Kennedy (1994) cited studies in which canopy cover was likely estimated much closer to the nest tree and by using on-the-ground, under-the-canopy estimates.

We found significantly more hemlock at goshawk nest areas compared to nearby areas. As with the canopy cover analysis, the difference was only 6%. This difference may have been associated with goshawk nesting areas being associated with productive forestlands and hemlock/spruce covertypes, whereas some random samples may have contained a greater component of cedar or spruce.

We did not test for differences in canopy structure or canopy texture between nest sites and random samples. The descriptive summary indicated that multistory canopies dominated the samples with 89% of the nest sites and 84% of the random samples occurring in multistory canopy forest stands. The aerial photograph interpreter determined that just 1 of 39 goshawk nesting areas had the majority of 9 subsamples defined as a single-canopy layer. This was a nest on Douglas Island located in ~70-year-old second-growth where 8 or 9 subsamples were in a single-canopy layer. Our on-the-ground knowledge of these nesting areas supports the notion that nearly all goshawk nests were in stands with multilayer canopies. Reynolds et al. (1982) described the multilayered canopy structure of goshawk nests in Oregon, but Hall (1984) described goshawk nesting stands and mentioned that goshawk nests in northwestern California were associated with dense single-storied stands of young Douglas fir (*Pseudotsuga menziesii*). It may be that the measurement instrument and/or availability of habitat types differed among areas.

Based on the aerial photograph interpretations, 30-acre areas surrounding goshawk nests, on average, comprised 56% medium-grained canopy texture, 24% fine-grained canopy texture, 19% coarse-grained canopy texture, and 1% nonforested. Comparable areas surrounding randomly selected points comprised 49% medium-grained canopy texture, 25% fine-grained canopy texture, 17% coarse-grained canopy texture, and 9% nonforest. Canopy texture is associated with tree size and canopy heterogeneity. Coarse-grained canopies contain large trees and higher volume old growth, while medium- and fine-grained canopy textures are either lower volume or younger even-aged stands. Inspection of the data indicated no differences in canopy texture between nest sites and random samples, considering the sampling variability indicative of the forest canopy heterogeneity. The CV for the average percentage of medium-grained canopy texture was 31% for nest plots and 45% for random plots.

Table 4-1. Land cover type areas surrounding 39 northern goshawk nest sites and paired random plots as determined by analysis of aerial photographs, Tongass National Forest, Alaska.

ACRONYM	VARIABLE	NEST SITE				RANDOM SITES				*P* value[a]
		MEAN	MEDIAN	SD	RANGE	MEAN	MEDI AN	SD	RANGE	
30 ac plots										
RB30A	Riparian area in 30ac plot	1.5	0	3.1	0 - 13.7	1.6	0	2.6	0 - 8.8	0.833
BB30A	Beach area in 30ac plot	0.02	0	0.13	0 - 0.8	0.46	0	2.6	0 -16	0.285
FOR30A	Forested area in 30 ac plot	29.3	30.0	1.1	25.7 - 30.0	27.1	30.0	4.1	16.0 -30.0	0.001
NF30A	Non-forested area in 30 ac plot	0.7	0	1.1	0 - 4.3	2.5	0	3.8	0 - 14.0	0.002
PFL30A	Productive forest land in 30ac plot	26.1	27.2	4.5	13.6 - 30.0	23.4	24.4	6.9	5.8 - 30.0	0.006
NPFL30A	Non-productive forest land in 30ac plot	3.5	2.0	4.2	0 - 16.4	3.7	0	5.8	0 - 24.2	0.659
FW30A	Freshwater in 30ac plot	0				0.14	0	0.7	0 - 3.9	0.180
SW30A	Saltwater in 30ac	0				0.2	0	1.1	0 - 7.1	0.180
160 ac plots										
RB160A	Riparian area in 160ac plot	10.4	9.0	9.4	0 - 36.1	10.4	8.9	10.1	0 - 50.4	0.777
BB160A	Beach area in 160ac plot	4.0	0	11.2	0 - 155.4	3.2	0	9.7	0 - 44.7	0.779
FOR160A	Forested area in 160 ac plot	149.4	153.1	11.6	104.6 - 160	141.3	150.0	19.7	82 - 160	0.108
NF160A	Non-forested area in 160 ac plot	7.0	5.0	8.9	0 - 39.9	14.7	9.0	16.0	0 - 58.1	0.010
PFL160A	Productive forest land in 160ac plot	128.1	136.7	27.5	47.9 - 160	119.4	129.8	38.0	10 - 160	0.192
NPFL160A	Non-productive forest land in 160ac plot	21.4	10.0	24.8	0 - 104.5	20.4	10.5	27.1	0 - 119.1	0.827
FW160A	Freshwater in 160ac plot	1.2	0	3.6	0 - 14.2	1.6	0	7.6	0 - 44.2	0.753
SW160A	Saltwater in 160ac	2.4	0	7.4	0 - 29.6	2.4	0	10.1	0 - 58.8	0.866

[a] *P* - value based on Wilcoxon matched-pairs signed-ranks test.

Table 4-2. Border lengths of land cover type areas surrounding 39 northern goshawk nest sites and paired random plots as determined by analysis of aerial photographs, Tongass National Forest, Alaska..

ACRONYM	VARIABLE	NEST SITES				RANDOM SITES				*P* value[a]
		MEAN	MEDIAN	SD	RANGE	MEAN	MEDIAN	SD	RANGE	
30 ac plots										
FE30L	Forest/Non-forest edge length	400	0	884	0 - 4488	667	264	2.6	0 - 8.8	0.014
FS30L	Freshwater shoreline length	45	0	162	0 - 762	39	0	169	0 - 760	0.715
SS30L	Salt water shoreline length	29	0	12	0 - 75	36	0	179	0 - 1080	0.285
STR30L	Stream/Riparian length	339	0	680	0 - 2976	341	0	556	0 - 1920	0.909
RD30L	Road length	53	0	188	0 - 794	53	0	242	0 - 1361	0.893
TR30L	Trail length	48	0	216	0 - 1188	39	0	183	0 - 1056	0.593
160 ac plots										
FE160L	Forest/Non-forest edge length	2674	1830	2957	0 - 11672	3687	3564	2670	0 - 10428	0.026
FS160L	Freshwater shoreline length	417	0	1305	0 - 5143	177	0	634	0 - 2661	0.249
SS160L	Salt water shoreline length	305	0	960	0 - 4338	289	0	880	0 - 4139	0.866
STR160L	Stream/Riparian length	2336	1848	2017	0 - 7855	2066	1942	1660	0 - 6336	0.913
RD160L	Road length	359	0	876	0 - 2956	228	0	793	0 - 3770	0.575
TR160L	Trail length	245	0	718	0 - 2772	229	0	751	0 - 2945	0.892

[a] *P* - value based on Wilcoxon matched-pairs signed-ranks test.

Table 4-3. Distances (in feet) to nearest land cover features 39 northern goshawk nest sites and paired random plots as determined by analysis of aerial photographs, Tongass National Forest, Alaska.

ACRONYM	VARIABLE		NEST SITE					RANDOM SITES				*P* value[a]
		n	MEAN	MEDIAN	SD	RANGE	*n*	MEAN	MEDIAN	SD	RANGE	
NFE30D	Forest/Nonforest edge	39	1177	833	1190	62 - 5984	38	887	645	1215	56 - 7480	0.230
FS30D	Freshwater shoreline	30	5902	4310	4269	479 - 16368	30	6047	4680	2.6	0 - 16	0.705
SS30D	Saltwater shoreline	39	11066	4310	4269	600 - 29040	36	11258	8486	8586	352 - 29040	0.480
STR30D	Stream/riparian	39	917	747	528	150 - 2426	39	984	833	798	54 - 3184	0.965
RD30D	Distance to road	28	5850	3127	7324	227 - 36960	29	5781	5317	4247	0 - 17952	0.118
TR30D	Distance to trail	9	5885	1414	11824	264 - 36960	11	1932	880	2355	0 - 7920	0.398
OPEN30D	Distance to forest opening	29	4510	3240	3143	1161 - 11300	28	5017	4121	4175	0 - 13800	0.409

[a] *P* - value based on Wilcoxon matched-pairs signed-ranks test.

Table 4-4. Canopy closure and percent hemlock forest cover types at 30 ac plots surrounding 39 northern goshawk nest sites and paired random plots as determined by analysis of aerial photographs, Tongass National Forest, Alaska.

ACRONYM	VARIABLE	NEST SITES				RANDOM SITES				*P* value[a]
		MEAN	MEDIAN	SD	RANGE	MEAN	MEDIAN	SD	RANGE	
CC10	% Canopy Closure	49.6	50.6	7.5	28.9 -66.1	42.9	45.0	13.1	10.6 - 60.7	0.063
SC10	% Hemlock	81	82	10.4	48 - 90	75	77	15	33 - 90	0.026

[a] *P* - value based on Wilcoxon matched-pairs signed-ranks test.

PART 5

Patterns of Goshawk Habitat Use and Selection Based on Radiotelemetry

METHODS

Our objective was to assess habitat selection at a variety of scales (Hilden 1965, Johnson 1980), but we were only able to assess within home range habitat selection. Our sampling unit was an individual goshawk, and from each goshawk we collected a varying number of radiotelemetry relocations throughout the year. Nearly all radiotelemetry relocations were collected using standard fixed-wing aerial telemetry methods (Samuel and Fuller 1994). Mountainous terrain, the lack of a road system, and goshawk movement patterns precluded the use of ground-based telemetry.

Observers collected information on covertype based on their estimate of the location of the birds' signal. Observers also plotted telemetry location estimates on maps and aerial photographs that were subsequently transposed to the Tongass National Forest geographic information system (GIS). GIS maps were then edited using check maps by those who collected the data. We believe that this editing protocol minimized errors. The GIS provided a land cover classification system common to other assessments produced for the forest planning process.

We produced minimum convex polygons (MCP) for each adult goshawk, 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; therefore, we prefer to use the term "use areas" rather than home ranges.

Within the MCP use area for each individual goshawk, using GIS we discerned 15 covertypes (Table 5-1). Similar covertypes were pooled, and unclassified types were eliminated, for a total of 8 usable covertypes. This data set constituted the use area habitat available to an individual bird. Not all goshawks had all covertypes available within their seasonal use areas. For instance, alpine habitat may not be available to all birds so for those that have no alpine habitat in their use area, they have no opportunity to select this type.

BREEDING SEASON ANALYSIS

The breeding season extended from 15 March through 15 August. All telemetry relocations for adult goshawks during this period were used in the analysis including those associated with the female during incubation. These form a relatively small percentage of the entire data set. Some goshawks moved >25 km from their nest site during the breeding season. Movements by individuals >40 km from the nest site during the breeding season were eliminated from the analysis and as data points in the estimation of minimum convex polygon use areas.

For the compositional analyses during the breeding season, our sampling units were individual goshawks with a few exceptions. Habitat used by an individual goshawk was considered unique and therefore an additional sample unit when the bird moved to a different nesting area between years. For the breeding season analysis, 25 adult goshawks represented 32 goshawk sampling units.

WINTER SEASON ANALYSIS

We considered the winter or nonbreeding season to extend from 16 August through 15 March. For the analyses presented, all telemetry locations for adult goshawks during the winter season were used to determine a minimum convex polygon use area for estimating abundance of available covertypes. For winter season compositional analyses, our sampling units were individual goshawks with 1 exception. We monitored 1 goshawk for 3 winters and her use area covered hundreds of km^2; therefore, we divided her use area into 2 areas of concentrated use resulting in 2 separate sampling units.

STATISTICAL ANALYSIS

Habitat Use

We described patterns of habitat use within use areas by pooling 14 habitat cover categories as determined by GIS into 8 variables for analyses. We also estimated goshawk habitat use by radiotelemetry relocation points. Covertypes were assigned from aircraft at the time of relocation, and using the relocation point intersecting the GIS covertype data layer, we created 2 sets of point estimates of habitat use. We were able to compare covertypes derived from biologists in the airplane with the GIS estimate of the same location. This presentation includes only those habitat estimates derived from GIS for standardized comparability of use and availability data sets.

HABITAT SELECTION ANALYSIS

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 non-independence of proportions, to scale the test for selection by the use-availability difference between each animal separately, and to test for between group (e.g., sex, season, study location) differences. J. Blick of ADF&G developed the compositional analysis program in SAS (1993). Our objective in choosing this method was to understand patterns of habitat selection for a sample of radiotagged goshawks considered representative of the goshawk population across the Tongass National Forest.

The compositional analysis method of Aebischer et al. (1993) uses the log-ratios of use habitat composition paired with that of its corresponding log-ratios of available habitat composition. We then use 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 covertypes. If differences were noted based on Wilks' lambda (Λ), we performed a series of t-tests and Wilcoxon rank tests measuring the difference between random use among all pairs of habitat variables. This allows assessment of patterns of differences in paired habitat variable combinations. Finally, we followed Aebischer et al. (1993) and Johnson's (1980) method to rank covertypes. 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 comprised varying numbers of missing covertypes that are not permitted in the log-ratio analyses. We substituted 0.0001 for missing covertypes that were much smaller than any corresponding real habitat value. We chose not to eliminate animals from the analyses if they had missing covertypes in their use area.

We chose to make most individual goshawks equal in terms of weighting for the compositional analyses, irrespective of the number of radiotelemetry relocations for that animal. Exceptions were those birds for which we had multiple years of data and which had moved to different use areas between years. This has some effect of weighting in that the 7 birds that moved to different areas during the nesting season and for which more relocations exist, counted >1 time in the analysis.

We performed 3 basic analyses to test for within use area habitat selection. The first analysis was an 8 variable analysis testing for selection between the breeding and winter seasons separately and evaluating any effects of sex in the 2 MANOVA's. The second analysis evaluated selection for or against forested edges by goshawks during the breeding and winter seasons. The 3 habitat variables used for this analysis differed from those of the 8 variable habitat analysis. For the edge analysis, 3 variables were created by GIS and included 1) nonproductive forest and nonforest, 2) productive forest <300 feet from forest edge, and 3) interior forest >300 feet from forest edge. Once again, we evaluated any sex effects in the 2 MANOVA's. The third analysis was performed on those goshawks that had use areas with clearcut habitat. Ten distance variables were created for this analysis and varied from >600 ft from a clearcut to the clearcut-forest edge to being >600 ft into the middle of a clearcut.

RESULTS

EIGHT VARIABLE HABITAT ANALYSIS

Nesting Season

Our sample of 32 goshawk sampling units was based on 614 radiotelemetry relocations that varied from 6 to 36 relocations per bird from 15 March through 15 August. Mean and median number of samples per bird were 19.1 and 18.5, respectively. We found that 40.6% of the relocations occurred in coarse- and fine-grained canopy old-growth forests (Table 5-2) as defined by GIS. When the coarse and fine-grained canopy habitat variables were combined with the forested riparian ecotone habitat variable, we found that 67.4% of the radiotelemetry relocations were in these covertypes. Habitat use as determined by telemetry relocations was low for alpine, subalpine, and unproductive lands >1500 ft

(7.0%), mature second-growth (5.2%), early succession and clearcut habitats (5.0%), and rock and ice habitats (1.5%). Sixty-five percent (21 of 32) of the goshawk sample units had no telemetry relocations in early succession or clearcut covertypes. We found 13.8% of the radiotelemetry relocations in unproductive lowland areas. The GIS-defined unproductive lowland covertype contains a variety of vegetative types including areas of productive old-growth forest too small to be detected by GIS. Visual inspection of relocation points on aerial photographs indicated that the point was often in a productive forested patch too small to be defined by GIS.

Habitat selection by goshawks (n = 32) was not random during the nesting season (MANOVA, P <0.001), and there was no difference in use between sexes (P = 0.803) when testing for a sex effect. Patterns of selection for specific habitat variables indicated nonrandom use of old-growth forests composed of coarse and fine-grained canopies and lowland forest riparian associated ecotones (Table 5-3). These covertypes encompass the medium and high-volume old-growth forest types found on the Tongass National Forest. None of these 3 variables differed from one another based on pair-wise analyses (P > 0.05 for all); our analyses could not discern differences in selection among the 3 forest habitat variables, with all being used significantly more than random. We found selection by goshawks against rock and ice, alpine and subalpine, and early succession and clearcut habitats when compared to their availability within use areas during the nesting season. Relatively few radiotelemetry locations occurred in these nonforested covertypes. Univariate t-tests indicated significant differences between the group of habitat variables. The 3 highest ranks differed from those of the 3 lowest ranks. We interpret this as a strong pattern for selection of old-growth forest and little use and nonselection of early succession, clearcut, alpine subalpine, and nonvegetated covertypes. Using our method for analyses testing for differences between adult male and adult female habitat selection, we were unable to discern statistical differences.

To better understand selection by goshawks for forest habitats, we pooled medium and coarse-grained old-growth covertypes (timber type volume classes P4+P5+P6) to form a single productive forest covertype. We then plotted the difference in percent use versus availability for each sample (Figure 5-1). Twenty-one of 32 goshawk samples had a higher ratio of use than availability for these pooled covertypes, compared to the other 6 habitat variables. In 4 goshawks the difference exceeded 50%, indicating that the proportional difference in use compared to availability was very high. This could be attributed to 1) nearly all of the telemetry locations for a bird being in productive old-growth forest, 2) little of the use area comprising productive old-growth forest, or 3) a combination of both high use and low availability with a high resultant difference.

The example in Figure 5-1 plots differences in use compared to availability for each goshawk for 1 covertype. Pooling mean differences for all goshawks by each of the 8 habitat variables allows a depiction of relative habitat selection and complements the statistical testing we performed based on Aebischer et al. (1993). These graphical patterns (Figure 5-2) agree with those in Table 3 with the exception of the mean difference for forested riparian ecotones compared to coarse and fine-crowned forests. We cannot explain why the forested riparian ecotone variable had the largest mean difference yet ranked third highest, based on our statistical analyses.

Winter Season

The sample of 27 goshawk sampling units was based on 610 radiotelemetry relocations that varied from 4 to 57 relocations per bird from 16 August through 14 March. Mean and median number of samples per bird were 22.6 and 21.0, respectively. We found that 46.4% of the 610 relocations were in coarse and fine-grained canopy old-growth forests. When we combined the coarse and fine-grained canopy covertypes with the forested riparian ecotone variable, 76.6% of the radiotelemetry relocations were in these covertypes. Only 8.9% of the relocations were in unproductive lowland areas during the winter. Like the nesting season we found low use of alpine, subalpine, and unproductive lands >1500 ft (8.7%), early succession and clearcut habitat (2.6%), and rock and ice (1.1%). Our data were not arranged to allow a test of seasonal changes in habitat use patterns or to test for shifts toward denser forests or riparian edges during the nonbreeding or winter seasons.

Habitat selection by goshawks was ($n = 27$) not random during the winter (MANOVA, $P = 0.008$), and there was no overall sex effect ($P = 0.713$). The patterns of habitat selection during the nonbreeding season were similar to those during the nesting season. We found strong selection for coarse-canopy old-growth forests. Like the nesting season analysis, we found no pairwise differences between habitat variables associated with coarse and fine-grained canopies and lowland riparian forest ecotones ($P > 0.05$ for all; Table 5-3). During the nonbreeding season we found selection against early succession and clearcut covertypes, rock and ice, and low elevation scrub habitats. Patterns of differences in mean and median habitat use versus availability for all 8 habitat variables during the winter were similar to that for the nesting season (Figure 5-3). Large differences between mean and median values were found for some variables such as coarse-crowned forest and rock and ice. We attribute this to zero values in the data.

We pooled GIS habitat variables P4+P5+P6 by goshawk for the winter season to portray patterns of habitat selection for a productive old-growth forest type (Figure 5-4). Twenty-one of 27 goshawk samples indicated within use area selection for productive old-growth forest.

FOREST-EDGE THREE-VARIABLE ANALYSIS

Nesting Season

Habitat selection by goshawks within use area was not random with regard to their selection of nonproductive lands, productive forest edge, and interior productive forest areas ($n = 32$, MANOVA, $P = 0.0033$). We found no differences in selection between sexes when testing for a sex effect ($P = 0.174$). Our primary interest in the forest-edge analysis was to understand if goshawks selected productive forest edges more or less than interior portions of forest patches. From the univariate testing we were unable to find differences in selection between productive forest edges compared to productive forest interior patches. Forested edge selection differed (Wilcoxon sign-rank test, $P < 0.0001$) from nonproductive lands but not from forested interior patches (Wilcoxon sign-rank test, $P = 0.812$). Selection for the interior of forest patches differed from nonproductive lands (Wilcoxon sign-rank test, $P < 0.0001$). This pattern of selection for forest edge and forest interior patches was apparent in a plot of differences in percent use versus availability by bird (Figure 5-5). Twenty-one of 32 goshawk samples used forest edge more than available in their use area and 21 of 32 goshawk samples used interior forest patches more than available in their use area.

Winter Season

Within use area habitat selection by goshawks was not random with regard to their selection of nonproductive lands, productive forest edge, and interior productive forest areas ($n = 26$, MANOVA, $P = 0.0021$). We found no differences in the selection between sexes when testing for a sex effect ($P = 0.726$). The ranking of selection for interior forest patches compared with forest edges was identical to that of the nesting season. Forested edges had the highest level of selection, followed by interior forest patches with nonproductive lands being used less than available. Like the nesting season analysis, there was no statistical difference in the 2 highest ranks, and their log-ratio mean difference was relatively small (0.106) compared to the log-ratio mean difference between forest edge and nonproductive lands (1.44) and the log-ratio mean difference between forest interior and nonproductive lands (1.33). Thus, the difference for selection between productive forests compared to all other areas of the landscape was great, but there was no detectable difference for selection between forest edges compared to interior forest patches.

General Patterns

We conducted additional compositional analyses of the 3-variable data set and found consistent patterns irrespective of the choice of effects (season, sex) and area (separating data from Chatham, Stikine, and Ketchikan areas). This inability to discern selection for or against edge and interior forest patches may be due to several factors. Goshawks may not be selecting for edges or for the interior of large forest patches. They may merely be selecting forested areas based on structure and not location relative to edge. Goshawks may be selecting or avoiding edge but our analyses, scale of resolution, and sampling error may preclude our understanding of any pattern. Finally, a pattern may exist but more samples are needed to discern it.

DISTANCE TO CLEARCUT ANALYSIS

We used GIS to determine the distance to clearcut edge within minimum convex polygon use area estimates for random and relocation data points and placed these distances into 10 distance codes. This procedure was performed only for goshawks with clearcut habitat in their use area and data were pooled across season and sex. We found that goshawks did not use distances from clearcuts randomly ($n = 21$, MANOVA, $P < 0.0001$) and there were no sex ($P = 0.960$) or season ($P = 0.831$) effects. The ranking procedure of the 10 distance categories indicated goshawks selected against areas >600 ft into the middle of clearcuts and selection for areas >600 ft away from clearcuts. This pattern was supported by the overall lack of use of clearcut habitat. This specific compositional analysis suffers from insufficient radiotelemetry samples in clearcut areas.

No edge effect was found in the overall edge analysis, but we did find an edge effect in the clearcut-edge analysis. We conclude that all ecotone edges are not structurally and functionally similar for goshawks. Goshawks selected against clearcut habitats. It is also possible that the ecotone from productive old-growth forest to clearcut may be selected against and is less suitable for goshawks.

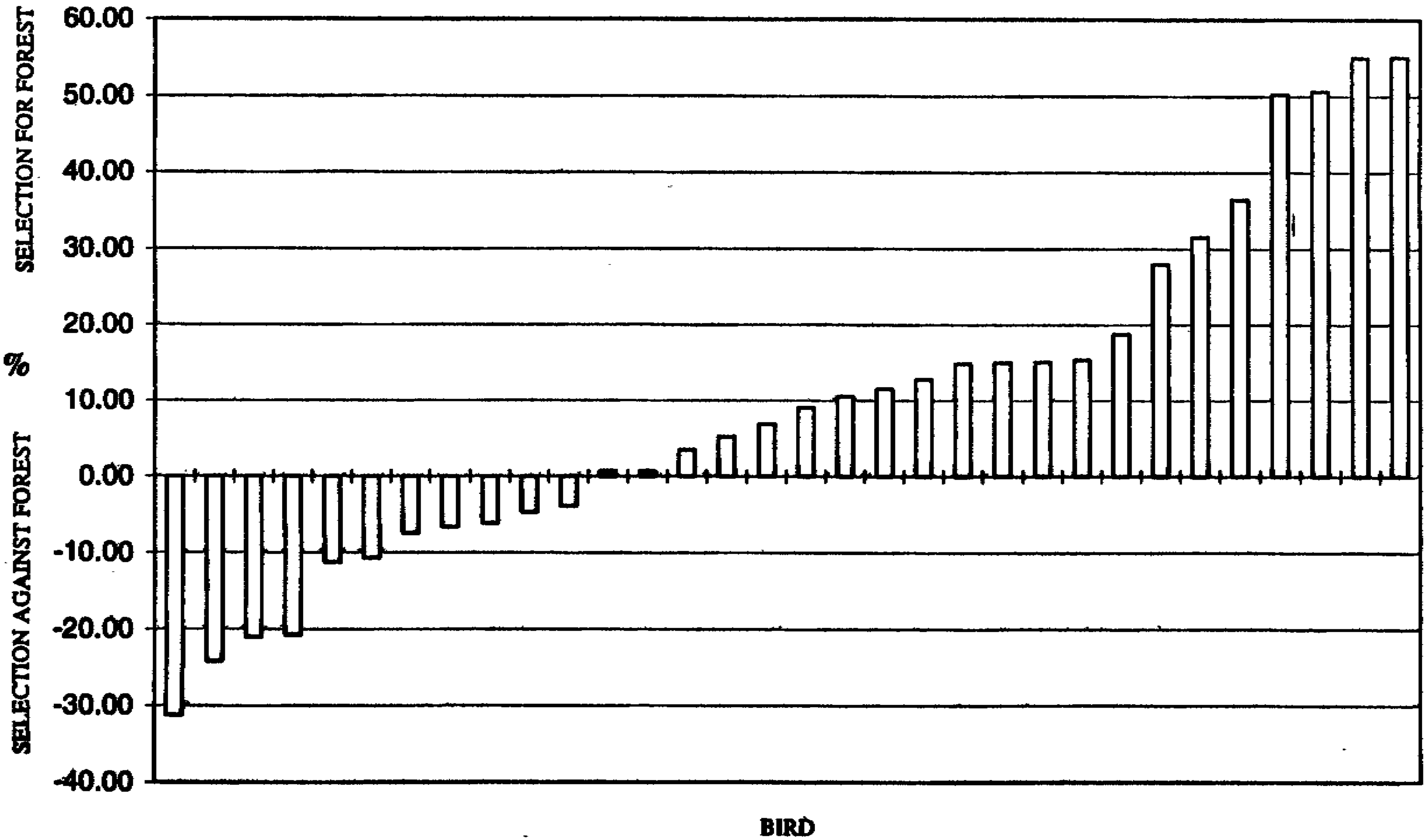

Figure 5-1. Difference in pecent use versus availability of adult northern goshawks for productive forest lands (habitat variables P4+P5+P6) by bird during the nesting season, Tongass National Forest.

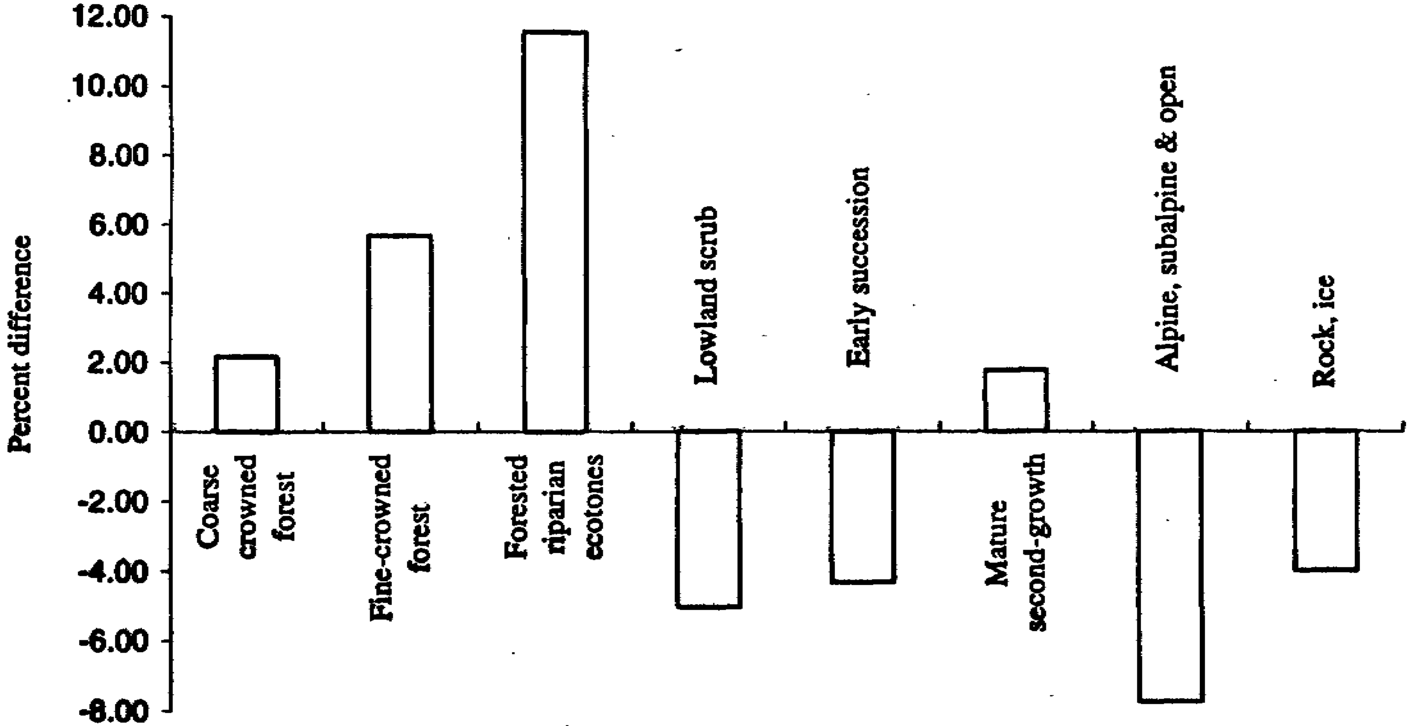

Figure 5-2. Difference in mean percent habitat use versus availability for eight variables comparing nesting season radio telemetry locations and minimum convex polygons of adult northern goshawks, Tongass National Forest.

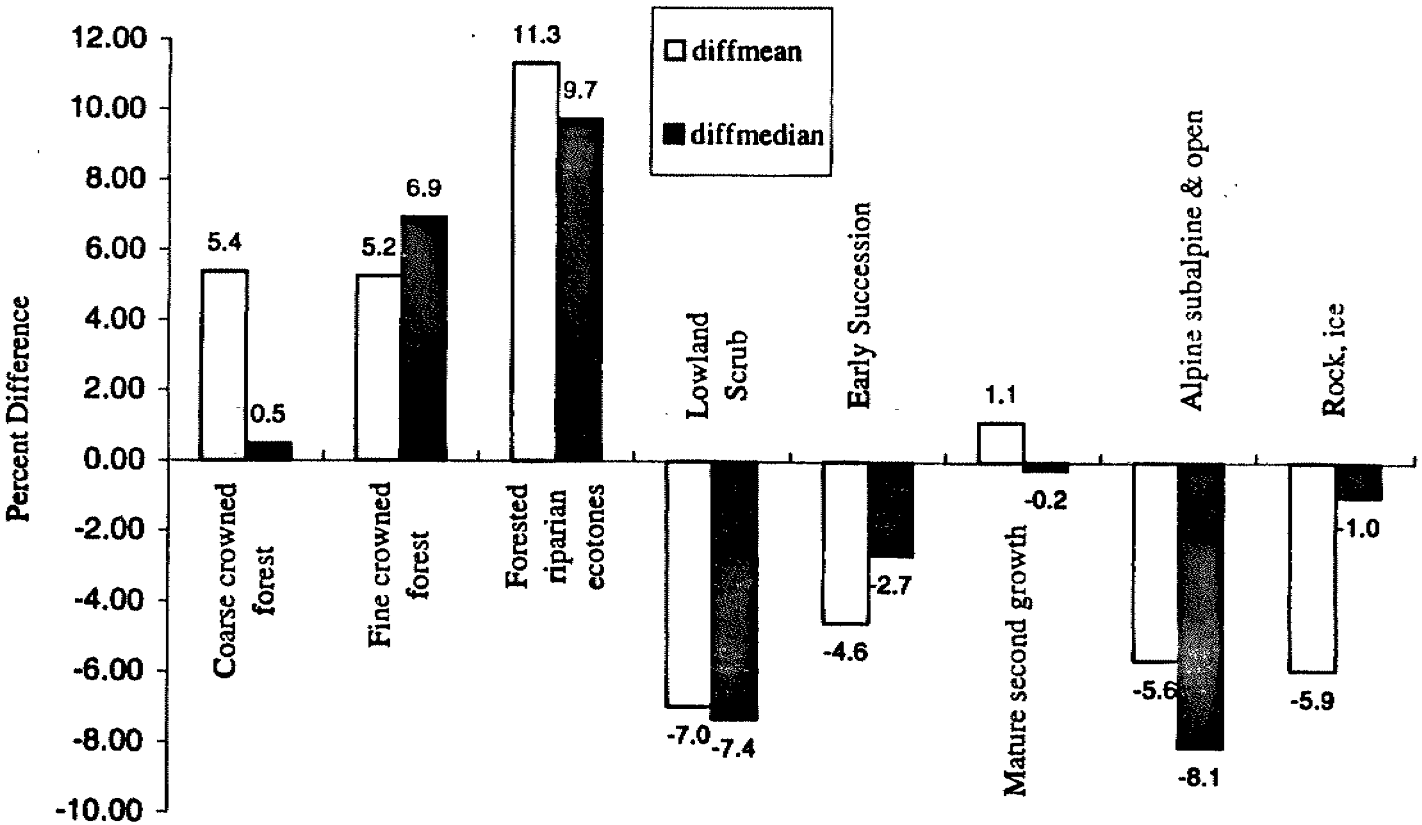

Figure 5-3. Difference in mean and median habitat use versus availability for eight habitat variables comparing winter season radio-telemetry locations and minimium convex polygon estimates of habitat availability of adult northern goshawks, Tongass National Forest.

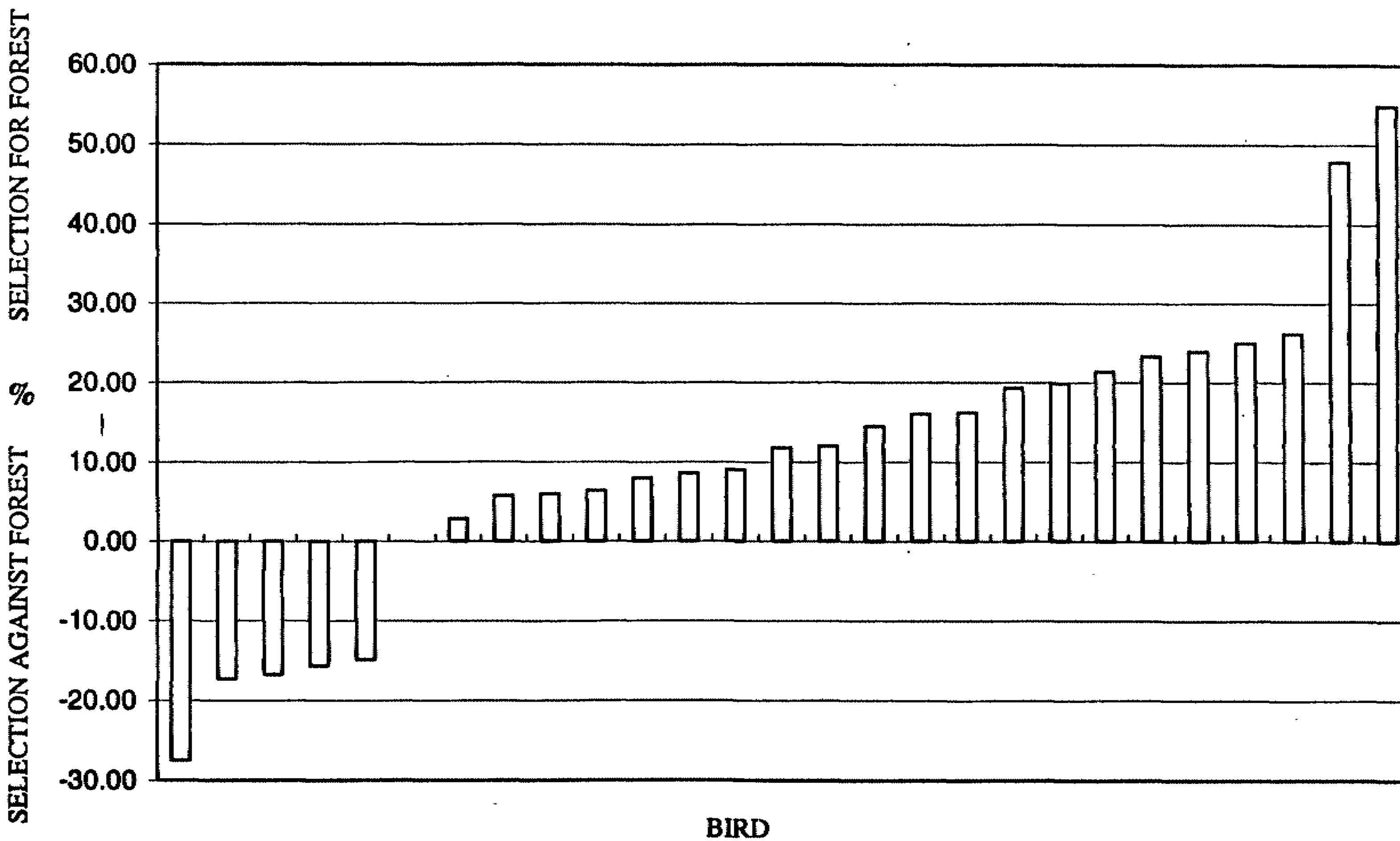

Figure 5-4. Difference in percent use versus availability of adult northern goshawks for productive forest lands (habitat variables P4+P5+P6) by bird during the winter, Tongass National Forest.

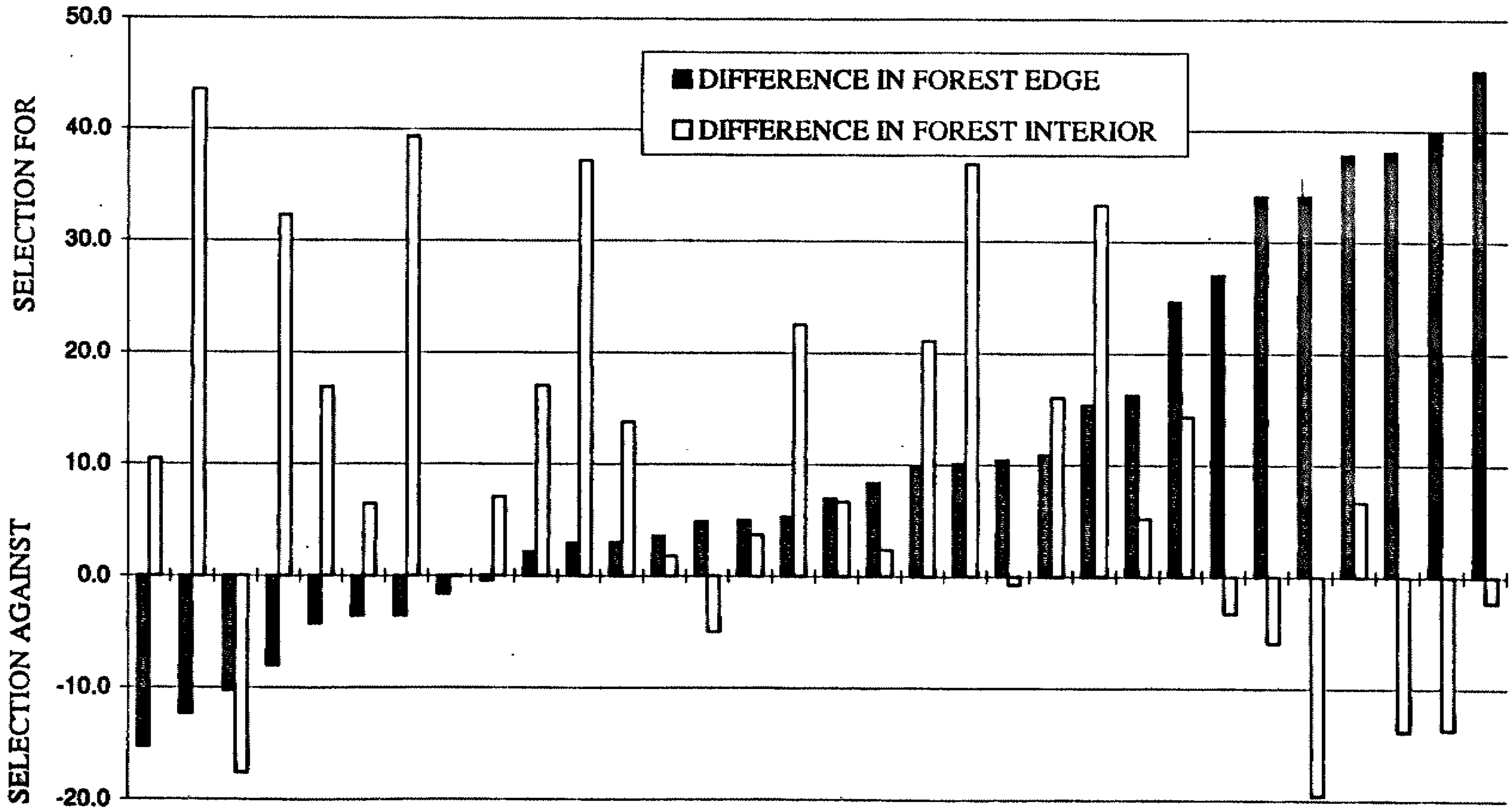

Figure 5-5. Difference in percent use versus availability (plotted by bird) of adult northern goshawks for forested edges (300') and forest interior patches during the nesting season, Tongass National Forest.

Table 5-1. Habitat covertypes as determined by the Tongass National Forest geographic system and used for northern goshawk radiotelemetry and habitat analyses.

Covertype	GIS Abbreviation	Description
Fine canopy old-growth forest	P4	timber volume class 4
Coarse-canopy old-growth forest	P5	timber volume class 5
Coarse-canopy old-growth forest	P6	timber volume classes 6&7
Productive riparian areas	PR	300 feet areas on each side of class 1 &2 streams, 100feet on class 3 streams
Productive beach areas	PB	500 foot fringe along beaches
Riparian beach & estuary	UR	1000 foot fringe along estuaries
Lowland scrub	UL	>10% tree cover and < 8mbf/ac, <1,500 foot elevation
Early successional clearcut	PC	mostrly clearcut but also primay succession areas
Mature second growth	PM	> 75 years old
Alpine	NA	
Upland scrub	UH	>10% tree cover and < 8mbf/ac, >1,500 foot elevation
Nonproductive nonforest	NF	nonproductive covertype including habitats not included in other categories
Rock & ice	NR	
Water	NW	fresh water
Unknown	XX	areas not classified by GIS

Table 5-2. Combined habitat covertypes from Table 1 as used in northern goshawk habitat selection analyses, Tongass National Forest.

Covertype	GIS Abbreviation	Description
Fine-canopy old-growth forest	P4	timber volume class 4
Coarse Canopy Old Growth Forest	P4 + P5	timber volume classes 5 & 6
Riparian Forest Ecotones	PR, PB, UR	
Early succession/clearcut	PC	primary and secondary succession covertypes
Mature sawtimber	PM	second growth forest > 75yrs
Alpine/subalpine	NA, UH, NF	
Lowland scrub	UL	
Rock, ice, water	NR, NW	

Table 5-3. Ranking matrix of habitat selection by adult northern goshawks testing for within minimum convex polygon use area selection compared with individual radio telemetry relocations.

+++ = selection for a habitat type P < 0.05					— = selection against a habitat type P < 0.05				
+ = positive selection, not significant					- = negative selection, not significant				
BASED ON MANOVA TESTING FOR SEX EFFECTS									
ANALYSIS 1 - NESTING SEASON									
Habitat	VOL56	VOL4	RIPARIAN FOREST	LOW SCRUB	EARLY SUCCESS	MATURE SAW	ALPINE	ROCK	RANK
VOL56	0	-	+	+++	+++	+	+++	+++	6
VOL4	+	0	+	+++	+++	+	+++	+++	7
RIPARIAN FOREST	-	-	0	+	+++	+	+++	+++	5
LOWSCRUB	—	—	-	0	+	-	+	+++	3
CLEARCUT	—	—	—	-	0	—	+	+	2
MATURE SAW	-	-	-	+	+++	0	+++	+++	4
ALPINE	—	—	—	-	-	—	0	+	1
ROCK/ICE	—	—	—	—	-	—	-	0	0
BASED ON MANOVA TESTING FOR SEX EFFECTS									
ANALYSIS 2 - WINTER SEASON									
Habitat	VOL56	VOL4	RIPARIAN FOREST	LOW SCRUB	EARLY SUCCESS	MATURE SAW	ALPINE	ROCK	RANK
VOL56	0	+	+	+++	+++	+	+++	+++	7
VOL4	-	0	+	+++	+++	+	+++	+++	6
RIPARIAN FOREST	-	-	0	+++	+++	+	+	+++	5
LOWSCRUB	—	—	—	0	+	-	-	+	2
CLEARCUT	—	—	—	-	0	—	-	-	0
MATURE SAW	-	-	-	+	+++	0	+	+++	4
ALPINE	—	—	-	+	+	-	0	+	3
ROCK	—	—	—	-	+	—	-	0	1

PART 6

Survival Rates of Adult Northern Goshawks on the Tongass National Forest as Determined by Radiotelemetry

INTRODUCTION

Understanding the patterns of survival and mortality for forest raptors is difficult (e.g., Newton 1986, Kenward 1993). To document annual survival rates for birds of prey, a sufficient number of a given species must be marked, followed, and their fates determined. For forest raptors, the only practical method to estimate rates of mortality and survival is through the use of radiotelemetry (White and Garrott 1990, Samuel and Fuller 1994). DeStefano et al. (1994) estimated adult survival using capture-recapture-resight methods, but they acknowledged that their estimates suffered from inadequate sample sizes.

Estimating annual survival rates for northern goshawks (*Accipiter gentilis*; hereafter goshawk) was a secondary study objective. Accurate estimates were not possible because of the difficulty in obtaining a sufficiently large sample size of radiomarked birds. Our objective in estimating survival was to describe the general patterns of survival and examine the instances of mortality. Survival estimates are an important component of any demographic analysis for a species, and these estimates are needed for population modeling and an understanding of the factors that may limit population size. Survival rates are an important component in estimating population rate change (λ) that can be used to infer the status of a population.

METHODS

In order to estimate survival we needed to radiotag adult goshawks on the Tongass National Forest and follow their movements as long as possible. We captured most adult goshawks at their nest sites using a great horned owl (*Bubo virginianus*) as a lure (Bloom et al. 1992). Captured adults were considered new recaptures from the month of the subsequent recapture. We did not consider these recaptured goshawks as being alive for the entire intervening period because the probability of finding them would not have been the same if recaptured goshawks had been dead or if they had moved from the study area. We determined the fate of most radiotagged goshawks. When the exact date of death could not be determined, we defined the month of death as the date midway between the date last presumed alive and the date we obtained relocations from the same location. Some goshawks could not be relocated on the periodic aerial telemetry flights, and we presumed they had left the region or were in remote areas of the Tongass National Forest. These animals were censored at a midway point between the last observation and disappearance (Pollock et al. 1989).

RESULTS AND DISCUSSION

We radiotagged 27 adult northern goshawks (15 males, 12 females) and monitored them from June 1992 through May 1995. We pooled data from adult males and females because of small sample sizes and, therefore, were unable to test for differences in survival between sexes. For the 3-year period, the mean number of adult goshawks monitored in any month was 9, with a range of 2 to 21 birds. Over much of 1992 and until July of 1993, only 2 goshawks were monitored; during summer of 1994 as many as 21 birds were monitored for a short period. The 3-year survival function estimated over the complete study period was 0.23 (95% CI, range = 0.10–0.36). Confidence intervals were large during the initial year of study because few birds were radiotagged and 2 deaths occurred during this period, resulting in a high mortality rate (Figure 6-1).

Seven radiotagged adult goshawks were confirmed dead during our study period including 4 females and 3 males. Eleven goshawks became censored during this period; most cases occurred when goshawks departed nesting areas during autumn or early winter, and we were unable to determine the fate of the bird. We do not believe that these goshawks migrated because we were able to locate the wintering areas for some goshawks that were >25 km from their nesting area. Some of these censored birds were relocated at a later date.

One adult female goshawk was monitored for 33 months from the time of her capture until she died. Twelve of 27 adult goshawks were monitored for ≥12 months. We had 3 instances in which adult goshawks became censored and disappeared during the winter and were subsequently relocated the following spring.

We pooled the 3 years of data into a 1-year period beginning in June (Table 6-1). This had the effect of increasing the number of adult goshawks at risk in any given month and allowed estimation of monthly confidence intervals (Figure 6-1). A total of 327 'at-risk months' were available for the survival estimate. Annual survival for adult goshawks was estimated at 0.76, given the 7 birds that died during our study. Most radiotagged goshawk mortalities occurred during the late winter or spring. Four adult goshawks were radiotagged on the Thorne Bay Ranger District, and they were at risk for 47 months. Three of these adults died during the study period and a fourth was censored. Three goshawks died on other portions of the Tongass National Forest; they were at risk for 280 months.

Our results are not readily comparable to other studies because there have been few studies of goshawk survival. DeStefano et al. (1994) estimated annual survival rates over a 10-year period using models based on Jolly-Seber mark-recapture methods. They indicated there may be yearly differences in goshawk survival and that female survival may be higher than that of males. Their confidence intervals were large, and they were unable to calculate survival estimates for all years. We pooled data across sexes and years to reduce variability, but all information about sex and year differences was lost through this approach. The advantages of the telemetry-based approach was that we were able to locate goshawks that moved large distances and we were able to determine the month of death. Goshawks from 2-6 weeks old were fitted with backpack or tail-mount radio transmitters (Kenward 1987), depending on the sex, weight, and stage of molt. Transmitters did not have mortality or position sensors. Using fixed-wing aircraft, we relocated individual goshawks more often during the nesting season than during the winter. Frequency of relocation varied from 3 to 6 times per week during the nesting season and was less frequent at other times of the year. Radiotelemetry flights may have occurred only once every 2 weeks in winter when inclement weather made aerial telemetry flights impossible. We assumed that a relocation that moved between consecutive aerial telemetry flights represented a goshawk that was alive during the 2 sampling periods. When a number (3–10) of relocations were recorded at the same location, the location was visited on foot to determine the status of the goshawk. Goshawk status determined by locating the transmitter on foot included 1) adult female goshawk incubating, 2) dead goshawk indicated by bones and feathers, and 3) tail-mount transmitter (for those goshawks with tail-mount transmitters) found, indicating a censored goshawk whose fate could not be determined. We were not able to determine the fate of all transmitters because some became stationary during the winter in mountainous areas of high snowfall and the transmitter subsequently failed.

We estimated the annual survival rates for northern goshawks across the Tongass National Forest using the staggered-entry design Kaplan-Meier estimator (Kaplan-Meier 1958, Pollock et al. 1989, White and Garrott 1990). We partitioned data into monthly periods, and for each goshawk we determined the month when the bird entered the Kaplan-Meier analysis and the fate of the individual through the analysis period. We selected an analysis period beginning in July 1992 and ending May 1995. The 3 possible fates included dead, survived, or censored. Some radiotagged goshawks were not found for >2 months and then subsequently relocated. Some had radio transmitters that stopped functioning or tail-mount radio tags that dropped; we recaptured and radiotagged these individuals. We considered these goshawks censored.

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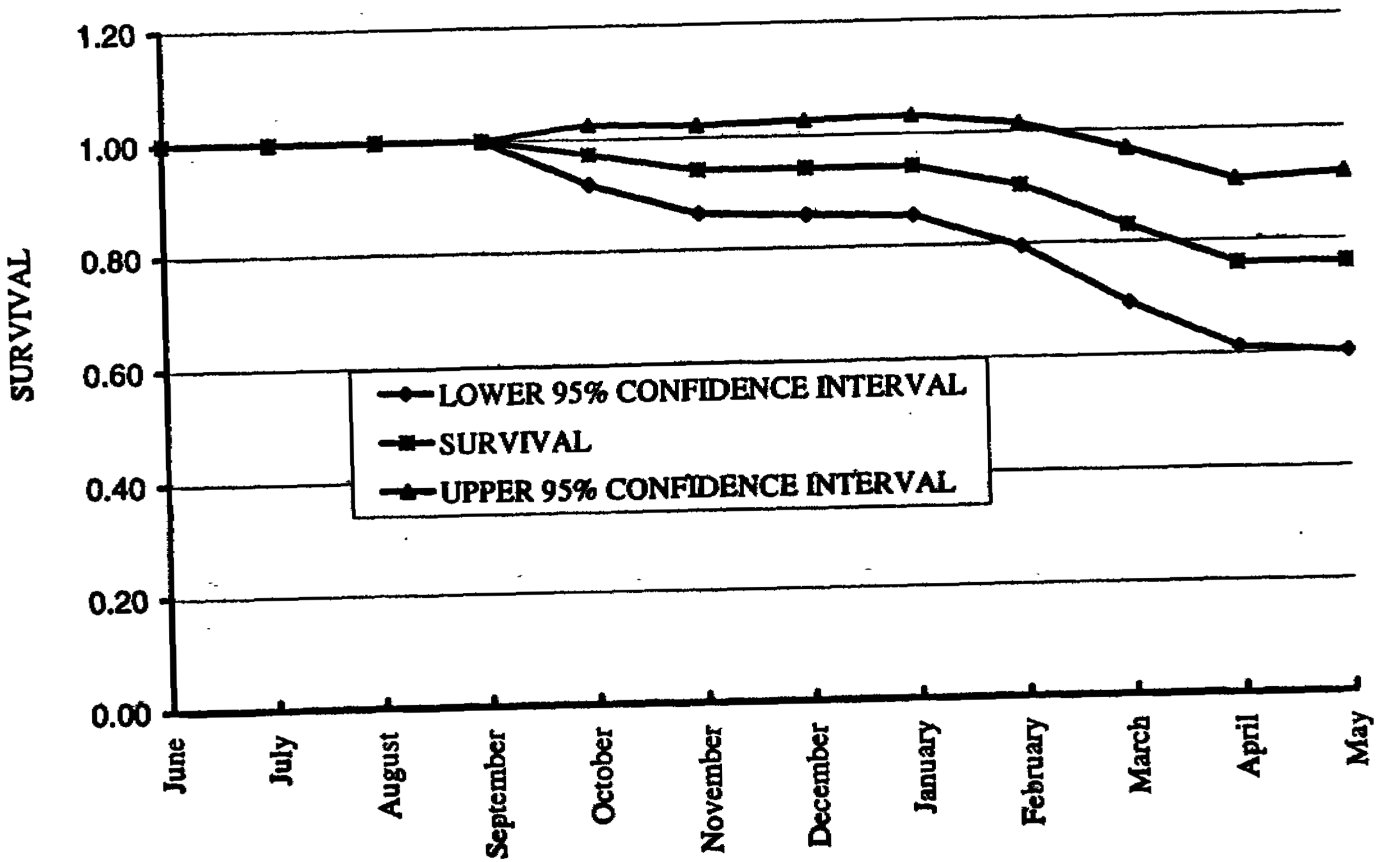
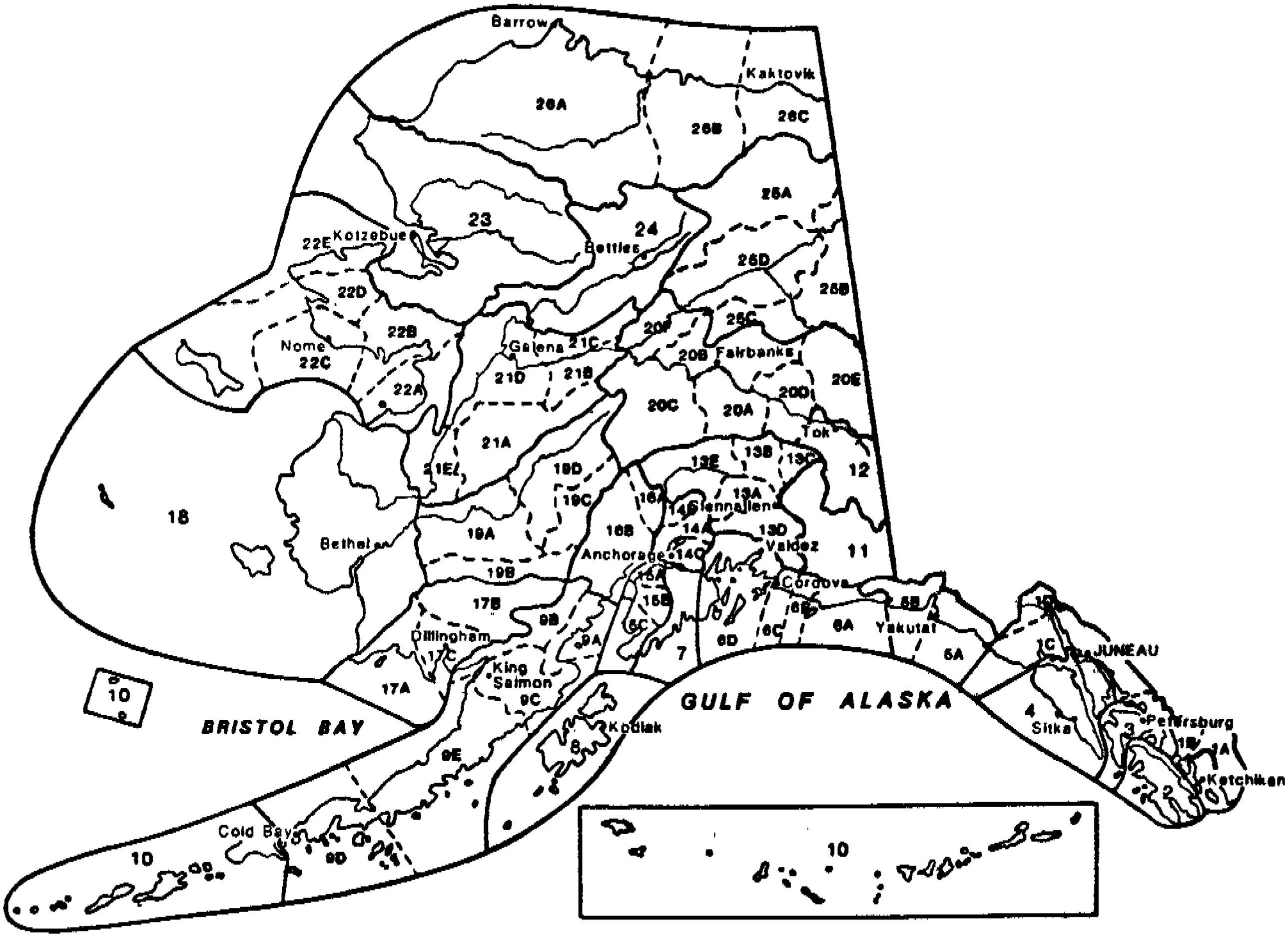


Figure 6-1. Pooled annual survival rate of adult northern goshawks, Tongass National Forest, Alaska, 1992-1995.

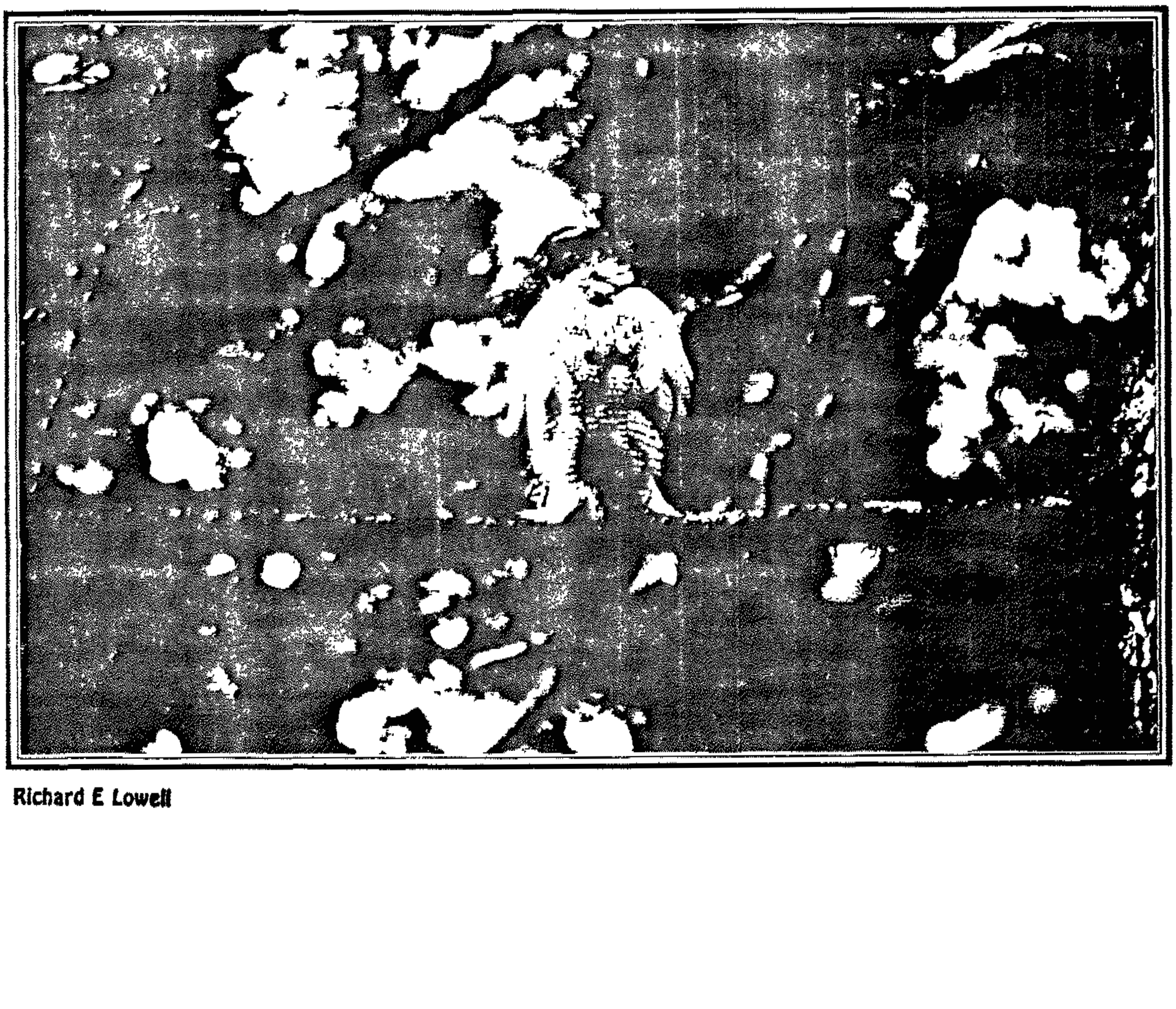
Table 6-1. **Pooled monthly Kaplan-Meier survival estimates for radio-tagged northern goshawks on the Tongass National Forest, 1992-95.**

	MONTH	NO.RISK	NO.DEATHS	SURVIVAL	NO.CENSORED	NO.ADDED	VAR(SURV)	LOWERCL	UPPERCL
1	June	14	0	1.00	0	9	0.0000	1.00	1.00
2	July	23	0	1.00	0	15	0.0000	1.00	1.00
3	August	38	0	1.00	2	1	0.0000	1.00	1.00
4	September	37	0	1.00	1	0	0.0000	1.00	1.00
5	October	36	1	0.97	3	0	0.0007	0.92	1.03
6	November	32	1	0.94	3	0	0.0016	0.86	1.02
7	December	28	0	0.94	4	1	0.0018	0.86	1.03
8	January	25	0	0.94	0	0	0.0021	0.85	1.03
9	February	25	1	0.90	0	0	0.0031	0.79	1.01
10	March	24	2	0.83	0	2	0.0049	0.69	0.97
11	April	24	2	0.76	2	1	0.0058	0.61	0.91
12	May	21	0	0.76	0	0	0.0066	0.60	0.92
Totals		327	7		15	29			

Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.



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