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# DISTRIBUTION, DENSITY AND PRODUCTIVITY OF GOSHAWKS IN INTERIOR ALASKA

By Jerry D. McGowan

STATE OF ALASKA
Jay S. Hammond, Governor

DIVISION OF GAME
Frank Jones, Director
Donald McKnight, Research Chief

DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner

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Job Title: Distribution, Density and Productivity of Goshawks in Interior Alaska

Period Covered: July 1, 1970 to June 30, 1974

## SUMMARY

Goshawk nesting and fall abundance were studied on a 144 square-mile (372 $km^2$) area in Interior Alaska between 1970 and 1974. Nesting occurred in all major forest types on this area, but a preference for birch, aspen or mixed birch-aspen woodlands was recorded. When available, birch was usually selected as the nest tree. Most eggs hatched between May 27 and June 5 and chicks remained in the nest for 37 to 41 days. From 1971 through 1973 the density of active nests ranged between one per 16 to 21 $mi^2$ (46-55 $km^2$). In 1974 one nest per 144 $mi^2$ (372 $km^2$) was found. Similarly, 44 to 56 percent of nest sites were occupied between 1971-73, but only 6 percent were occupied in 1974. The same pattern of occupancy was recorded at nest sites located off the study area between 1971 and 1974, suggesting that a marked population decline occurred throughout a major portion of Interior Alaska in 1974. Over the same period, declines in fall-winter trapping success and juvenile to adult ratios of captured birds provided further evidence that numbers had declined on the study area and adjacent areas in 1974. The observed changes in goshawk abundance probably occurred in response to changes in prey densities. During the study, tetraonid abundance was low and snowshoe hare numbers declined after a peak in 1970-71. Other aspects of goshawk biology including growth and development of chicks, morphology and molting are discussed.

CONTENTS



## BACKGROUND

The goshawk (*Accipiter gentilis*) is an important predator throughout the year in wooded regions of Alaska. Goshawks are known to prey on snowshoe hares (*Lepus americanus*) and upland game birds. On Alaska's Kenai Peninsula the major cause of winter mortality among spruce grouse (*Canachites canadensis*) was predation by raptors, particularly goshawks (Ellison 1972). In Minnesota goshawk predation was found to be the major cause of ruffed grouse (*Bonasa umbellus*) mortality during spring and fall (Eng and Gullion 1962). Studies in Finland indicate that grouse are preferred prey of goshawks even when other birds are available (Sulkava 1964).

Presently, there is great international concern for the well-being of raptor populations because of decreased productivity resulting from contamination by chlorinated hydrocarbons. Declines of peregrine falcons (*Falco peregrinus*) have been discussed by Hickey (1969), Cade et al. (1968) and others. Because goshawks, as well as gyrfalcons (*Falco rusticolus*), are permanent residents of Alaska, pesticide contaminations are probably not reducing productivity of these species to the extent recorded for migratory raptors.

Goshawks have long been recognized as excellent birds for falconry and the demand for raptors to be used for this purpose may be increasing. In view of the recent decrease in productivity of peregrine falcons and other birds of prey, goshawks and gyrfalcons may be the only species available in numbers adequate to satisfy this demand in Alaska. We have good, general knowledge of gyrfalcon populations on the Seward Peninsula (Roseneau 1969, 1970 and 1971), but little information on Alaska goshawks has been reported. A literature review revealed few references to this species from elsewhere in North America and no information concerning population densities or productivity was found. Initial studies on Alaska goshawks were reported by McGowan (1971, 1972 and 1973). This final report summarizes findings of goshawk studies conducted during the period 1970 through 1974.

## OBJECTIVES

To determine distribution, density and productivity of goshawks in Interior Alaska.

## The Study Area

The 144 square-mile (372km$^2$) study area (Fig. 1), located directly north of Fairbanks (147°40'W Long. x 64°50'N Lat.), is composed of several forest types in various stages of succession. Gentle slopes, rising to approximately 1,200 feet (360m), are covered with pure to mixed stands of quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*) and black spruce (*Picea mariana*). The vegetative pattern reflects, to a large extent, a history of burning over the last 70 years. Aspen and birch stands occur on south facing slopes, while birch dominates the east and west aspects. These types give away abruptly to scrubby black spruce on northern exposures. A mixture of these forest types, interrupted by willow (*Salix* sp.) and alder (*Alnus* sp.) thickets, predominate in the lowlands. Homogenous stands of white spruce are not widespread on the study area but isolated pockets of white spruce, often mixed with mature birch, are common. The study area is considered typical of hilly, forested regions throughout Central Alaska.

## PROCEDURES

### Nest Surveys

Intensive nest surveys, in all birch and aspen stands within the study area, were conducted using a Piper Super Cub aircraft in late April and early May 1970 through 1972. This amounted to approximately eight hours of actual survey time annually. Particular attention was given to hardwood stands which generally occur on south and west facing slopes, while little time was spent surveying white spruce stands. Most pure spruce stands on the study area are composed of trees too small to support goshawk nests, hence, these stands were considered unsuitable nesting habitat. Consequently, spring nesting surveys were not conducted at random, but were based on physiographic and vegetative conditions.

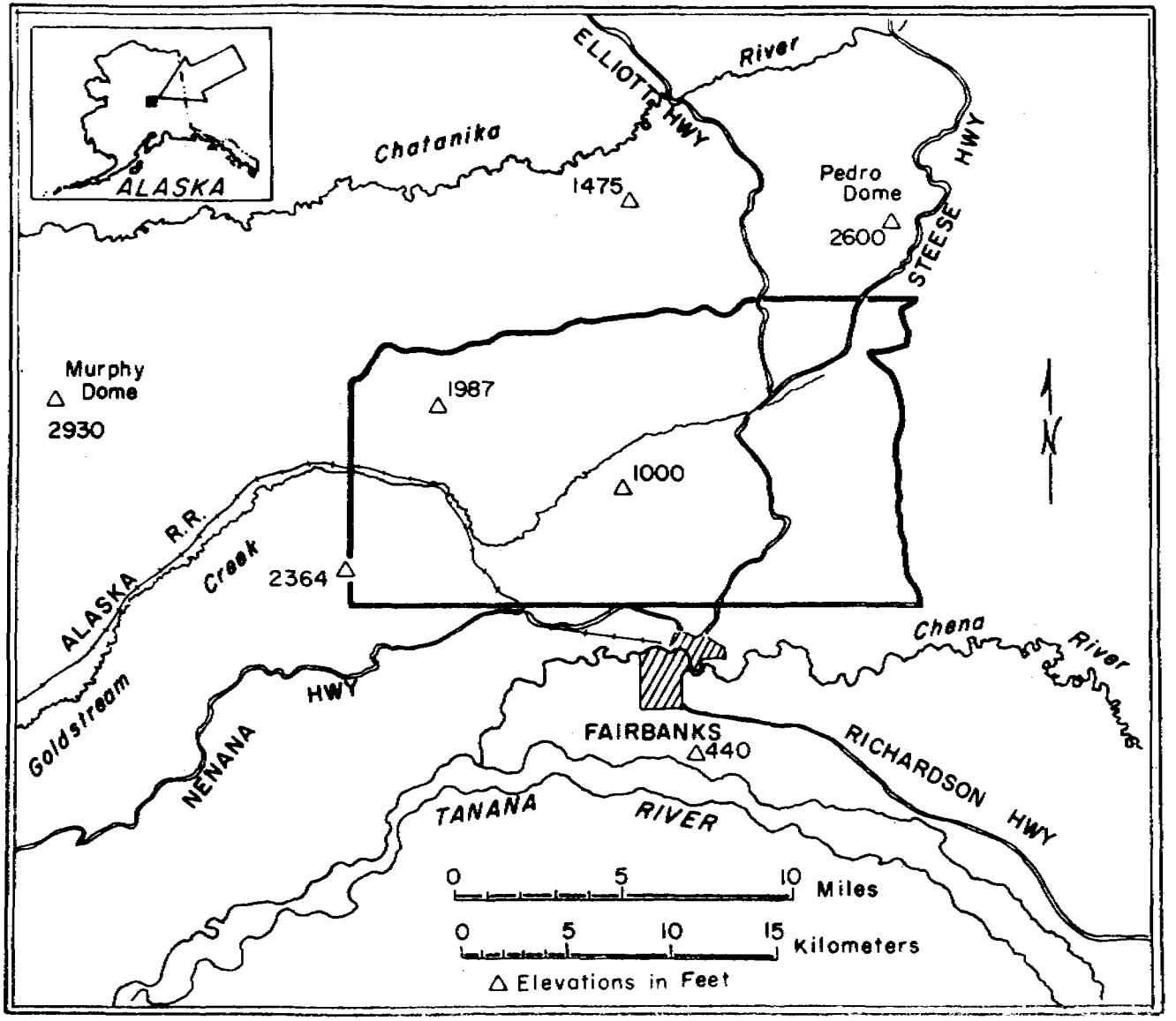



Figure 1. Location of the goshawk study area.

Stick nests were easily observed from the air when snow was on the ground and the trees were devoid of leaves. Surveys were conducted by flying approximately 200 feet (60m) above the tree tops with an observer systematically searching all suitable habitat. Stick nests observed were plotted on maps and visited on the ground in late April to determine activity. Attempts were made to locate all stick nests on the study area, but some nests were probably overlooked. The effectiveness of the aerial survey technique was not evaluated, hence, the extent to which nests may have gone undetected is unknown. Several nests located off the study area were found and data from these nests were used to augment productivity information.

Nesting Studies

Once active nests were located, visits were scheduled in order to determine the following: laying dates, clutch sizes, incubation times, hatching dates, hatching success, period of time spent in nests by chicks, fledging dates and fledging success. In most cases about five visits were made to each nest between late April and late July. During visits attempts were made to minimize disturbance and, whenever possible, a tree other than the nest tree was selected for climbing. At each nest site the following physical and biological data were collected: nest size, height of nest above ground, diameter of nest tree, position of nest in tree, position of nest tree on slope, aspect of slope, elevation of nest site, presence of other stick nests nearby, species of nest tree and general vegetative composition of the stand in which the nest occurred. Note was also made of plumage coloration, stage of wing and tail molt and behavior of adults.

Pole climbing irons and a lineman's belt were used for climbing. It was necessary to wear a hard hat and heavy leather jacket for protection against aggressive adult hawks.

Trapping and Banding

Seven Swedish goshawk traps, baited with three or more pigeons (*Columba livia*), were operated during September through December on the study area. The traps were similar to those described by Beebe and Webster (1964) and Meng (1971). Clearings surrounded by deciduous woodlands were selected as trapping sites and three trap locations were used throughout the 1971, 1972 and 1973 trapping seasons to yield comparative information for those years. Other traps were moved as many as three times between October and December in order to capture as many hawks as possible.

Trapped hawks were banded with size 7B bands provided by the U. S. Fish and Wildlife Service (Appendix I). Color bands were used in 1970, but their use was discontinued because they did not prove adequate for positive identification of individuals under field conditions, and hawks often lost their plastic color bands even though all seams were bonded with acetone.

It is generally believed that male goshawks are approximately one-third smaller than females (Mueller and Berger 1968, Storer 1966). When hawks were trapped their sex was initially judged by general body and foot size; however, all hawks captured were weighed and subjected to the following measurements as described by Pettingill (1939): length, wing chord length, length of the first, fourth and fifth primary (numbering 1-10 proximately) and length of center rectrix. Measurements of primaries were the lengths of flattened feathers. Originally, extent and bill lengths were taken, but these measurements were deleted from banding procedures in 1972.

Trapped hawks were placed in three age categories as described by Mueller and Berger (1968). Yearlings (birds less than 1 year of age) are typified by a brownish, streaked breast, while Adult I birds (assumed to be 1 but less than 2 years of age) display a mixture of gray, adult and some brownish, juvenile plumage. Adult II birds (2 or more years of age) have gray, adult plumage with no brown. General observations on eye color, condition, molted feathers and presence of "shock marks" were also made. All trapped birds were released at the same location as trapped. Similar measurements obtained from dead goshawks allowed confirmation of sex by internal examination.

### Food Habits

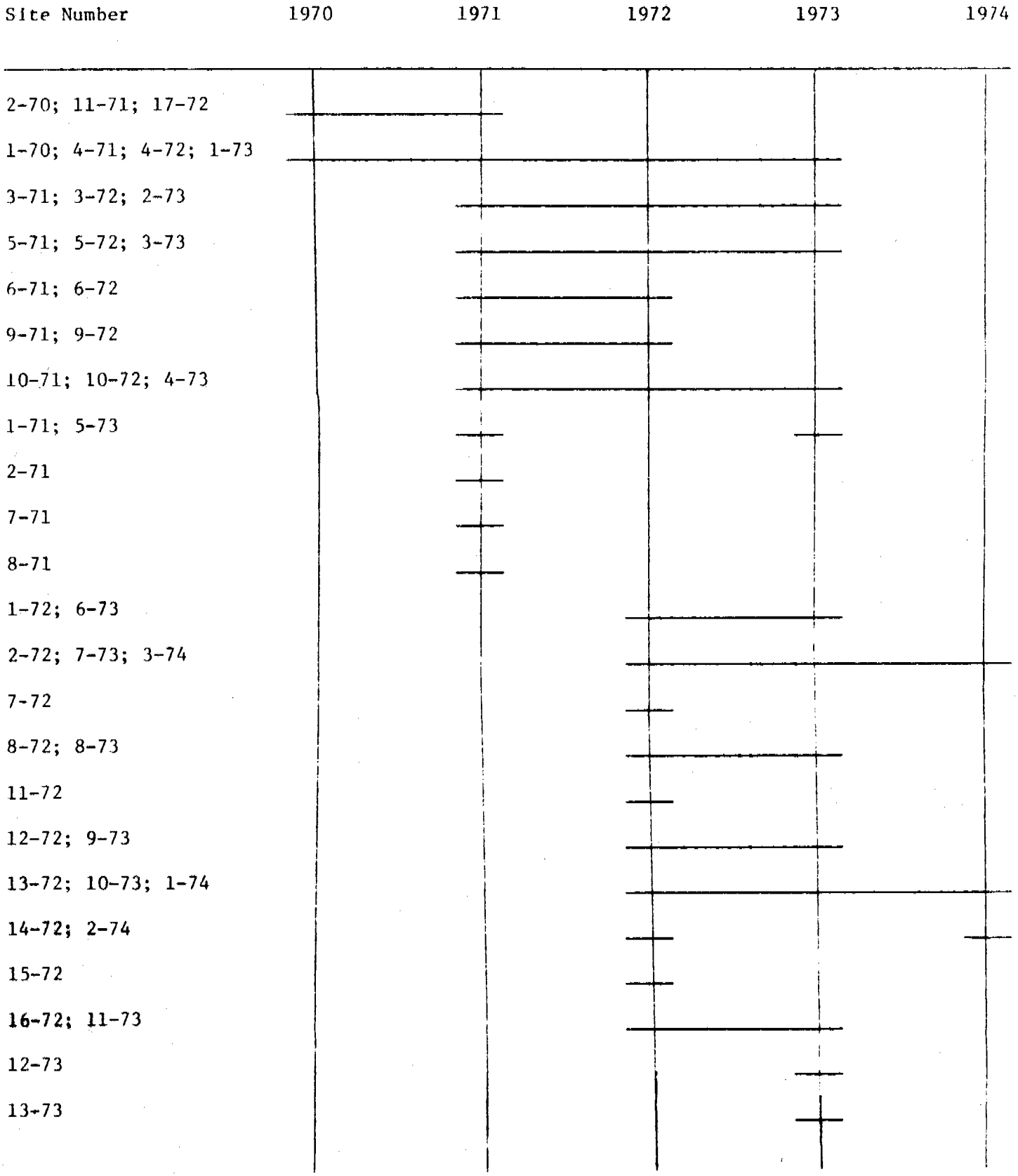
After the young had fledged, castings (regurgitated pellets) and skeletal remains of prey items were collected both from the nest and the immediate nesting area. Castings were dried and later analyzed to reveal food habits. Errington (1932) and Glading et al. (1943) concluded that casting analysis reflects food habits of hawks qualitatively but not quantitatively. It is not possible to differentiate between castings deposited by nesting females and chicks, consequently, food habits information presented here is intended merely as a listing of summer prey species and their relative frequency of occurrence as hawk prey.

## FINDINGS

### Use of Nesting Sites

Twenty-three active nesting areas were located between 1970 and 1974. No nest sites occupied in 1970 remained active through 1974 and only one site was used for four consecutive years (Fig. 2). Nevertheless, 100, 59 and 69 percent, respectively, of the nests active in 1971 through 1973, had been active the previous years. Owing at least in part to a low breeding density, only 23 percent of the nests active in 1973 were used in 1974. These findings indicate that goshawks demonstrate definite preferences for certain sites. They may: 1) repeatedly use the same nest, 2) alternate yearly between existing nests present in the area, or 3) build a new nest in the same area. Attempts to mark nesting birds to allow identification of specific individuals in relation to specific nest sites were unsuccessful. Consequently, it is not certain whether traditional sites are occupied yearly by either or both members of a pair during the nesting season throughout their lives, or whether such areas are highly preferred and yearly attract birds at random.

Figure 2. Patterns of use at goshawk nesting sites, 1970-74.



Aerial surveys coupled with intensive ground search revealed stick nests were distributed over the entire study area (Fig. 3). I feel certain that in most cases these nests were built by goshawks. Other common birds in Interior Alaska utilizing large, arboreal stick nests include great horned owls (*Bubo virginianus*), great gray owls (*Strix nebulosa*), ravens (*Corvus corax*) and Harlan's or red-tailed hawks (*Buteo jamaicensis*). It is generally agreed that great horned and great gray owls rarely build their own nests (Bent 1937a), and I have recorded two instances of great horned owls utilizing nests that had been occupied by goshawks the previous year. In both cases, goshawks did not nest in the area when owls were present, but it is not known whether the hawks were displaced or replaced. Because ravens and red-tailed hawks have rarely been found nesting on the study area, they probably were responsible for few, if any, of the stick nests located. In most cases, several nests were situated relatively close together (Fig. 3). At 21 sites where stick nests were observed from the air, intensive ground searches revealed that only four sites contained a single nest. Such locations, with two or more nests clumped within an area 0.5 mi (0.8 km) in diameter, are considered to be traditional goshawk nesting sites.

Not all areas containing stick nests were used by goshawks during the study. Of the 16 known potential nest sites on the study area, 56 percent were active in 1972, 44 percent in 1973, and 4 percent in 1974. During this period only one new site was known to have been established. Throughout the study most active sites were of the traditional type, but traditional site usage increased from 83 percent in 1971 to 100 percent in 1974. All non-traditional sites active between 1971 and 1974 were occupied by yearling females, while only one instance of a yearling bird using a traditional site was recorded. Yearling females are probably rarely, if ever, successful in displacing adults at nesting sites and during periods of high breeding density young birds will be forced to establish new nesting territories. The yearly decline in use of available sites coupled with an increase in the proportion of traditional sites used annually, strongly indicates that the period 1971-74 was one of decreasing breeding densities.

## Description of Nests and Nesting Sites

Specific physiographic data for each of the 45 nest sites studied between 1970 and 1974 appear in Appendix II. Paper birch is obviously an important component of nesting habitat and pure stands of this species were used more commonly than any other forest type (Table 1). Approximately half the nests studied occurred in mixed stands, but even in these situations birch was a significant member of the forest community in 78 percent of the cases. The importance of birch to nesting goshawks is further reflected in the species of nest tree selected (Table 2). In mixed stands, where two or more tree species suitable for nesting occurred, birch was selected in 94 percent of the cases. Furthermore, 90 percent of the aspen nest trees occurred in pure stands, which precluded selection of another species. Although birch woodlands may be preferred nesting habitat, both yearling and adult goshawks have nested in aspen forests. This may be theoretically explained assuming that: 1) yearlings are relatively unsuccessful in competition with older birds for the most

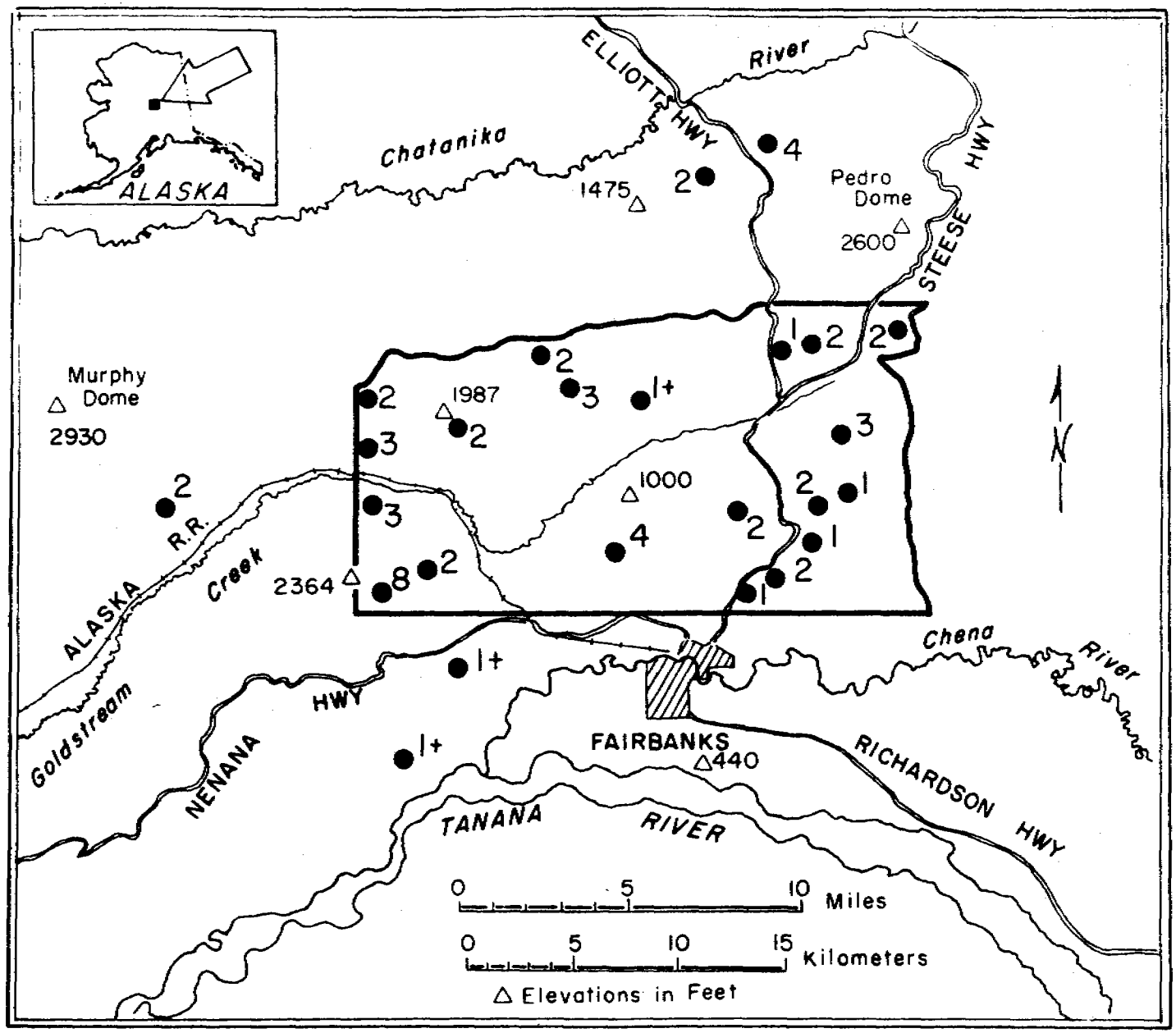



Figure 3. Distribution of known potential goshawk nesting sites showing the number of stick nests at each site in 1974.

Table 1. Number of active goshawk nests in various timber types.

| Timber Type | 1970(%) | 1971(%) | 1972(%) | 1973(%) | 1974(%) | Total(%) |
|---|---|---|---|---|---|---|
| Birch | 1(50) | 4(36) | 7(44) | 4(31) | 1(33) | 17(38) |
| Aspen | 0(0) | 4(36) | 1(6) | 3(23) | 0(0) | 8(18) |
| Birch-Aspen | 0(0) | 1(9) | 5(31) | 2(15) | 0(0) | 8(18) |
| Birch-Spruce | 0(0) | 1(9) | 3(19) | 3(23) | 1(33) | 8(18) |
| Birch-Spruce-Aspen | 0(0) | 0(0) | 0(0) | 1(8) | 1(33) | 2(4) |
| Spruce- Balsam poplar *(Poplus balsamifera)* | 1(50) | 1(9) | 0(0) | 0(0) | 0(0) | 2(4) |
| Total | 2 | 11 | 16 | 13 | 3 | 45 |

Table 2. Number of goshawk nests in various tree species.

| Nest Tree Species | 1970(%) | 1971(%) | 1972(%) | 1973(%) | 1974(%) | Total(%) |
|---|---|---|---|---|---|---|
| Birch | 1(50) | 6(55) | 14(88) | 10(77) | 3(100) | 34(76) |
| Aspen | 0(0) | 4(36) | 2(12) | 3(23) | 0(0) | 9(20) |
| Balsam poplar | 1(50) | 1(9) | 0(0) | 0(0) | 0(0) | 2(4) |
| Total | 2 | 11 | 16 | 13 | 3 | 45 |

desirable nest sites and 2) individual female goshawks demonstrate a high degree of fidelity to specific nest sites. Hence, during years of high breeding density, such as in 1971, yearling females attempting to nest may, to a large extent, be forced to select sites in aspen woodlands. Once established, these sites would show continued use for several years even though the population may have declined leaving preferred nest sites in birch woodlands available to yearling females.

Nests were constructed of twigs and branches of several species varying in size up to 0.5 inches (1.3 cm) in diameter and placed in trees where forks or branches provided a strong foundation. New twigs were added when existing nests were reused. The majority of nests were lined with deciduous twigs and green leaves, coniferous twigs with needles, or bark. Sometimes only one type of lining was used, while in other cases, several types were used. Lining material was added as the nesting season progressed. In all cases, eggs were laid in cup-shaped depressions, but as chicks matured, trampling reduced the cup depth to a point where the nest resembled a platform.

Mature birch trees are preferred for nesting probably because of their tendency, unlike aspen, to have large forks required for stable foundations. The diameter (DBH) of all nest trees varied between 7.0 inches (18.0 cm) and 19.0 inches (48.0 cm), averaging 11.0 inches (28.0 cm). The mean DBH for birch nest trees was 12.0 inches (30.0 cm), while the average for aspen trees was 8.0 inches (20.0 cm). Sixty-one and 37 percent of the nests were located in the upper or middle portions of trees, respectively. The height of nests above the ground ranged from 15 feet (4.5 m) to 54 feet (16.2 m), averaging 30.0 feet (9.0 m). Approximate nest size (diameter x depth) averaged 35 inches x 20 inches (88.0 cm x 50.0 cm). There were no significant differences with respect to height above the ground, position of nests in the nest tree or nest size among nests in the various species of trees.

Since 1970 all but 8 of 45 nests studied were situated on hillside situations. Those nests in flat terrain were located along stream courses near the town of Central in the Birch Creek Flats. In this area, timber of suitable size for nesting goshawks is restricted to narrow bands along water courses. In hillside situations 46 percent of the nests occupied the middle portion of the slope, 38 percent were on the lower portion and 16 percent on the upper portion. Nest sites ranged in elevation from 640 feet (195 m) to 1,800 feet (540 m). Sixty-four percent of the nests occupied slopes of southerly exposure and 36 percent were on northerly slopes. Although nest trees were distributed about equally between slopes of northern and southern exposures, aspen nest trees were restricted to south facing slopes. This probably reflects differences in the distribution of birch and aspen communities more than selectivity by goshawks.

Nesting Chronology

Data reflecting times of territory establishment, breeding, nest building and egg laying are limited. Goshawk pairs were observed in the vicinity of nest sites as early as March, but few visits were made to

nesting areas early in the season, in order to minimize chances of desertion. Nests were being constructed or repaired during mid to late April even though they may have contained several inches of snow at that time. Back dating from the day of hatch to the time of clutch completion for 12 nests showed the incubation period to be approximately 29 days which generally agrees with findings of Craighead and Craighead (1956) and Bent (1937b). Generally, goshawks in Interior Alaska are on their territories and associated with a specific nest by mid-April. Egg laying probably occurs during the last week of April and most clutches are complete and incubation underway by May 5. These findings are in general agreement with those reported for goshawks from similar latitudes in Norway by Myrberget (1970). Cade (1970) found that spring weather affected the onset of reproduction in Alaskan gyrfalcons and this probably holds true for goshawks.

A summary of hatching and fledging dates for all nests studied appears in Table 3. The earliest hatching was recorded on May 13 (1972) and the latest recorded was June 25 (1972 and 1973). While renesting has not been documented for Alaskan goshawks, it may have occurred in the case of the unusually late hatches. It is of interest to note that both cases of early hatching occurred at the same nest site. Whether this resulted from microclimatic conditions unique to the site or from other factors was not determined. Despite the unusually cool spring temperatures and persistent snow cover in 1972, the mean hatching date of June 1 was four days earlier than that of 1971. The mean hatching date of May 27, recorded in 1973, followed a spring with normal temperatures. The range in hatching dates (May 13 and June 25) probably approximates the potential range in hatching dates for goshawks in Interior Alaska, with 75 percent of nests hatching between May 27 and June 5 in most years. There was some indication that hatching may occur consistently earlier at some sites than at others and that nests of yearling females hatch later than those of adults, but small sample sizes precluded statistical comparison or definite conclusions in this respect.

Exact fledging dates are difficult to determine. Chicks were observed frequenting the nest or nest tree for at least a week after making their first flight. By July 15 the chicks from most nests had fledged (Table 3), and by August 1 they had vacated the general nesting area. The period between hatching and fledging ranged from 37 to 41 days. On the average, chicks spent 39 days in the nest, or 10 days longer than reported for Wyoming goshawks by Craighead and Craighead (1956).

Females openly attacked and often struck observers and adult females seemed to be more aggressive than yearlings. Defense displays consisted of loud calling and numerous low "passes" at intruders. In some cases males joined in defense displays but they usually stayed further away, and rarely struck the observers. In general, nesting birds were far more aggressive after hatching than in earlier stages of the nesting season and the females remained highly protective of their nests and young for some time after the chicks had fledged.

Table 3. Goshawk hatching dates, fledging dates, and number of days chicks occupied nests.

| Year | Hatching | | Fledging | | Mean number days chicks in nest (n) |
|---|---|---|---|---|---|
| | Range | Mean (n) | Range | Mean (n) | |
| 1971 | May 29-June 25 | June 5 (8) | July 5 - July 28 | July 11 (8) | 37 (8) |
| 1972 | May 13-June 25 | June 1 (12) | June 22-July 14 | July 5 (5) | 39 (4) |
| 1973 | May 18-June 2 | May 27 (9) | June 28-July 8 | July 8 (6) | 41 (5) |

## Age of Breeding Birds

In 1971, 36 percent of the active nests were occupied by yearling females. This was the only year in which yearlings were known to have nested. Males were observed at only 37 percent of the nests studied, and in all cases they were in adult plumage. Males were never seen at nests occupied by yearling females. Similarly, yearling females but not yearling males were found to breed in Finland. As a general rule, however, Finnish goshawks of both sexes do not breed until their second year of life (Haukioja and Haukioja 1970, Höglund 1964a). The high proportion of nesting yearlings in 1971 indicates high production and winter survival in 1970. While polygamy has not been documented for the goshawk, it has been reported for other raptors and can not be ruled out as a possible explanation for the absence of males at the nests occupied by yearling females.

## Breeding Density

Sixteen potential goshawk nest sites on the study area were checked yearly between 1971 and 1973. Despite ground and aerial searching to locate new territories that may have been established during the investigation, only one such site was located, and it was used only in 1973. Nesting densities were relatively high during the period 1971-73, with a marked decline occurring in 1974 when only one of 17 nest sites was occupied (Table 4). Breeding densities of one pair per 16 to 144 square miles (41-372 $km^2$) are somewhat lower than those recorded in Finland where densities ranged between 9-39 square miles (22-100 $km^2$) per nesting pair over a seven year period (Höglund 1964a). Other studies in Finland by Hakala (1969) revealed nesting densities as high as one pair per six square miles (16.4 $km^2$). In two instances goshawk nests on our study area were situated as close together as 1.5 and 1.9 miles (2.4 and 3.1 km) in 1971 and 1972, respectively, further evidence that under certain conditions relatively high nesting densities can be attained. In Germany the distance between adjacent pairs of goshawks was sometimes less than 1.6 miles (2.6 km) and pairs hunted over areas of 15-19 square miles (38.8-49.3 $km^2$) during summer depending on habitat quality (Rust 1971). Apparently goshawks are capable of existing, even during the breeding season, at densities considerably higher than reflected by the nesting densities I have reported. Whether or not it is possible to attain breeding densities as high as those in Finland remains unknown due to gaps in our knowledge concerning goshawk-prey relationships and other aspects of habitat quality. The densities reported here must be considered as yearly minimums.

Nest sites located outside the study area, including several as far as 100 miles (160 km) to the northeast, were checked annually for activity. Occupancy of these sites was high during the period 1971-1973, preceding a marked decline in 1974 (Table 5). The similarity in trends of nest site occupancy on and off the study area suggests that the decline in 1974 may have occurred concurrently over a large portion of Interior Alaska.

Table 4. Occupancy of nest sites and densities of breeding goshawks on the 144 square mile (372 $km^2$) study area.

| | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|
| Nest sites checked | 16 | 16 | 16 | 17 |
| Active Nests | 7 | 9 | 8 | 1 |
| Percent Occupancy | 44 | 56 | 50 | 6 |
| Square miles per active nest ($km^2$) | 21(55) | 16(41) | 18(46) | 144(372) |

Table 5. Occupancy of goshawk nest sites located off the study area.

| | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|
| Nest sites checked | 7 | 9 | 9 | 9 |
| Active nests | 6 | 7 | 7 | 2 |
| Percent Occupancy | 86 | 78 | 78 | 22 |

## Production

Productivity data are summarized in Table 6. Over a 3-year period clutch sizes averaged 3.2 eggs and the number of chicks reared to fledging age averaged 2.0 per nest started. These figures are well within the ranges for goshawks breeding in Scandanavia reported by Höglund (1964a) and Hakala (1969). It should be noted, however, that I never observed a 5-egg clutch in Alaska, while this occurred rather commonly during some years in Finland.

Production was highest in 1971 when a mean of 2.5 chicks were fledged per nest started. Each successful nest fledged an average of 3.0 chicks that year. During this study mean clutch sizes varied between 3.0 and 3.8, egg hatching success between 85 and 96 percent and chick survival between 93 and 100 percent and the major cause of reproductive failure in all years occurred prior to hatching.

In 1971 only two nests failed before hatching. Both contained fertile eggs and were occupied by yearling females. Inspection of the nests revealed no signs of predation and this, coupled with the fact that the eggs were still present, suggested desertion due to excessive human disturbance. The deserted sites received no more disturbance during the course of investigation than did other successful sites occupied by yearling females. Ratcliffe (1962) indicated that marginal nest sites are more readily deserted than ideal sites and that desertion results from psychological factors. Most yearling females nesting during a population high are probably forced into less desirable territories, consequently this segment of the population may be more susceptible to desertion than older birds utilizing preferred habitats. While yearlings may be more prone to desertion, yearlings that nested successfully produced at a rate comparable to that of older birds. If the pre-hatching failures in 1971 were caused by human disturbance, the potential productivity that year should be considered even higher than reported here.

Even though yearlings were not found nesting in 1972 or 1973, the proportion of nests failing prior to the hatch increased each year. In 1972, 5 of 17 nests failed. With the exception of one nest which fell from the tree, causes for failure were unknown. Although the eggs were missing no other signs of disturbance were noted. One case of chick mortality resulting from infection by *Trichomonas* sp. occurred in 1972. The disease killed two chicks, but the other two nest mates fledged normally.

In 1973, 4 of 12 nests failed prior to hatching. At one unsuccessful nest claw marks of an unidentified mammalian predator were found leading up the nest tree. At another site three nest trees had been climbed suggesting that a predator was selectively searching for nests. Höglund (1964b) stated that the pine marten (scientific name not given) may prey on nestling goshawks in Finland. While marten (*Martes americana*) may have been responsible for nest losses in 1973, lynx (*Lynx canadensis*) and porcupines (*Erethizon dorsatum*) should not be overlooked as possible nest predators. Eating of eggs by the parent raptors and subsequent

Table 6. Summary of goshawk production data, 1971-73.

| Year | Clutch size range | Clutch size mean (n) | Percent nests failing prior to hatching | Percent eggs hatched among successful nests* | Percent chick survival to fledging | Mean production per nest started | Mean production per successful nest* |
|---|---|---|---|---|---|---|---|
| 1971 | 1-4 | 3.1(10) | 18 | 96 | 100 | 2.5 | 3.0 |
| 1972 | 1-4 | 3.0(14) | 29 | 85 | 93 | 1.8 | 2.3 |
| 1973 | 2-4 | 3.8(9) | 33 | 90 | 100 | 1.8 | 2.9 |
| 1971-73 combined | 1-4 | 3.2(33) | 28 | 90 | 98 | 2.0 | 2.7 |

*Successful nests are all active nests excluding those failing prior to hatching.

desertion of the nest have been noted by Hickey (1969), Cade et al. (1968) and others as a symptom of raptors carrying high levels of pesticide residues. Recent, unpublished studies conducted at the University of Alaska by Dr. L. G. Swartz have not revealed alarmingly high pesticide residues in Alaskan goshawks. Consequently, predation, perhaps in conjunction with desertion, though undetected in 1972, probably accounted for most pre-hatching nest failures both in 1972 and 1973.

From production studies we can definitely account for 29, 37 and 30 goshawks on the study area in late July of 1971 through 1973, respectively. Converted to square miles per bird, these figures indicate the following late summer densities: 5.3 (13.3 $km^2$), 1971; 3.9 (10.1 $km^2$), 1972 and 4.8 (12.4 $km^2$), 1973. Unknowns concerning factors controlling the probability of females nesting as yearlings, differences in mobility between age and sex groups and mortality rates preclude direct comparisons of fall to subsequent spring nesting densities. The various indicators of population trends are evaluated and discussed later.

Fall and Winter Abundance

Höglund (1964b) stated that autumn and winter capture figures from a given area do not provide a sound basis for estimating the previous summer's goshawk production on that area. This also appeared true for the present study. In most years juvenile to adult ratios of autumn trapped birds (Table 7) were markedly higher than those computed from production figures the previous July. Due, at least in part, to their relatively high mobility juveniles are more readily trapped than adults. While age ratios of trapped birds may not precisely reflect changes in productivity, they are useful in conjunction with trapping success. figures in determining periods of extremely high or low abundance. The number of goshawks and proportion of juveniles handled annually declined steadily between 1970 and 1974 (Table 7). Fall trapping success also declined markedly between 1971 and 1973 (Table 8) as did the number of observations reported by persons rearing domestic fowl in the Fairbanks vicinity. Hence, trapping success, age composition of birds captured and general observations all indicated a declining population during the period 1970-73.

It is assumed that birds in Adult I plumage captured during fall or winter are yearlings (15-25 months of age) and those in Adult II plumage are more than two years old as suggested by Mueller and Berger (1968). There probably was not a trap bias between the two adult age categories. Assuming that the proportion of adults trapped in each category truly reflected their occurrence in the population, the Adult I segment showed a decline while the Adult II segment increased between 1970 and 1974 (Table 9). This trend further suggests that the population on the study area declined throughout the investigation despite moderately high production in most years. Juveniles are the most mobile age group and also sustain the highest mortality rate (Haukioja and Haukioja 1970, Mueller and Berger 1967 and Höglund 1964a). Whether the failure to recruit juveniles into the Adult I category resulted primarily from movement off the study area or from direct mortality remains unknown.

Table 7. Fall and winter juvenile to adult ratios of goshawks handled, 1970-74.

| Year | Fall*(n) | Winter**(n) | Fall-Winter combined(n) |
|---|---|---|---|
| 1970 | 5.0:1.0(6) | all juvenile (2) | 7.0:1.0(8) |
| 1971 | 3.3:1.0(56) | all juvenile (9) | 4.0:1.0(65) |
| 1972 | 1.2:1.0(11) | 2.2:1.0(29) | 1.9:1.0(40) |
| 1973 | 4.0:1.0(5) | 1.1:1.0(30) | 1.3:1.0(35) |
| 1974 | - | 0.1:1.0(11) | 0.1:1.0(11) |
| Total | 3.5:1.0(78) | 1.5:1.0(81) | 2.0:1.0(159) |

* Fall figures from live trapping during September to December.
**Winter figures from dead goshawks donated by fur trappers.

Table 8. Goshawk trapping success on the study area, 1971-73.

| Year | Trap days | Captures | Trap days per capture |
|---|---|---|---|
| 1970 | - | 6 | - |
| 1971 | 486 | 59 | 8.2 |
| 1972 | 364 | 12 | 30.3 |
| 1973 | 326 | 5 | 65.2 |
| Total | 1176 | 76 | 15.5 |

Table 9. Number and percentage of Adult I and II goshawks handled, 1970-74.

| | 1970(%) | 1971(%) | 1972(%) | 1973(%) | 1974(%) |
|---|---|---|---|---|---|
| Adult I | 1(100) | 9(69) | 7(50) | 6(40) | 1(10) |
| Adult II | 0(0) | 4(31) | 7(50) | 9(60) | 9(90) |
| Total | 1 | 13 | 14 | 15 | 10 |

## Movements

All goshawks captured were banded and are recorded in Appendix I. Recoveries were too few to allow population estimates, but some data concerning movements were obtained. Of 139 goshawks banded between 1970 and 1974, only 12 (9 percent) were recovered. Seven of these recoveries were birds found dead, having been shot in most cases. Fifteen percent of the birds banded as adults were recaptured and only six percent of birds banded as nestlings or juveniles were recaptured. Band recoveries revealed that movements of eight juvenile goshawks ranged between 5.5 and 20.8 miles (8.9-33.5 km) averaging 12.0 miles (19.3 km). Juvenile males averaged slightly longer movements (13.2 miles or 21.3 km) than juvenile females (12.3 miles or 19.8 km). Goshawks banded as nestlings and later recovered moved an average of 12.2 miles (19.6 km) as compared with movements averaging 11.6 miles (18.7 km) for birds both banded and recaptured as juveniles. Ten adult recoveries indicated movements ranging from 0 to 8.5 miles (0-13.7 km) averaging 2.1 miles (3.4 km).

Apparently juveniles are more mobile than adults and males, particularly juveniles, are probably more mobile than females. Further evidence of relatively low mobility of adults comes from multiple recoveries of three adults (2 males and 1 female) in which movements of less than two miles (32 km) had occurred. One male goshawk banded as an adult in 1967 was subsequently captured in the same area three times (April 1971, July 1971 and February 1973). This bird was at least seven years of age in 1973 and definitely a local resident. Multiple recaptures did not occur among juveniles with one exception. In this instance a female banded as a nestling in 1971 was captured in September 1972 as an Adult I, 13.5 miles (21.7 km) from the nest. This bird was later captured twice during the winter of 1972 in the same area having taken up residence (at least during winter) in the vicinity of the trap site. Movements as reflected by roosting site locations further suggest that during winter adults do not wander greatly (see Appendix III).

In summary, juveniles were more commonly captured than adults probably reflecting both their relative abundance in the population and their mobility. Their low recapture rate indicated that: 1) unlike adults, juveniles commonly wandered out of the study area and did not return, 2) juveniles suffer from high mortality during this period, or 3) both egress and mortality were occurring. Relatively high trapping success during September suggests that movement is highest in early fall and decreases somewhat with the onset of winter. The majority of adults probably winter in the vicinity of their nesting territory, while juveniles wander significantly during their first fall and winter. Therefore, fall trapping probably samples from: 1) the resident adult population, and 2) a highly mobile population of juveniles that have not yet settled on territories.

## Food Habits

Castings (regurgitated pellets) were collected at successful nests in 1971 through 1973. Collections from each nest, usually 17 to 20 castings, were considered a single sampling unit. During the three nesting seasons snowshoe hares comprised the major food of goshawks although red squirrels (*Tamiasciurus hudsonicus*) and birds, probably passerines in most cases, were also commonly taken (Table 10). Nesting

Table 10. Food item frequencies for castings collected at goshawk nest sites, 1971-73.

| Food Item | Frequencies | | | |
|---|---|---|---|---|
| | 1971 | 1972 | 1973 | 1971-73 combined |
| Snowshoe hare | 100 | 100 | 100 | 100 |
| Unidentified feathers | 100 | 67 | 100 | 88 |
| Red squirrel | 67 | 44 | 83 | 54 |
| Passerines | 44 | 22 | 67 | 54 |
| Grouse | 33 | 11 | 0 | 17 |
| Rodents | 0 | 33 | 17 | 13 |
| Mammals | 100 | 100 | 100 | 100 |
| Birds | 100 | 89 | 100 | 96 |

goshawks have been observed to take nestling robins (*Turdus migratorius*) and microtines. A large proportion of the hares taken during the summer are probably young animals. According to parturition dates for snowshoe hares in the Fairbanks area (Ernest 1974), first and second litters were born, in most years, at about the time goshawks hatched and fledged, respectively.

It is of interest that few grouse remains occurred in castings in view of findings from Finland where grouse comprise the major food item (Hŏglund 1964b). Grouse populations were low throughout the study (McGowan, in press), but the high snowshoe hare population in 1970 had declined markedly by 1974 (Ernest 1974).

Food habits of goshawks in Finland vary widely with respect to prey abundance (Sulkava 1964) and grouse may assume higher importance as a food item in Alaska during other years. Red squirrels were found to be an important food source for nesting goshawks in the northeastern United States (Meng 1959). This may be especially true in Alaska during years of simultaneous lows in grouse and hare populations as evidenced by the relatively high occurrence of red squirrel remains among castings collected in 1973.

Discussion of Population Trends

Nesting densities, occupancy of nest sites, production, fall trapping success and age ratios of trapped birds can each yield some indication of abundance. The precision of individual indicators was not determined but implications of these parameters are discussed below.

Breeding populations as reflected by nesting density and proportion of nest sites occupied, were relatively high in 1971, peaked in 1972, declined slightly in 1973 and dropped markedly in 1974. In 1970 the spring population was not monitored closely but general observations suggested that a moderately high breeding population existed that year. Consequently it is not known in which year breeding numbers peaked, nor for how long prior to 1970 spring abundance had been relatively high. Production and fall trapping success peaked in 1971, while late summer density (known number of nesting adults plus known number of young fledged) was highest in 1972. Juvenile to adult ratios of fall- and winter-trapped goshawks declined during the period 1970-74. This steady decline, in view of moderately high production, suggests a high rate of egress and/or mortality among juveniles. General observations also suggested a sharp decline in abundance prior to the winter of 1973-74. Therefore it is concluded that goshawks were abundant on the study area during the 4-year period 1970-73, but the year that numbers actually peaked is unknown. In the autumn of 1973 the population declined sharply and persisted at a low level through 1974. This trend probably occurred throughout Interior Alaska.

Although this study was not designed to explore the mechanisms of goshawk population control, some speculation concerning the cause of the observed change in abundance seems warranted. Goshawk and other raptor populations have been shown to fluctuate numerically in response to changing prey densities (Pitelka et al. 1955, Southern and Lowe 1968,

Sulkava 1964). A great horned owl population in Wisconsin that was largely dependent on snowshoe hares for food, responded to increasing hare abundance by increases in population density and proportion of the population attempting to breed (Rush et al. 1972). In Finland, where tetraonids provide the primary goshawk food, clutch size varied in accordance with tetraonid, but not squirrel, abundance. During periods of low tetraonid abundance, goshawk populations declined through emigration, nesting failure and direct mortality as a result of starvation (Sulkava 1964). These findings apply directly to resident Alaskan raptor populations, and changes in prey abundance probably accounted for the observed fluctuations in goshawk abundance reported here. Availability of resident prey species such as hares, grouse and red squirrels is almost certainly more critical to goshawks during winter than in spring and summer when a wide array of migrant prey species are present. In Interior Alaska, where two (hares and tetraonids) of the three major prey groups undergo pronounced, generally synchronous fluctuations (McGowan, in press), goshawk abundance may vary more widely than in southern latitudes. Unlike grouse and hares, red squirrel abundance reportedly varies directly with spruce cone production. Annual excesses of cones stored by squirrels for food eventually accrue to quantities adequate for sustaining the squirrels through a winter following a cone failure (Smith 1968). Red squirrels probably do not fluctuate violently nor in synchrony with other prey species and consequently assume a major role in goshawk population regulation.

## Miscellaneous Findings

Growth and Development of Chicks: Twenty-seven goshawk chicks at 11 nests were observed periodically after hatching in order to determine the preferred age for banding. Through these observations, plus weights and measurements taken at the time of banding, a general impression of nestling development was obtained. The weekly description presented below summarizes findings of observations at nests where both known and estimated hatching dates were obtained. The post-fledging (after five weeks of age) description is based on weekly observations and measurements of a captive male goshawk held for this purpose. The hawk was taken at about 28 days of age and held in captivity by Terrence Bendock under Scientific Collection Permit #417-14 1971. Snowshoe hares comprised the main diet of this bird during the observation period. The fact that captivity and an "artificial" diet may have affected development must be kept in mind. Furthermore, feather lengths would be somewhat greater for females than reported here for males. This summary is presented merely as a general description of development, from the time of hatching until full juvenile development is attained, as an aid in determining the approximate age of nestlings.

One week - Chicks are covered with gray down. Body feather growth is not apparent, the egg tooth prominent and the eyes light blue-gray in color. Chicks will hold their heads upright but little other movement occurs.

Two weeks - Chicks are about two-thirds their adult weight but are still down-covered. All primaries and secondaries

are visible. The egg tooth is still visible and body feathers appear through the down in the scapular region. Chicks are unstable on their feet, however, the feet have developed some gripping power and chicks cling to nest material when disturbed.

Three weeks - Chicks have reached their full weight (approximately 900 to 1200 gms). All primaries and rectrices are visible and sheathed. Primaries 4 and 5 are 6-8 cm long. Contour feathers appear on back, but head and breast are down covered.

Four weeks - Brown, juvenile plumage appears on all portions of the bird except the forehead, upper legs, lower back and mid-breast. Down is localized and appears patchy. Chicks stand for short periods and begin to show aggressiveness. This is the ideal age for banding.

Five weeks - Chicks generally appear fully plumaged with brown juvenile feathers. Small patches of down are still present on the forehead and thighs. The feet are strong and well developed, however, the eyes are still blue-gray in color. Fledging occurs shortly hereafter despite the fact that primaries and rectrices have not completed their growth.

Six weeks - Juvenile plumage covers entire body with very little, if any, down visible. Eye color is gray-yellow, primaries and rectrices are sheathed. Primaries 1, 4, and 5 are approximately 14, 21, and 23 cm in length, respectively. Central rectrices about 19 cm long.

Seven weeks - Chicks are juvenile in appearance. No down visible at this time. Sheathing is present on primaries and rectrices. Primaries 1, 4 and 5 are approximately 14, 23, and 25 cm in length, respectively. Central rectrices are about 21 cm long.

Older than 7 weeks- Sheathing on primaries and rectrices disappears shortly after six weeks of age. Primaries and rectrices continue to grow at a relatively slow rate until their full length is obtained at about 14 weeks of age.

Like most raptors, goshawks develop rapidly during the early stages of life, their full body weight being attained by the age of three weeks. Based on weekly measurements of a single individual, approximately 61 percent of the feather growth is completed by 28 days of age (Table 11), however, fledging occurs long before feather growth is complete. The rate of primary and rectrix growth appears to be inversely proportional to age and at about 14 weeks of age juvenile plumage development is completed.

Table 11. Percent of total growth in length of selected feathers of a captive male goshawk between 28 and 103 days of age.

| Feather Measured | Percent Total Growth | | | | |
|---|---|---|---|---|---|
| | 28 days | 35 days | 42 days | 49 days | 103 days |
| Primary 1 | 64.2 | 81.1 | 91.9 | 97.3 | 100 |
| Primary 4 | 62.2 | 71.5 | 85.4 | 95.1 | 100 |
| Primary 5 | 65.1 | 78.3 | 90.8 | 98.8 | 100 |
| Center rectrix | 51.9 | 64.1 | 78.9 | 89.5 | 100 |
| Mean | 60.8 | 73.8 | 86.8 | 95.0 | 100 |

Morphology: It is generally agreed that male goshawks are approximately one third smaller than females, but there are few references to actual measurements in the literature. Sexual dimorphism of goshawks has been discussed by Mueller and Berger (1968) and Storer (1966) and these authors agree that by using body weight plus a combination of measurements, sex can be determined accurately in most instances. In order to place some absolute values on certain measurements of Alaskan goshawks that would allow accurate identification of sex, weights and selected measurements were obtained from goshawks of known and assumed sex. Only fully grown feathers, as evidenced by lack of sheathing, were measured. The sample size for adults was relatively small so both adult categories (I and II) were lumped for comparisons between age groups. Data from birds of known sex are summarized in Appendix IV. Live-trapped hawks were placed in categories of assumed sex according to general body size. The means of weights and measurements were statistically compared using the student "t" tests. These tests were designed to determine statistical differences between means of various age and sex (both known and assumed) groups.

In the case of most measurements there was no sound statistical difference between means for males of known and assumed sex as well as between females of known and assumed sex (Table 12). This leads to the conclusion that, with some experience, the sex of live-trapped goshawks can be accurately determined by general observation of body size. Of 159 live-trapped goshawks there were only four instances in which difficulty was encountered in placing hawks into sex categories based on general body and foot size.

None of the measurements comparing juvenile to adult females were significantly different at a level greater than 76 percent, however, five of the measurements comparing juvenile to adult males differed at the 98 percent level (Table 13). Mueller and Berger (1968) found adult goshawks to be longer winged and heavier than juveniles, and the tails of adult males to be shorter than those of juvenile males. Although on the average juvenile males had longer tails than adults, the difference was not highly significant.

Comparisons of the means of various measurements suggest significant differences between males and females both of known and assumed sex in most cases (Tables 14 and 15). Morphological data indicate that there is little difference in size between fully developed juveniles and adults of the same sex, with a few exceptions in the case of males. Females are larger than males, and the length of the first, fourth or fifth primary, as well as the length of the central rectrix, are probably the best measurements for sex determination. Body weight, body length and wing chord length may also be of value as sex indicators.

Morphology data from goshawks of known sex are being treated statistically in a test of discriminant variables which will provide a better basis for assessing differences between age and sex groups than the "t" tests described here. Results of these tests for discriminate variables will appear in a future publication.

Table 12. Results of 't' tests comparing means of various measurements for juvenile goshawks of known and assumed sex.

| Measurements | Males: Known sex compared to assumed sex | | | Females: Known sex compared to assumed sex | | |
|---|---|---|---|---|---|---|
| | D.F. | t | P | D.F. | t | P |
| Length P1 (cm) | 27 | 0.473 | .65 | 5 | 0.366 | .75 |
| Length P4 (cm) | 26 | 0.784 | .55 | 28 | 0.646 | .50 |
| Length Center Rectix (cm) | 26 | 0.088 | .90 | 28 | 0.711 | .50 |
| Body Length (cm) | 25 | 1.064 | .30 | 28 | 3.039 | .01 |
| Wing Chord (cm) | 24 | 1.612 | .13 | 26 | 0.632 | .50 |
| Extent (cm) | 23 | 2.234 | .05 | 25 | 2.079 | .05 |
| Bill Length (cm) | 24 | 0.026 | .80 | 28 | 1.271 | .22 |

Table 13. Results of 't' tests comparing means of various measurements for juvenile and adult goshawks of assumed sex.

| Measurements | Juvenile males compared to adult males | | | Juvenile females compared to adult females | | |
|---|---|---|---|---|---|---|
| | D.F. | t | P | D.F. | t | P |
| Body Weight (gm) | 31 | 5.104 | .01 | 28 | 1.116 | .30 |
| Length P1 (cm) | 25 | 1.044 | .30 | 24 | 0.998 | .32 |
| Length P4 (cm) | 27 | 2.454 | .02 | 26 | 1.171 | .25 |
| Length P5 (cm) | 23 | 3.246 | .01 | 25 | 0.200 | .85 |
| Length Center Rectrix (cm) | 24 | 1.217 | .23 | 26 | 1.004 | .30 |
| Body Length (cm) | 27 | 1.012 | .30 | 26 | 0.461 | .65 |
| Wing Chord (cm) | 26 | 3.984 | .01 | 25 | 0.391 | .70 |
| Extent (cm) | 26 | 2.943 | .01 | 24 | 0.503 | .60 |
| Bill Length (cm) | 26 | 2.011 | .05 | 26 | 0.683 | .50 |

Table 14. Results of "t" tests comparing various measurements for juvenile males and juvenile females of known sex.

| Measurements | D.F. | t | P |
|---|---|---|---|
| Length P1 (cm) | 10 | 4.246 | .01 |
| Length P4 (cm) | 10 | 6.324 | .01 |
| Length Center Rectrix (cm) | 10 | 6.822 | .01 |
| Body Length (cm) | 9 | 7.455 | .01 |
| Wing Chord (cm) | 8 | 7.101 | .01 |
| Extent (cm) | 7 | 1.127 | .30 |
| Bill (cm) | 10 | 11.377 | .01 |

Table 15. Results of "t" tests comparing means of various measurements for goshawks of known age and assumed sex.

| | Juvenile males compared to juvenile females | | | Adult males compared to adult females | | |
|---|---|---|---|---|---|---|
| Measurements | D.F. | t | P | D.F. | t | P |
| Body Weight (gm) | 47 | 10.699 | .01 | 12 | 2.885 | .02 |
| Length P1 (cm) | 44 | 12.332 | .01 | 5 | 4.323 | .01 |
| Length P4 (cm) | 44 | 11.932 | .01 | 9 | 8.093 | .01 |
| Length P5 (cm) | 40 | 12.504 | .01 | 8 | 6.380 | .01 |
| Length Center Rectrix (cm) | 44 | 12.925 | .01 | 6 | 4.561 | .01 |
| Body Length (cm) | 44 | 10.834 | .01 | 9 | 5.301 | .01 |
| Wing Chord (cm) | 42 | 8.994 | .01 | 9 | 2.996 | .02 |
| Extent (cm) | 41 | 12.858 | .01 | 9 | 2.562 | .04 |
| Bill Length (cm) | 42 | 1.650 | .10 | 10 | 2.663 | .02 |

Molting: All nesting goshawks observed were molting the more proximal primaries in late April, and observation throughout the summer suggested that dropping of these feathers proceeds distally as described by Beebe and Webster (1964) and Stabler (1943). Fall-trapped hawks in Adult I and II plumage had the first (outermost) primary sheathed as late as October 13 indicating that wing molt is not complete and new feathers are not fully grown until mid-October. Molt of tail feathers was first noted while visiting active nests in mid-June. This molt could have commenced earlier and gone undetected because no hawks were trapped and examined closely in early summer. Fall-trapped Adult I and II hawks had sheathed tail feathers as late as October 30. Apparently the tail molt commences later and is completed later than that of the primaries. This is in agreement with Stabler (1943).

Fall-trapped goshawks designated as Adult I had mostly adult (blue-gray) feathers with the exception of a few juvenile (brownish) feathers in the scapular and lower back regions. The eyes of Adult I birds were yellowish-orange, while in Adult II hawks eye color was rust to red.

A summary of all molt data collected during the period 1970-74 (Appendix V) leads to the following speculations. The typical juvenile plumage and yellow eye color are retained throughout the first winter. In late April goshawks start to molt into adult plumage. Contrary to Bent (1937b), however, this molt is not complete and a few juvenile feathers are retained in the scapular and lower back regions. In April, when the bird is about 11 months of age, the eye color starts to change from yellow to orange. The intermediate (Adult I) plumage is worn throughout the second winter and the following April, when the bird is about 22 months of age, another molt commences. Completion of this molt the following October results in a bird displaying full adult plumage. At this age (28 months) the eyes are rust in color but further information on eye color change is not available.

The foregoing statements are based on the few data available and do not take into account individual variation, or variation between sexes. It is not known whether the molt commencing just prior to the second year of life is always complete allowing precise identification of yearlings and those birds two years of age and older. This summary and Appendix V are presented here primarily for future reference.

Parasite Investigations: Intensive studies of goshawk parasites were not attempted, however, 31 goshawks, mostly from 1973, were necropsied by Terrence Bendock. The birds, obtained from the Alaska Department of Fish and Game, had been illegally shot, found as road kills, or caught inadvertently in steel traps by fur trappers during the 1972-73 winter. Some of the carcasses had been frozen for as long as five months, in some instances making species identification of parasites difficult or impossible. A general summary of parasite occurrence appears in Appendix VI for future reference.

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PREPARED BY:

Jerry D. McGowan
Game Biologist

APPROVED BY:

Frank Jones
Director, Division of Game

Donald E. McKnight
Research Chief, Division of Game

SUBMITTED BY:

Richard Bishop
Regional Research Coordinator

Appendix I. Goshawks banded in Interior Alaska, 1970-73.

| Band# | Band Color* | Date | Location | Sex | Plumage |
|---|---|---|---|---|---|
| 617-2-3499 | R. L. | 6/30/70 | St. Patricks Creek | - | Downy Chick |
| 617-2-3417 | G. | 9/20/70 | Goldstream Creek | M | Juvenile |
| 617-2-3218 | B. | 9/21/70 | Pearl Creek | F | Juvenile |
| 617-2-3219 | G. | 10/4/70 | Goldstream Creek | M | Ad I |
| 617-2-3420 | G. | 10/5/70 | Goldstream Creek | M | Juvenile |
| 877-1-0001 | R.R. | 11/8/70 | Steele Creek | F | Juvenile |
| 877-1-0002 | R.R. | 11/12/70 | Steele Creek | M | Juvenile |
| 877-10003 | R.Rt. | 4/14/71 | Pearl Creek | M | Juvenile |
| 557-47116 | B.L. | 4/30/71 | Pearl Creek | M | Ad II |
| 877-10004 | B.L. | 6/8/71 | Pearl Creek | M | Ad I |
| 877-10014 | B.L. | 6/18/71 | Pearl Creek | M | Ad I |
| 877-10005 | R.Rt. | 6/18/71 | Birch Creek | - | Downy Chick |
| 877-10006 | R.Rt. | 6/18/71 | Birch Creek | - | Downy Chick |
| 877-10007 | R.Rt. | 6/18/71 | Birch Creek | - | Downy Chick |
| 877-10008 | R.Rt. | 6/22/71 | Gilmore Creek | - | Downy Chick |
| 877-10009 | R.Rt. | 6/22/71 | Gilmore Creek | - | Downy Chick |
| 877-10010 | R.Rt. | 6/22/71 | Gilmore Creek | - | Downy Chick |
| 877-10011 | R.Rt. | 6/22/71 | Grenac Road | - | Downy Chick |
| 877-10012 | R.Rt. | 6/22/71 | Grenac Road | - | Downy Chick |
| 877-10013 | R.Rt. | 6/22/71 | Grenac Road | - | Downy Chick |
| 877-10015 | R.Rt. | 6/23/71 | St. Patricks Creek | - | Downy Chick |
| 877-10016 | R.Rt. | 6/23/71 | St. Patricks Creek | - | Downy Chick |
| 877-10017 | R.Rt. | 6/23/71 | St. Patricks Creek | - | Downy Chick |
| 877-10018 | R.Rt. | 6/23/71 | St. Patricks Creek | - | Downy Chick |
| 877-10019 | R.Rt. | 6/23/71 | Vault Creek | - | Downy Chick |
| 877-10020 | R.Rt. | 6/23/71 | Vault Creek | - | Downy Chick |
| 877-10021 | R.Rt. | 6/22/71 | Dome Creek | - | Downy Chick |
| 877-10022 | R.Rt. | 6/23/71 | Vault Creek | - | Downy Chick |
| 877-10023 | R.Rt. | 6/23/71 | Vault Creek | - | Downy Chick |
| 877-10024 | R.Rt. | 6/24/71 | Engineer Creek | - | Downy Chick |
| 877-10025 | R.Rt. | 6/24/71 | Engineer Creek | - | Downy Chick |
| 877-10026 | R.Rt. | 6/24/71 | Engineer Creek | - | Downy Chick |
| 877-10027 | R.Rt. | 7/6/71 | Birch Hill | - | Downy Chick |
| 877-10028 | R.Rt. | 7/6/71 | Birch Hill | - | Downy Chick |
| 877-10029 | R.Rt. | 7/7/71 | Ketchem Creek | - | Downy Chick |
| 877-10030 | R.Rt. | 7/7/71 | Ketchem Creek | - | Downy Chick |
| 877-10031 | R.Rt. | 7/7/71 | Ketchem Creek | - | Downy Chick |
| 877-10032 | R.L. | 8/4/71 | Pearl Creek | F | Juvenile |
| 617-23811 | Y.Rt. | 8/17/71 | Pearl Creek | M | Ad I |
| 877-10033 | R.L.#2 | 8/29/71 | Frenchman Creek | M | Juvenile |
| 877-10034 | Y.Rt. | 8/30/71 | Gilmore Trail | M | Ad I |
| 877-10035 | R.L.#3 | 9/4/71 | Frenchman Creek | M | Juvenile |
| 877-10036 | R.L.#4 | 9/6/71 | Gilmore Trail | F | Juvenile |
| 877-10037 | R.L.#5 | 9/5/71 | Goldstream Creek | F | Juvenile |
| 877-10038 | R.L.#1 | 8/28/71 | Frenchman Creek | F | Juvenile |
| 877-10039 | R.L.#6 | 9/6/71 | Frenchman Creek | M | Juvenile |
| 877-10040 | R.L.#7 | 9/10/71 | Frenchman Creek | F | Juvenile |
| 877-10041 | G.Rt. | 9/11/71 | Frenchman Creek | F | Ad II |

Appendix I. (continued).

| Band# | Band Color* | Date | Location | Sex | Plumage |
|---|---|---|---|---|---|
| 877-10042 | R.L.#8 | 9/12/71 | Gilmore Trail | M | Juvenile |
| 877-10043 | R.L.#9 | 9/2/71 | Birch Hill | M | Juvenile |
| 877-10044 | R.L.#10 | 9/14/71 | Gilmore Trail | M | Juvenile |
| 877-10045 | R.L.#11 | 9/19/71 | Gilmore Trail | M | Juvenile |
| 877-10046 | Y.L. | 9/20/71 | Gilmore Trail | F | Ad I |
| 877-10047 | R.L.#12 | 9/25/71 | Gilmore Trail | M | Juvenile |
| 877-10048 | R.L.#13 | 10/1/71 | Gilmore Trail | F | Juvenile |
| 877-10049 | R.L.#14 | 10/5/71 | Gilmore Trail | M | Juvenile |
| 877-10050 | R.L.#15 | 10/5/71 | Yankovich Road | M | Juvenile |
| 877-10051 | R.L.#16 | 10/5/71 | Harper Creek | F | Juvenile |
| 877-10052 | R.L.#17 | 10/6/71 | Gilmore Trail | F | Juvenile |
| 877-10053 | Y.R. | 10/7/71 | Yankovich Road | M | Ad I |
| 877-10054 | R.L.#18 | 10/9/71 | Harper Creek | F | Juvenile |
| 877-10055 | R.L.#20 | 10/9/71 | Gilmore Trail | M | Juvenile |
| 877-10056 | R.L.#19 | 10/10/71 | Gilmore Trail | F | Juvenile |
| 877-10057 | R.L.#21 | 10/10/71 | Yankovich Road | M | Juvenile |
| 877-10058 | Y.Rt. | 10/12/71 | Pearl Creek | F | Ad I |
| 877-10059 | R.L.#22 | 10/13/71 | Gilmore Trail | M | Juvenile |
| 877-10060 | G.Rt. | 10/13/71 | Harper Creek | F | Ad II |
| 877-10061 | R.L.#23 | 10/14/71 | Harper Creek | F | Juvenile |
| 877-10062 | R.L.#24 | 10/16/71 | Harper Creek | F | Juvenile |
| 877-10063 | R.L.#25 | 10/21/71 | Harper Creek | M | Juvenile |
| 877-10064 | R.L.#1 | 10/22/71 | Gilmore Trail | F | Juvenile |
| 877-10065 | R.L.#2 | 10/22/71 | Gilmore Trail | M | Juvenile |
| 877-10066 | G.Rt. | 10/23/71 | Harper Creek | M | Ad II |
| 877-10067 | R.L.#3 | 10/24/71 | Gilmore Trail | M | Juvenile |
| 877-10068 | R.L.#4 | 10/26/71 | Harper Creek | F | Juvenile |
| 877-10069 | R.L.#5 | 10/27/71 | Gilmore Trail | F | Juvenile |
| 877-10070 | R.L.#6 | 10/27/71 | Harper Creek | M | Juvenile |
| 877-10071 | G.Rt. | 11/1/71 | Pearl Creek | F | Ad II |
| 877-10072 | R.L.#7 | 11/3/71 | Gilmore Trail | F | Juvenile |
| 877-10073 | R.L.#8 | 11/5/71 | Frenchman Creek | F | Juvenile |
| 877-10074 | R.L.#9 | 11/9/71 | Gilmore Trail | F | Juvenile |
| 877-10075 | R.L.#10 | 11/10/71 | 35 Mile Nenana Road | M | Juvenile |
| 877-10077 | R.L.#12 | 11/10/71 | Gilmore Trail | F | Juvenile |
| 877-10076 | Y.Rt. | 11/13/71 | Gilmore Trail | M | Ad I |
| 877-10078 | R.L.#13 | 11/18/71 | Harper Creek | F | Juvenile |
| 877-10079 | R.L.#14 | 11/26/71 | Yankovich Road | F | Juvenile |
| 877-10080 | R.L.#15 | 11/28/71 | Gilmore Trail | F | Juvenile |
| 877-10081 | R.L.#17 | 11/29/71 | Gilmore Trail | M | Juvenile |
| 877-10082 | R.L.#18 | 11/30/71 | Gilmore Trail | F | Juvenile |
| 877-10083 | B.Rt.#1 | 6/15/72 | St. Patricks Creek | - | Downy Chick |
| 877-10084 | B.Rt.#2 | 6/15/72 | St. Patricks Creek | - | Downy Chick |
| 877-10085 | B.Rt.#3 | 6/15/72 | St. Patricks Creek | - | Downy Chick |
| 877-10086 | B.Rt.#4 | 6/16/72 | Isabella Creek | - | Downy Chick |
| 877-10087 | B.Rt.#5 | 6/16/72 | Isabella Creek | - | Downy Chick |
| 877-10088 | B.Rt.#6 | 6/16/72 | Isabella Creek | - | Downy Chick |
| 877-10089 | B.Rt.#7 | 6/19/72 | Grenac Road | - | Downy Chick |

Appendix I. (continued).

| Band# | Band Color* | Date | Location | Sex | Plumage |
|---|---|---|---|---|---|
| 877-10090 | B.Rt.#8 | 6/19/72 | Grenac Road | - | Downy Chick |
| 877-10091 | B.Rt.#9 | 6/19/72 | Goldstream Creek | - | Downy Chick |
| 877-10092 | B.Rt.#10 | 6/19/72 | Goldstream Creek | - | Downy Chick |
| 877-10093 | B.Rt.#11 | 6/20/72 | Goldstream Creek | - | Downy Chick |
| 877-10094 | B.Rt.#12 | 6/20/72 | Goldstream Creek | - | Downy Chick |
| 877-10095 | B.Rt.#13 | 6/21/72 | Vault Creek | - | Downy Chick |
| 877-10096 | B.Rt.#14 | 6/21/72 | Vault Creek | - | Downy Chick |
| 877-10097 | B.Rt.#15 | 6/21/72 | Engineer Creek | - | Downy Chick |
| 877-10098 | B.Rt.#16 | 6/21/72 | Engineer Creek | - | Downy Chick |
| 877-10099 | B.Rt.#17 | 6/21/72 | Engineer Creek | - | Downy Chick |
| 877-10100 | B.Rt.#18 | 6/21/72 | Engineer Creek | - | Downy Chick |
| 877-14201 | B.Rt.#19 | 6/22/72 | Goldstream Creek | - | Downy Chick |
| 877-14202 | B.Rt.#20 | 6/22/72 | Goldstream Creek | - | Downy Chick |
| 877-14203 | B.Rt.#21 | 6/22/72 | Cripple Creek | - | Downy Chick |
| 877-14204 | B.Rt.#22 | 6/22/72 | Cripple Creek | - | Downy Chick |
| 877-14205 | B.Rt.#23 | 6/22/72 | Cripple Creek | - | Downy Chick |
| 877-14207 | B.Rt. | 6/23/72 | Goldstream Creek | - | Downy Chick |
| 877-14206 | None | 10/8/72 | French Gulch | F | Ad I |
| 877-14208 | None | 10/11/72 | O'Connor Creek | F | Ad I |
| 877-14209 | None | 10/14/72 | Gilmore Trail | M | Juvenile |
| 877-14210 | None | 10/17/72 | O'Connor Creek | F | Juvenile |
| 877-14211 | None | 10/21/72 | O'Connor Creek | F | Juvenile |
| 877-14212 | None | 11/5/72 | Gilmore Trail | F | Juvenile |
| 877-14213 | None | 11/9/72 | Goldstream Creek | F | Juvenile |
| 877-14214 | None | 11/16/72 | Goldstream Creek | F | Ad II |
| 877-14215 | None | 2/9/72 | Gilmore Trail | F | Ad II |
| 877-14216 | None | 6/11/73 | Chena Ridge | - | Downy Chick |
| 877-14217 | None | 6/11/73 | Chena Ridge | - | Downy Chick |
| 877-14218 | None | 6/11/73 | Chena Ridge | - | Downy Chick |
| 877-14219 | None | 6/11/73 | Chena Ridge | - | Downy Chick |
| 877-14220 | None | 6/14/73 | Grenac Road | - | Downy Chick |
| 877-14221 | None | 6/14/73 | Grenac Road | - | Downy Chick |
| 877-14222 | None | 6/14/73 | Grenac Road | - | Downy Chick |
| 877-14223 | None | 6/14/73 | Grenac Road | - | Downy Chick |
| 877-14224 | None | 6/14/73 | Gilmore Creek | - | Downy Chick |
| 877-14225 | None | 6/14/73 | Gilmore Creek | - | Downy Chick |
| 877-14226 | None | 6/15/73 | Sheep Creek | - | Downy Chick |
| 877-14227 | None | 6/15/73 | Sheep Creek | - | Downy Chick |
| 877-14228 | None | 6/15/73 | Sheep Creek | - | Downy Chick |
| 877-14229 | None | 6/15/73 | Sheep Creek | - | Downy Chick |
| 877-14230 | None | 6/21/73 | Murphy Dome | - | Downy Chick |
| 877-14231 | None | 6/21/73 | Murphy Dome | - | Downy Chick |
| 877-14232 | None | 6/21/73 | Murphy Dome | - | Downy Chick |
| 877-14233 | None | 6/25/73 | Deadwood Creek | - | Downy Chick |
| 877-14234 | None | 6/25/73 | Deadwood Creek | - | Downy Chick |
| 877-14235 | None | 10/17/73 | Gilmore Trail | M | Juvenile |
| 877-14236 | None | 10/19/73 | Gilmore Trail | F | Juvenile |
| 877-14237 | None | 10/21/73 | Gilmore Trail | F | Juvenile |
| 877-14238 | None | 10/30/73 | Pearl Creek | M | Ad II |
| 877-14339 | None | 12/3/73 | Engineer Creek | M | Ad I |

* Color Code: R = Red, B = Blue, G = Green, Y = Yellow
Rt. = Right Leg, L = Left Leg

Appendix II. Data collected at 45 goshawk nest sites, 1970–74.

| Nest No. | Nest Size (cm) | Height of Nest Above Ground (m) | Position of Nest in Tree | Tree Species | D.B.H. of Nest Tree (cm) | Timber Type | Position on Slope | Aspect of Slope | Elevation of Nest Site (m) | Stick Nests Nearby | Adults' Plumage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-70 | -- | 25' (7.5) | -- | birch | 10" (25) | birch | mid 1/3 | S.E. | 1,000' (300) | 6 | -- |
| 2-70 | -- | -- | upper 1/3 | cottonwood | -- | spruce-cottonwood | flat | flat | 1,800' (540) | -- | -- |
| 1-71 | 32"x12" (80x30) | 25' (7.5) | lower 1/3 | aspen | 9" (23) | aspen | lower 1/3 | S. | 1,000' (300) | 1 | M Ad./F Ad. |
| 2-71 | 36"x36" (90x90) | 25' (7.5) | mid 1/3 | aspen | 9" (23) | aspen | lower 1/3 | S.W. | 1,000' (300) | 1 | M Ad./F Ad. |
| 3-71 | 45"x24" (113x60) | 30' (9.0) | upper 1/3 | birch | 12" (30) | birch | mid 1/3 | N.E. | 850' (255) | 2 | M Ad./F Ad. |
| 4-71 | 45"x20" (113x50) | 30' (9.0) | upper 1/3 | birch | 14" (36) | birch | mid 1/3 | N.E. | 1,000' (300) | 6 | M --/F Ad. |
| 5-71 | 33"x32" (83x80) | 37' (11.1) | upper 1/3 | aspen | 9" (23) | aspen | mid 1/3 | S.W. | 1,100' (330) | 0 | M --/F Juv. |
| 6-71 | 38"x20" (95x50) | 29' (8.7) | upper 1/3 | birch | 12" (30) | birch | upper 1/3 | S. | 1,150' (345) | 1 | M Ad./F Ad. |
| 7-71 | 36"x24" (90x60) | 20' (6.0) | mid 1/3 | birch | 12" (30) | birch | lower 1/3 | N.W. | 650' (195) | 0 | M --/F Juv. |
| 8-71 | 32"x16" (80x40) | 35' (10.5) | upper 1/3 | aspen | 8" (20) | aspen | mid 1/3 | S.E. | 1,100' (330) | 1 | M --/F Juv. |
| 9-71 | 30"x18" (75x45) | 30' (9.0) | upper 1/3 | birch | 12" (30) | birch-aspen | lower 1/3 | S. | 1,000' (300) | 2 | M --/F Juv. |
| 10-71 | 36"x28" (90x70) | 15' (4.5) | mid 1/3 | birch | 7" (18) | birch-spruce | flat | flat | 900' (270) | 0 | M --/F Ad. |

Appendix II. Continued.

| Nest No. | Nest Size (cm) | Height of Nest Above Ground (m) | Position of Nest in Tree | Tree Species | D.B.H. of Nest Tree (cm) | Timber Type | Position on Slope | Aspect of Slope | Elevation of Nest Site (m) | Stick Nests Nearby | Adults' Plumage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11-71 | 35"x18" (88x45) | 37' (11.1) | upper 1/3 | cottonwood | 9" (23) | spruce-cottonwood | flat | flat | 1,800' (540) | 1 | M —/F Ad. |
| 1-72 | 30"x16" (75x40) | 30' (9.0) | mid 1/3 | birch | 13" (33) | birch-aspen | mid 1/3 | S.E. | 1,100' (330) | 1 | M --/F Ad. |
| 2-72 | 41"x30" (103x75) | 45' (13.5) | upper 1/3 | birch | 10" (25) | birch-spruce | lower 1/3 | N.E. | 850' (255) | 2 | M --/F Ad. |
| 3-72 | 44"x12" (110x30) | 44' (13.2) | upper 1/3 | birch | 19" (48) | birch | mid 1/3 | N.E. | 850' (255) | 3 | M Ad./F Ad. |
| 4-72 | 40"x15" (100x38) | 22' (6.6) | mid 1/3 | birch | 14" (36) | birch | mid 1/3 | N.E. | 1,260' (378) | 7 | M Ad./F Ad. |
| 5-72 | 30"x18" (75x45) | 25' (7.5) | mid 1/3 | aspen | 9" (23) | aspen | mid 1/3 | S.W. | 1,000' (300) | 1 | M --/F Ad. |
| 6-72 | 38"x18" (95x45) | 35' (10.5) | upper 1/3 | aspen | 10" (25) | birch-aspen | upper 1/3 | S. | 1,150' (345) | 2 | M Ad./F Ad. |
| 7-72 | 48"x18" (120x45) | 25' (7.5) | upper 1/3 | birch | 9" (23) | birch | mid 1/3 | N.W. | 820' (246) | 1 | M Ad./F Ad. |
| 8-72 | 46"x18" (115x45) | 40' (12.0) | upper 1/3 | birch | 14" (36) | birch-aspen | lower 1/3 | S.E. | 1,000' (300) | 2 | M --/F Ad. |
| 9-72 | 18"x12" (45x30) | 35' (10.5) | upper 1/3 | birch | 14" (36) | birch-aspen | lower 1/3 | S.W. | 1,000' (300) | 2 | M Ad./F Ad. |
| 10-72 | 36"x28" (90x70) | 15' (4.5) | mid 1/3 | birch | 7" (18) | birch-spruce | flat | flat | 960' (288) | 1 | M --/F Ad. |

Appendix II.Continued.

| Nest No. | Nest Size (cm) | Height of Nest Above Ground (m) | Position of Nest in Tree | Tree Species | D.B.H. of Nest Tree (cm)* | Timber Type | Position on Slope | Aspect of Slope | Elevation of Nest Site (m) | Stick Nests Nearby | Adults' Plumage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11-72 | 40"x15" (100x38) | 25' (7.5) | mid 1/3 | birch | 13" (33) | birch-aspen | mid 1/3 | S. | 840' (252) | -- | M --/F Ad. |
| 12-72 | 40"x18" (100x45) | 30' (9.0) | upper 1/3 | birch | 11" (28) | birch | lower 1/3 | S.W. | 900' (270) | 1 | M --/F Ad. |
| 13-72 | 40"x12" (100x30) | 30' (9.0) | upper 1/3 | birch | 14" (36) | birch | upper 1/3 | N.E. | 960' (288) | -- | M Ad./F Ad. |
| 14-72 | 40"x16" (100x40) | 25' (7.5) | mid 1/3 | birch | 10" (25) | birch | upper 1/3 | S.E. | 640' (192) | -- | M --/F Ad. |
| 15-72 | 40"x40" (100x100) | 30' (9.0) | upper 1/3 | birch | 9" (23) | birch-spruce | flat | flat | 1,100' (330) | -- | M --/F Ad. |
| 16-72 | 30"x30" (75x75) | 30' (9.0) | mid 1/3 | birch | 10" (25) | birch | flat | flat | 900' (270) | 2 | M --/F Ad. |
| 1-73 | -- | 25' (7.5) | upper 1/3 | birch | 9" (23) | birch | mid 1/3 | S.E. | 1,000' (300) | 8 | M Ad./F Ad. |
| 2-73 | 28"x10" (70x25) | 35' (10.5) | mid 1/3 | birch | 13" (33) | birch | mid 1/3 | E. | 850' (255) | 3 | M Ad./F Ad. |
| 3-73 | -- | -- | -- | aspen | -- | aspen | mid 1/3 | S.W. | 1,000' (300) | 2 | M --/F Ad. |
| 4-73 | 38"x28" (95x70) | 23' (6.9) | upper 1/3 | birch | 9" (23) | birch | flat | flat | 900' (270) | 2 | M --/F Ad. |
| 5-73 | -- | 30' (9.0) | mid 1/3 | aspen | -- | aspen | upper 1/3 | S.E. | 1,250' (375) | 2 | M --/F Ad. |
| 6-73 | 30"x16" (75x40) | 30' (9.0) | mid 1/3 | birch | 13" (33) | birch-aspen | mid 1/3 | S.E. | 1,000' (300) | 1 | M --/F Ad. |

Appendix II. Continued.

| Nest No. | Nest Size (cm) | Height of Nest Above Ground (m) | Position of Nest in Tree | Tree Species | D.B.H. of Nest Tree (cm) | Timber Type | Position on Slope | Aspect of Slope | Elevation of Nest Site (m) | Stick Nests Nearby | Adults' Plumage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7-73 | 40"x15" (100x38) | 33' (9.9) | upper 1/3 | birch | 12" (30) | birch-spruce | lower 1/3 | N.E. | 850' (255) | 3 | M --/F Ad. |
| 8-73 | -- | -- | -- | birch | -- | birch-aspen | lower 1/3 | S.E. | 1,000' (300) | 3 | M --/F Ad. |
| 9-73 | 36"x24" (90x60) | 54' (16.2) | upper 1/3 | birch | 13" (33) | birch-spruce | lower 1/3 | S.W. | 1,000' (300) | 1 | M Ad./F Ad. |
| 10-73 | 22"x16" (55x40) | 37' (11.1) | upper 1/3 | birch | 12" (30) | birch-aspen-spruce | mid 1/3 | N.E. | 960' (288) | 2 | M Ad./F Ad. |
| 11-73 | 36"x30" (90x75) | 30' (9.0) | mid 1/3 | birch | 10" (25) | birch | flat | flat | 900' (270) | 2 | M --/F Ad. |
| 12-73 | 30"x14" (75x35) | -- | -- | birch | 14" (36) | birch-spruce | lower 1/3 | N.E. | 850' (255) | 1 | M --/F -- |
| 13-73 | -- | 30' (9.0) | upper 1/3 | aspen | 10" (25) | aspen | lower 1/3 | S.E. | 690' (207) | 0 | M --/F -- |
| 1-74 | 22"x16" (35x40) | 37' (11.1) | upper 1/3 | birch | 12" (30) | birch-aspen-spruce | mid 1/3 | N.E. | 960' (288) | 2 | M --/F -- |
| 2-74 | 40"x16" (100x40) | 25' (7.5) | mid 1/3 | birch | 10" (25) | birch | upper 1/3 | S.E. | 640' (192) | 0 | M --/F -- |
| 3-74 | 40"x15" (100x38) | 33' (9.9) | upper 1/3 | birch | 12" (30) | birch-spruce | lower 1/3 | N.E. | 850' (255) | 3 | M --/F Ad. |

Appendix III. Winter roosting behavior of a northern goshawk - a radio-telemetry study by Terrence Bendock.

## SUMMARY

An adult female goshawk was trapped and radio-tagged in the early spring of 1973. Its roosting behavior was observed for a period of one month. At the end of one month, the study ended due to the bird leaving the area, death of the bird or failure of the telemetry equipment. A new modification of a tail-clip design was successfully used in this study. Techniques and equipment are discussed. The average distance between roosting sites was 1.5 miles, ranging from 0.1 mile to 3.9 miles. An abrupt change in roosting pattern during late February may have coincided with the onset of breeding activities. Future work will be conducted to determine goshawk nesting activity within this winter range.

## INTRODUCTION

The objectives of this study were: (1) to design a radio-telemetry study suitable for locating goshawk (*Accipiter gentilis*) winter roosting sites, (2) to design and implement techniques for study under sub-arctic winter conditions, (3) to implement a new modification of a tail-clip attachment for radio-tagging large raptors and (4) to gain valuable laboratory and field experience in the use of radio-telemetry equipment and techniques under the guidance of Dr. Jay Schnell, Department of Wildlife and Fisheries, University of Alaska.

A literature review revealed little information concerning winter behavior of large northern raptors. Craighead and Craighead (1956) discussed winter movements and range patterns of several species of raptors. Amadon and Brown (1970) briefly discussed winter territoriality. Both of these studies, however, relied heavily on human observations of marked and unmarked individuals. Recently, small radio transmitters have been refined and improved to such an extent that they are now a valuable asset in gathering certain types of biological information. Radio-telemetry is still in its infancy, and new methods, techniques and equipment are showing up in the literature with regularity.

## MATERIALS AND METHODS

### The Transmitter

A single-stage, pulsing transmitter was used in this study. See Appendix A for circuit diagram, components list and diagrammatic sketch of the transmitter. Transmitter components were soldered in place and dipped in hot bee's wax to prevent corrosion and movement of the coils after fine tuning. A small spring from a ball point pen was used for a shock bumper at the base of the antenna. The transmitter was given a final covering of dental acrylic to protect the components from damage. An observed current drain of 0.13 volts gave the transmitter a theoretical life expectancy of 150 days using a RM 640, 1.4 volt power source. The crystal frequency was 150.969 $MH_Z$ and the receiving range was from three to four linear miles.

Transmitter Attachment

A tail clip was designed for placement of the transmitter on the bird. This consisted of a flat piece of boltaron (General Tire and Rubber Co.) 1 x 1 x 1/8 inches in thickness. The transmitter was placed in the center of the boltaron and a small hole was melted directly beneath each side of the transmitter. Dental acrylic was then used to adhere the transmitter to the boltaron, being careful not to plug up the two holes. Brass shimstock was looped through the holes and over the transmitter body.

The total package weighed under 20 grams which is little more than 1.5 percent of the study bird's body weight. Other observers have successfully used tail-clip packages weighing up to four percent of the bird's body weight (Bray and Corner 1972 and Dunsten 1972).

The transmitter package is attached to the underside of the two center rectricies, as close to the body as possible. The shimstock loops go around the feather shafts and are tightened in place using pliers. The remaining tabs of shimstock are then soldered together to prevent slipping out of place. The entire procedure takes only a few minutes, however, the soldering iron requires a power source which may be a problem in the field. The attached transmitter "hangs" from the tail and with exception of the antenna is completely concealed by the under tail coverts. There was no apparent problem with flight or balance using this clip design nor was the tail restricted from necessary movement during flight. The main disadvantage of this attachment design is that it cannot be used during the molt, however, it has no loops or wires to restrict movement or entangle in the brush.

Antenna and Receiver

A double yagi, four element antenna system tuned for 150 MHZ was used in this study. The antennas were mounted on a mast that was securely held by a wooden frame. The frame could be easily attached to a pair of vehicle luggage racks using four steel pins. This system had the advantages of being portable and mobile and could be removed during the day, being re-attached only for the time that actual tracking took place. The mast and attached antennas could rotate $360^{o}$. A disk, marked off in one degree increments, was slipped around the base of the mast along with an adjustable sight apparatus. An adjustable pointer was also attached to the mast.

A peak-null box (Appendix B) was used in this system to deliver a null pattern of signal strength to the receiver. A Cocheran AVM LA 12 receiver was also used. Occasionally, a two element, hand-held yagi antenna (Appendix C) was taken into the field in order to determine the general vicinity of the study bird.

## Tracking Procedure

Radio fixes were made from known locations along a road system that intersected the study area. After receiving a signal, a compass bearing was taken on a landmark or reference point (i.e. hilltop or house light in the distance). The movable sight at the base of the mast was also set at the same reference point. The rotating compass dial was then turned to the corresponding compass bearing which calibrated the whole system to true North. The signal null was found by rotating the antenna. The direction of the roosting hawk in reference to true North was read directly off the compass dial at the base of the mast. Thirty degrees was added to this bearing to adjust for declination and the location was plotted on a topographic map. An attempt was made to get a minimum of three readings to triangulate on the roosting site. After practice, each reading took two to three minutes. All locations were made after dark and it was assumed that the bird did not move between readings. This procedure required: (1) that a known location of the fix could be plotted on a map and (2) that visibility was sufficient to locate a reference point after dark.

# RESULTS

## The Study Area

The study area was located in the Tanana-Yukon uplands slightly northeast of Fairbanks, Alaska. The area is characterized by hilly terrain with moderate slopes. Maximum hilltop altitudes were just over 2,000 feet. The vegetation of this region is a mosaic, determined by such factors as slope, exposure, drainage or forest fire history. The dominant tree species are paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*) and black spruce (*Picea mariana*). Treeline occurs at approximately 2,500 feet. Minimum winter temperatures in this area approach -50° F. Goshawks are known to nest in suitable timber stands throughout this region and are a common winter resident (McGowan 1972).

## Roosting Behavior

On February 8, 1973 an adult female goshawk was captured using a Swedish goshawk trap baited with three feral pigeons. The bird was held overnight and outfitted with a transmitter the following morning. It was released at the place of capture. Notes were taken on the sex, weight, age and plumage of the captured bird as well as standard feather measurements. A U. S. Fish and Wildlife band (#877-14215) was also attached to the bird. The hawk was force-fed one-quarter crop of pigeon before being released.

The portable directional antenna was not available until February 12. Until that time, however, the general vicinity of the bird was found with a hand-held yagi antenna. Roosting locations were determined as many nights as possible between February 12 and March 11. See Appendix D for dates and compass bearings of roosting sites.

Craighead and Craighead (1956) defined winter range as an area of land over which a hawk moves and hunts in a given period of time. Such a definition implies that hawks do not wander indiscriminately, but confine their activities over local, measurable areas. This study showed that over a period of one month, the average distance moved between roosting sites was 1.5 miles (see Appendix E). Movement ranged from 0.1 mile to 3.9 miles. With the exception of two evenings, all roosting was confined to the Steele Creek drainage and was furthermore restricted to hillsides with southerly or easterly exposures (see Fig. 1). Locations taken with a hand-held yagi antenna indicated that daytime foraging or hunting was not necessarily restricted to Steele Creek. The temperature during this one month period ranged from $-10^{\circ}$F to $+25^{\circ}$F. There was no correlation between temperature and altitude of roosting site. By connecting the outermost roosting sites with straight lines, and calculating the area within this perimeter, the "roosting area" of this goshawk was 4.5 square miles.

The roosting pattern changed abruptly from a scattered to a clumped distribution during the study (Fig. 1). Potentially, a correlation may exist between the change in roosting pattern and the onset of breeding activities. Coincidentally, an adult pair of goshawks was seen in a traditional nest site on February 25 about three miles east of this study. This roughly corresponds to the date at which the radio-tagged bird changed its roosting pattern. Craighead and Craighead (1956) suggested that some species of raptors will roost at the nest site or potential nest site long before nest building activities commence.

On March 12, 1973 the bird's location could not be determined due to a problem with the antenna. The following night the bird could not be located and subsequent attempts from the ground and air were also unsuccessful. There are a number of possible explanations for failure to locate the bird: (1) it may have flown out of the area; (2) the bird may have died; or (3) the transmitter or battery may have quit operating. It is unlikely that the bird left the area. Approximately 300 miles were driven in all directions without success after failing to locate the bird. It is also unlikely that the bird died. If the bird died while the transmitter was functioning properly, the carcass could have been located with the receiver.

Appendix III (Continued)

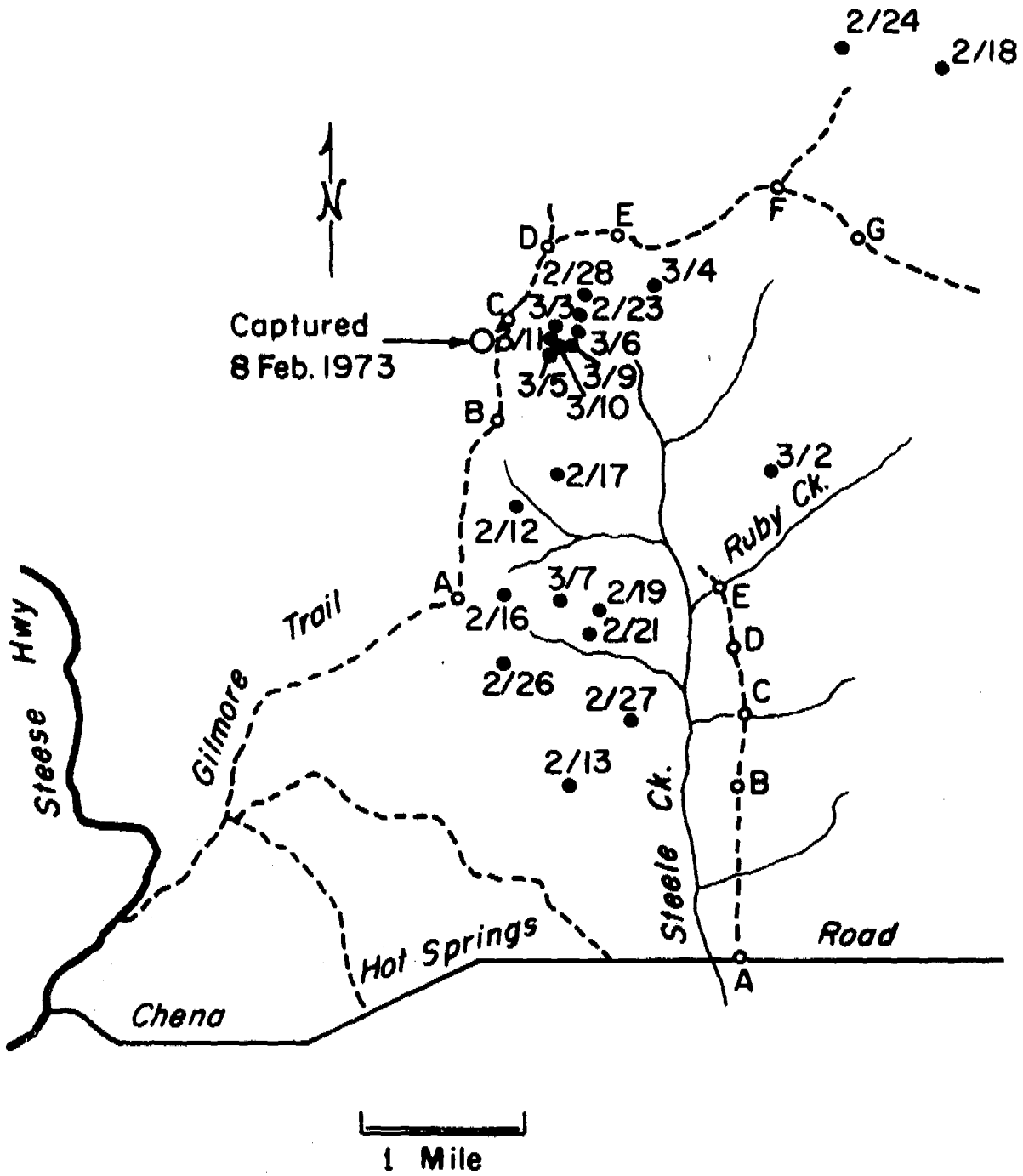


Figure 1. Roosting dates and locations as determined by telemetry for an adult female goshawk, February 12-March 11, 1973.

Appendix III (continued).

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Appendix III (continued).

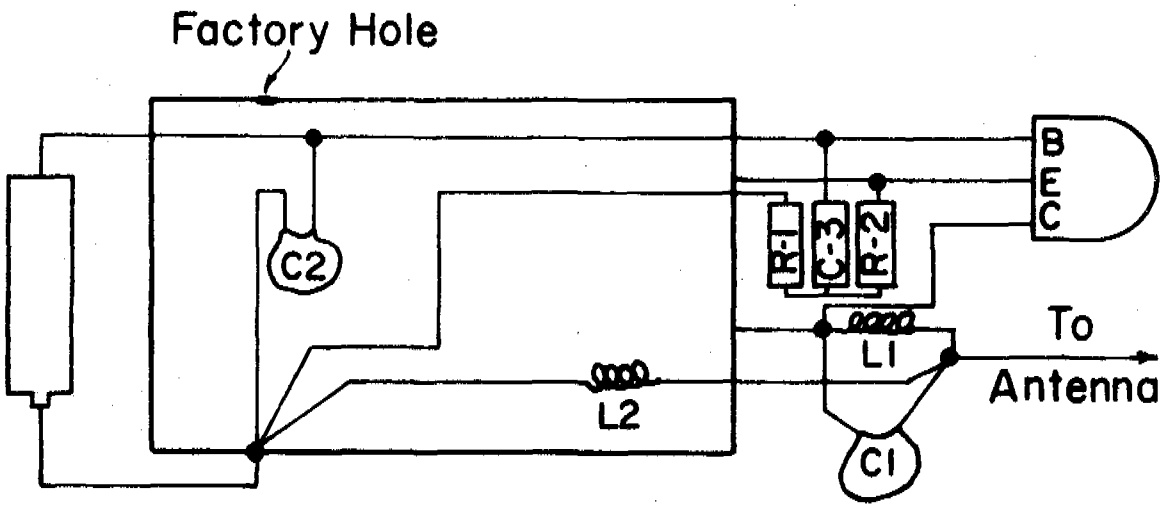
Appendix A. List of components and circuit diagram of transmitter showing placement of components.

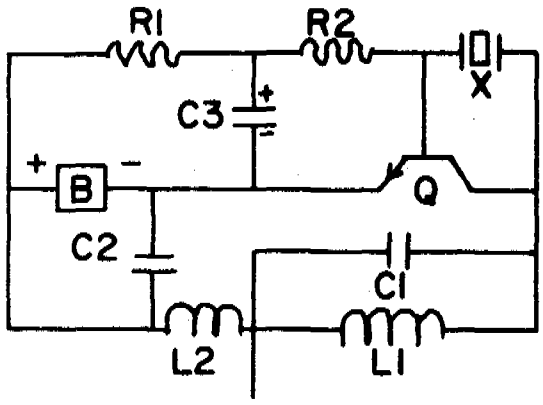
Single-Stage Pulse Transmitter

| Component | Identification |
|---|---|
| Q - Transistor | MPS 918 |
| R1 - Resistor | 470 K |
| R2 - Resistor | 1500 ohms. |
| C1 - Capacitor | 18 K |
| C2 - Capacitor | .001 mf |
| C3 - Pulse Capacitor | 3.3 pf |
| L1 - Coil | (7") #36 Magnetic Wire |
| L2 - Coil | (3 7/8) #36 Magnetic Wire |
| X - Crystal | 150.948 mhz |
| Battery | RM 640 1.4 volts |
| Antenna | .020" E-Guitar String |

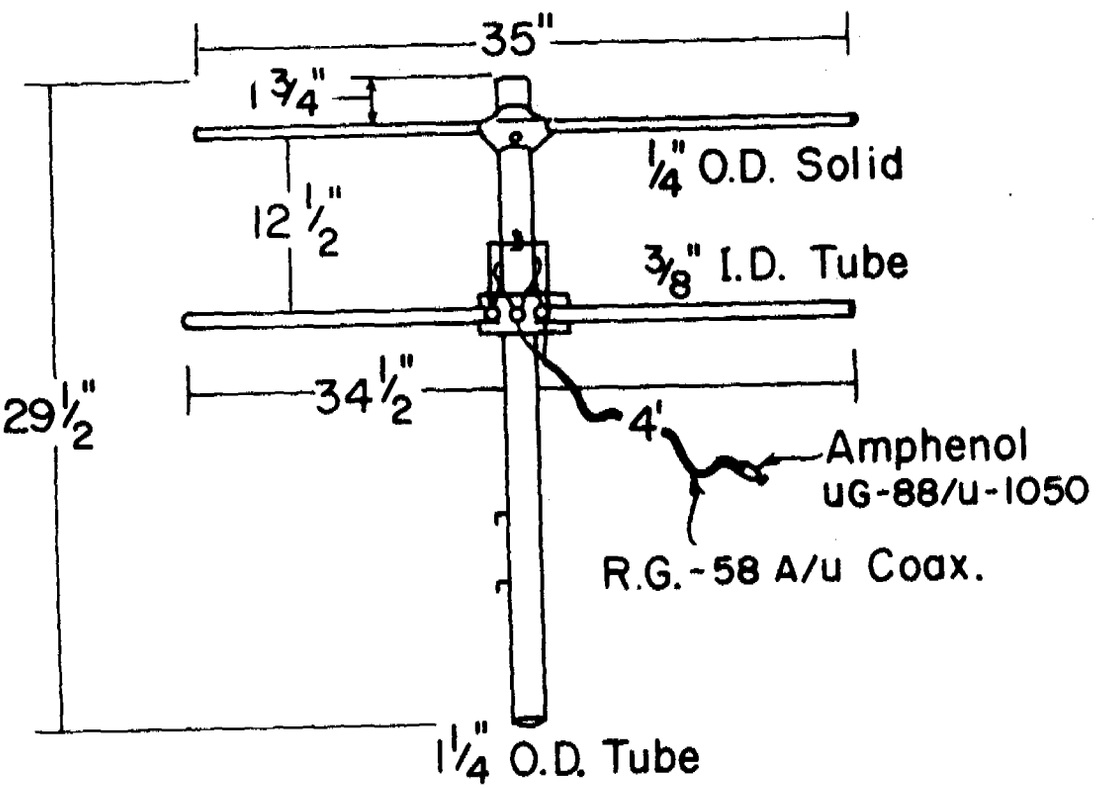
Appendix III. (continued)

Appendix A. (continued)



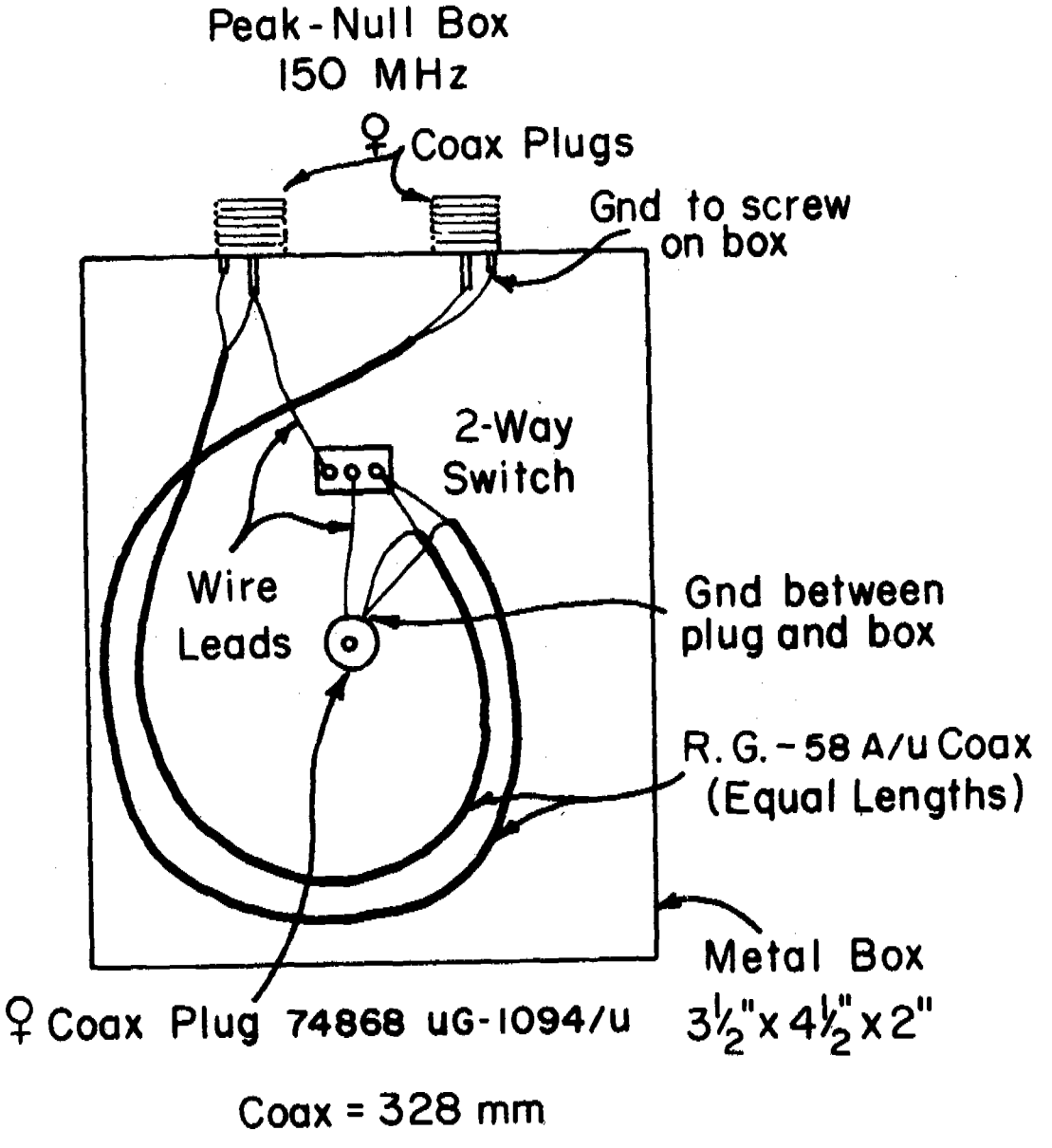



# Hand Held
# Directional Yagi Antenna
# 150 MHz




Ballun = $\frac{1}{2}\lambda$ 656 mm

Appendix C. Diagrammatic sketch showing components of two element yagi antenna.




Appendix B. Diagrammatic sketch of Peak-Null box.

Appendix III (continued).

Appendix D. Compass bearings of roosting site locations.

| Date | Location* | Bearing (Magnetic) | |
|---|---|---|---|
| 12 February 1973 | Gilmore Trail (C) | 176° | |
| | Gilmore Trail (E) | 200° | |
| 13 February 1973 | Essro Road (B) | 298° | |
| | Essro Road (A) | 316° | |
| 16 February 1973 | Essro Road (A) | 325° | |
| | Essro Road (B) | 313° | |
| | Essro Road (D) | 280° | |
| | Gilmore Trail (A) | 73° | |
| 17 February 1973 | Essro Road (B) | 330° | |
| | Essro Road (D) | 325° | |
| | Essro Road (E) | 305° | |
| 18 February 1973 | Gilmore Trail (C) | 58° | |
| | Gilmore Trail (E) | 66° | |
| | Gilmore Trail (G) | 30° | |
| 19 February 1973 | Gilmore Trail (E) | 183° | |
| | Gilmore Trail (F) | 202° | |
| | Gilmore Trail (G) | 210° | |
| 21 February 1973 | Essro Road (B) | 317° | |
| | Essro Road (D) | 277° | |
| | Essro Road (E) | 250° | |
| 23 February 1973 | Gilmore Trail (C) | 84° | |
| | Gilmore Trail (E) | 201° | |
| | Gilmore Trail (B) | 35° | |
| 24 February 1973 | Gilmore Trail (E) | 50° | |
| | Gilmore Trail (F) | 345° | |
| 26 February 1973 | Gilmore Trail (C) | 180° | |
| | Gilmore Trail (E) | 195° | |
| | Gilmore Trail (F) | 212° | |
| 27 February 1973 | Essro Road (B) | 306° | |
| | Essro Road (D) | 237° | |
| | Essro Road (C) | 268° | |
| 28 February 1973 | Gilmore Trail (E) | 205° | |
| | Gilmore Trail (B) | 35° | |
| 2 March 1973 | Essro Road (B) | 5° | east of road |
| | Essro Road (C) | 7° | east of road |
| | Essro Road (E) | 43° | west of Ruby Creek |
| 3 March 1973 | Gilmore Trail (A) | 20° | |
| | Gilmore Trail (B) | 40° | |
| | Gilmore Trail (C) | 90° | |
| 4 March 1973 | Gilmore Trail (A) | 33° | |
| | Gilmore Trail (C) | 73° | |
| | Gilmore Trail (E) | 154° | |
| 5 March 1973 | Gilmore Trail (A) | 20° | east of road |
| | Gilmore Trail (B) | 48° | east of road |
| | Gilmore Trail (C) | 105° | |

Appendix III (continued).

Appendix D (continued).

| Date | Location | Bearing (Magnetic) |
|---|---|---|
| 6 March 1973 | Gilmore Trail (A) | 24° |
| | Gilmore Trail (C) | 92° |
| | Gilmore Trail (E) | 210° |
| 7 March 1973 | Gilmore Trail (E) | 190° |
| | Gilmore Trail (F) | 207° |
| | Gilmore Trail (B) | 155° |
| 9 March 1973 | Gilmore Trail (A) | 25° |
| | Gilmore Trail (C) | 109° |
| 10 March 1973 | Gilmore Trail (A) | 25° |
| | Gilmore Trail (C) | 95° |
| | Gilmore Trail (D) | 180° |
| 11 March 1973 | Gilmore Trail (E) | 213° |
| | Gilmore Trail (D) | 185° |
| | Gilmore Trail (C) | 90° |

*See Fig. 2 for map locations.

Appendix III (continued).

Appendix E. Distance between roosting sites.

| Date | Distance between roosts |
|---|---|
| 12 February to 13 February | 0.9 mi. |
| 13 February to 16 February | 0.4 mi. |
| 16 February to 17 February | 0.8 mi. |
| 17 February to 18 February | 3.3 mi. |
| 18 February to 19 February | 3.7 mi. |
| 19 February to 21 February | 0.2 mi. |
| 21 February to 23 February | 1.9 mi. |
| 23 February to 24 February | 2.3 mi. |
| 24 February to 26 February | 3.9 mi. |
| 26 February to 27 February | 1.1 mi. |
| 27 February to 28 February | 2.8 mi. |
| 28 February to 2 March | 1.4 mi. |
| 2 March to 3 March | 1.5 mi. |
| 3 March to 4 March | 0.9 mi. |
| 4 March to 5 March | 0.7 mi. |
| 5 March to 6 March | 0.1 mi. |
| 6 March to 7 March | 1.6 mi. |
| 7 March to 9 March | 1.4 mi. |
| 9 March to 11 March | 0.1 mi. |

Mean distance between roosts = 1.5 miles
Range = 0.1 mile to 3.9 miles

Appendix IV. Weight and measurement data for goshawks of known sex.

| Measurement | Age | Sex | n | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Body weight (grams) | Juv. | M | 21 | 845.1 | 94.10 |
| | Ad. | M | 15 | 858.4 | 126.18 |
| | Juv. | F | 16 | 1,037.6 | 133.50 |
| | Ad. | F | 12 | 1,014.6 | 118.92 |
| Primary 1 length (cm) | Juv. | M | 23 | 14.9 | 0.42 |
| | Ad. | M | 16 | 14.5 | 0.63 |
| | Juv. | F | 16 | 16.4 | 0.71 |
| | Ad. | F | 13 | 15.8 | 0.40 |
| Primary 4 length (cm) | Juv. | M | 23 | 24.8 | 0.50 |
| | Ad. | M | 16 | 25.1 | 0.82 |
| | Juv. | F | 17 | 27.4 | 0.73 |
| | Ad. | F | 13 | 27.3 | 0.34 |
| Primary 5 length (cm) | Juv. | M | 21 | 25.0 | 0.54 |
| | Ad. | M | 16 | 25.1 | 0.53 |
| | Juv. | F | 13 | 27.7 | 0.75 |
| | Ad. | F | 13 | 27.6 | 0.39 |
| Length center rectrix (cm) | Juv. | M | 23 | 24.3 | 0.86 |
| | Ad. | M | 16 | 23.8 | 1.15 |
| | Juv. | F | 16 | 28.2 | 0.66 |
| | Ad. | F | 13 | 27.3 | 0.64 |
| Wing chord (cm) | Juv. | M | 19 | 31.7 | 0.71 |
| | Ad. | M | 16 | 32.2 | 1.23 |
| | Juv. | F | 13 | 34.8 | 0.64 |
| | Ad. | F | 12 | 34.7 | 0.46 |
| Body length (cm) | Juv. | M | 20 | 54.5 | 2.05 |
| | Ad. | M | 14 | 53.2 | 1.81 |
| | Juv. | F | 16 | 61.4 | 1.80 |
| | Ad. | F | 12 | 59.1 | 2.01 |

Appendix V. Summary of Goshawk Molting Data

| Sex | Date of First Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color | Date of Second Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color | Date of Third Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color |
|---|---|---|---|
| F | June 22, 1971<br>3 weeks<br>Typical nestling plumage<br>Eye gray in color | September 25, 1972<br>1 year, 4 months<br>Typical Adult I body plumage<br>Eye orange in color | December 22, 1972<br>1 year, 7 months<br>Typical Adult I body plumage<br>Eye orange in color |
| M | September 20, 1970<br>4 months<br>Typical juvenile body plumage<br>Eye yellow in color | August 25, 1971<br>1 year, 3 months<br>Typical Adult I body plumage<br>Primaries 1 and 2 in sheath. Primary 1, 6.4 cm in length. Two center rectrices recently molted, many adult body feathers sheathed. | |
| M | October 13, 1971<br>5 months<br>Typical juvenile plumage<br>Eye yellow in color | May 15, 1972<br>1 year<br>Typical juvenile body plumage<br>Primary 1 in pulp. Primaries 8-10 Adult and sheathed. Proximal secondaries and primary coverts adult and sheathed. This pattern was the same for both wings. Rectrices were juvenile except center two in pulp (2.0 cm in length) | |
| M | June 18, 1971<br>1 year<br>Typical Adult I body feathers. Center rectrices adult but not completely grown. Primary coverts adult and sheathed.<br>Eye dark yellow in color | | |
| M | August 30, 1971<br>1 year, 3 months<br>Typical Adult I center rectrices recently molted<br>Eye orange in color | | |

Appendix V (continued)

| Sex | Date of First Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color | Date of Second Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color | Date of Third Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color |
|---|---|---|---|
| F | September 20, 1971<br>1 year, 4 months<br>Typical Adult I body plumage<br>Primaries 1 and 2 sheathed.<br>Primary 1, 5.0 cm in length.<br>Rectrices adult except outter feather on each side. Tail molt pattern symmetrical with new sheathed feathers next to the center and outter pairs.<br>Eye yellow orange in color | | |
| M | October 7, 1971<br>1 year, 5 months<br>Typical Adult I body plumage.<br>Alula feathers juvenile.<br>Eye orange in color | | |
| F | October 8, 1972<br>1 year, 4 months<br>Typical Adult I body plumage<br>One juvenile secondary<br>Eye orange in color | | |
| F | October 11, 1972<br>1 year, 4 months<br>Typical Adult I plumage<br>Eye orange in color | | |
| F | October 12, 1971<br>1 year, 4 months<br>Typical Adult I plumage<br>No feathers sheathed<br>Eye orange in color | | |
| M | November 13, 1972<br>1 year, 5 months<br>Typical Adult I plumage<br>Eye yellow in color | | |
| M | December 3, 1973<br>1 year, 6 months<br>Typical Adult I plumage<br>some juvenile secondaries<br>Eye yellow orange in color | | |

Appendix V (continued)

| Sex | Date of First Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color | Date of Second Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color | Date of Third Observation<br>Estimated Age<br>Plumage Description*<br>Eye Color |
|---|---|---|---|
| M | June 8, 1971<br>2 years<br>Typical Adult I plumage<br>center rectrices 6.0 cm out of pulp<br>Eye yellow orange in color | November 8, 1971<br>2 years, 4 months<br>Typical Adult II plumage<br>center rectrices full grown<br>Eye red orange in color | |
| M | August 7, 1971<br>2 years, 2 months<br>Typical Adult I plumage<br>primaries 1 and 2 sheathed. Primary 1, 8.5 cm in length<br>Eye yellow in color | November 20, 1971<br>2 years, 5 months<br>Typical Adult II plumage<br>primaries fully grown<br>Eye orange in color | December 12, 1971<br>2 years, 6 months<br>Typical Adult II plumage<br>Eye orange in color |
| F | February 9, 1973<br>Older than 2 years<br>Typical Adult II plumage<br>No sheathing on feathers<br>Eye rusty in color | | |
| F | October 13, 1971<br>Older than 2 years<br>Typical Adult II plumage<br>Primary 1 sheathed and 15.9 cm in length. Rectrix next to center missing on each side.<br>Eye rust in color | | |
| M | October 30, 1973<br>Older than 2 years<br>Typical Adult II plumage.<br>Left member of center pair of rectrices sheathed (17.0 cm long)<br>Eye red in color | | |
| F | November 11, 1971<br>Older than 2 years<br>Typical Adult II plumage.<br>No sheathing on feathers.<br>Eye yellow orange in color | | |
| F | November 16, 1972<br>Older than 2 years<br>Typical Adult II plumage<br>No sheathing on feathers.<br>Eye orange in color | | |

* Typical juvenile plumage is brown mottled on dorsal surface with brown longitudinaly-streaked breast

  Typical Adult I plumage is gray body feathers with some brown, juvenile feathers in scapular region and/or on lower back anterior to base of tail.

  Typical Adult II plumage is blue-gray on dorsal surface with gray, transverse barring on breast.

Appendix VI. Summary of parasite occurrence in 31 Interior Alaska goshawks, 1972-73.

| | |
|---|---|
| Birds with parasites | 22 (71%) |
| Birds with cestods | 14 (45%) |
| Birds with trematodes | 10 (32%) |
| Birds with both cestods and trematods | 2 (7%) |

of 9 females 7 (78%) had parasites

of 22 males 14 (64%) had parasites

of 19 juveniles: 12 (63%) had parasites
10 (53%) had cestods
3 (16%) had trematods

of 12 adults: 10 (83%) had parasites
4 (33%) had cestods
7 (58%) had trematods