SUSITNA HYDROELECTRIC PROJECT

ENVIRONMENTAL STUDIES

SUBTASK 7.11: BIRDS AND NON-GAME MAMMALS
PHASE I REPORT
APRIL, 1982

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SUSITNA HYDROELECTRIC PROJECT

ENVIRONMENTAL STUDIES PHASE I FINAL REPORT

SUBTASK 7.11
BIRDS AND NON-GAME MAMMALS

April 1982

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SUMMARY

To aid in determining the potential effects that the proposed Susitna Hydroelectric Project might have on the fauna of the upper Susitna River Basin, field studies on birds and small (non-game) mammals were conducted from 6 July to 4 October 1980, 8 to 10 February 1981, and 17 April to 23 October 1981. The overall study area extended from near Sherman on the west to the mouth of the MacLaren River on the east and for approximately 15 km (10 miles) on either side of the Susitna River channel. Within this region, we 1) established twelve 10-ha (25-acre) bird census plots and 49 small mammal trapline transects and sampled populations on them, 2) flew aerial waterfowl surveys in spring 1981 and in falls 1980 and 1981, and conducted ground surveys of 28 waterbodies (20.5 km^2 wetlands) in July 1981, 3) flew surveys of cliff habitat along the Susitna River and its tributaries to determine use by raptors and ravens in July 1980 and May 1981, and made ground visits during 1981 to the vicinity of all 1980 and 1981 active sites, 4) undertook frequent general surveys to obtain supplemental information about the birds and small mammals of the region, and 5) measured up to 60 habitat variables on the bird census plots and small mammal trapline transects for subsequent analyses of animal species-habitat relationships. Sites for the bird census plots and small mammal trapline transects were selected to represent as broad a spectrum as possible of the various vegetation types used by small mammals and terrestrial birds in the region.

During the study period, 135 species of birds were recorded in the region; the Common Redpoll, Savannah Sparrow, White-crowned Sparrow, Lapland Longspur, and Tree Sparrow were the most numerous. Fifteen species were ranked as rare in the region, mostly birds at the periphery of their geographic ranges or for which appropriate habitat was lacking. All are represented by larger populations in other portions of Alaska. Population levels among the different habitats varied greatly. Generally, the forest and woodland habitats supported higher densities

and/or biomasses of birds than the shrub communities. Highest densities in forests were found at the downstream (Sherman) Cottonwood Forest plot, the lowest in the White Spruce Forest plot at the mouth of Kosina Creek. Of the shrub habitats, Low-Medium Willow Shrub had the highest densities and the Dwarf Shrub-Alpine Tundra, the lowest. Tall Alder Shrub also had low densities. Alpine tundra areas had the lowest bird usage, but supported some bird species generally not found in other habitats.

The wetlands of the region supported relatively few waterbirds, both during summer and during migratory periods. Densities of 23.8 adults/km^2 of wetlands in July 1981 were one-fifth those of the upper Tanana River Valley, east-central Alaska. The region was of less importance to migratory waterfowl in spring than fall, primarily because ice breakup did not occur until after the main spring migratory movement of many ducks; during both seasons, most waterbodies received far less use than those in the upper Tanana Valley.

The two most important waterbodies in the immediate vicinity of proposed impoundments were Stephan and Murder lakes. In addition to supporting relatively high numbers of species and individuals, they had the longest ice-free season and thus were important to early spring and late fall migrants. Swans used these lakes until late October.

During 1980 and 1981, 43 raptor/raven nest sites were found, 20 of which were inactive in both years. Of the 23 active sites, five were used both years, each year by the same species. These active sites included ten of Golden Eagle, six of Bald Eagle, four of Common Raven, one, perhaps two, of Gyrfalcon, and one of Goshawk. A single observation of an Osprey was reported during the two seasons of study. There were no confirmed sightings of Peregrine Falcons.

Of the 16+ members of the Susitna River Basin's small mammal fauna, the most abundant and widespread were masked shrew, northern red-backed vole, and arctic ground squirrel. The last two are probably the most important prey species for bird and mammal predators. Trapline capture information indicated considerable temporal variation in population levels for most shrews and voles, but their relative abundance rankings remained the same. Patterns of habitat occupancy among these species indicated that shrews and red-backed voles were habitat generalists, exploiting a wide range of vegetation types, while Microtus and lemmings were habitat specialists, using a narrow range of tundra and herbaceous vegetation types. Meadow voles and singing voles were the most selective, the former preferring wet-mesic sedge-grass meadows and the latter, herbaceous shrub tundra. Habitat occupancy patterns were affected by changes in density and probable species interactions.

Collared pikas and hoary marmots were locally common in the alpine zone of the region, while red squirrels, snowshoe hares, and porcupines were fairly common to uncommon in forest and shrubland at lower elevations.

The major impacts of the Susitna Hydroelectric Project would be from habitat destruction due to flooding and from a range of habitat alterations due to various construction and operational factors. Flooding would destroy a large percentage of the riparian cliff habitat used by nesting raptors and ravens. It would also inundate most of the major forest habitats upriver of the Devil Canyon dam site, habitats that support the highest avifaunal occupancy levels in the region and support bird and mammal species unable to use non-forested habitats. In all, the breeding habitat used by over 40,000 pairs of small- and medium-sized upland birds would be inundated. Flooding of the fluviatile shorelines and alluvia, both along the Susitna River and up the mouths of tributary creeks, would destroy breeding habitat of a few bird species and wintering habitat of the Dipper. It would also deprive early spring migrant waterfowl of one of the first sources of open water in the region--the rapidly flowing waters of the Susitna River. The new impoundments could provide habitat for waterbirds, but the degree of utilization would depend upon the rate and kind of development of food resources in the lakes. The drawdown zone would be an ecological desert for small mammals, but would probably be used in May by migrant shorebirds.

Impacts of other habitat alterations would depend on the type of alteration, i.e., which habitats would be destroyed or altered or which replacement habitats developed. Birds and small mammals dependent on the destroyed or altered habitats would disappear, whereas new habitats formed would increase populations of species that favor the newly created habitats. The construction zones for building and operation and the access road right-of-way and borrow areas would destroy (or alter in the case of borrow areas) the breeding habitat used by about 60,000 pairs of small- and medium-sized upland birds. Generally, impacts on regional populations from forest destruction would be greater than those from destruction of shrub habitats. Other than eliminating entire communities through habitat destruction, some of the most striking anticipated impacts of habitat changes would be increased populations of ground squirrels, Mew Gulls, ravens, and magpies about human habitations and/or refuse sites and increased populations of ground squirrels, tundra and meadow voles, and several sparrow species along the edges of access roads.

Impacts would also result from direct disturbance to animals by various human activities. The most prominent of these would be ground and aerial activity too close to raptor nest sites during the breeding season, and too close to wetlands during the ice-free season. Establishment of habitations near wetlands would also improve human access to these areas and increase various types of disturbance, including hunting.

PROPOSED DEVELOPMENT

Two major reservoirs would be formed in the full-basin development plan for the proposed Susitna Hydroelectric Project. The larger reservoir would extend 77 km (48 miles) upstream of the Watana site and have an average width of about 2 km (1 mile) and a maximum width of 8 km (5 miles). The Watana reservoir would have a surface area of 154 km^2 (38,000 acres) and a maximum depth of about 207 m (680 ft) at normal operating level.

The Devil Canyon reservoir would be about 42 km (26 miles) long and 1 km (0.5 mile) wide at its widest point. A surface area of 32 km^2 (7,800 acres) and a maximum depth of about 168 m (550 ft) would exist at normal operating level.

Staged development is planned. An initial installation of 680-MW of capacity at Watana would be available to the system in 1993 and 340 MW would be added in 1994. If the mid-range forecast in growth in energy demand were realized, Devil Canyon would be completed by 2002 and would have an installed capacity of 600 MW.

The Watana dam would be an earth-fill structure, with a maximum height of 270 m (885 ft), a crest length of 1250 m (4,100 ft), and a total volume of about 47,400,000 m^3 (62,000,000 yd^3). During construction, the river would be diverted through two concrete-lined diversion tunnels, each 11.5 m (38 ft) in diameter, in the north bank of the river. Upstream and downstream cofferdams would protect the dam construction area. The power intake would include an approach channel in rock on the north bank. A multilevel, reinforced concrete, gated intake structure capable of operating over a full 43-m (140-ft) drawdown range would be constructed.

The Devil Canyon dam would be a double-curved arch structure with a maximum height of about 197 m (645 ft) and a crest elevation of 446 m (1463 ft). The crest would be a uniform 6-m (20-ft) width and the maximum base width, 27 m (90 ft). A rock-fill saddle dam on the south bank of the river would be constructed to a maximum height of about 75 m (245 ft) above foundation level. The power intake on the north bank would include an approach channel in rock, leading to a reinforced concrete gate structure, which would accommodate a maximum drawdown of 17 m (55 ft). Flow construction would be diverted through a single 9-m-diameter (30-ft-diameter) concrete-lined pressure tunnel in the south bank. Cofferdams and the diversion tunnel would provide protection against floods during construction.

About 2.5 yr of average streamflow would be required to fill the Watana reservoir. Filling would commence after dam construction had proceeded to a point where impoundment concurrent with continued construction could be accommodated. Post-project flows would be lower in summer and higher in winter than current conditions. Downstream of the project, differences between pre- and post-project flow conditions would be progressively less pronounced, because the entire upper basin contributes less than 20% of the total discharge into Cook Inlet.

The selected access plan consists of a road from a railhead at Gold Creek to Devil Canyon on the south side of the river. At Devil Canyon the road would cross the Susitna and proceed east to the Watana site on the north side of the river. The plan also includes access by road connecting Gold Creek to the Parks Highway. Construction of a limited access between Gold Creek and the Watana site, by way of a pioneer road, would commence in mid-1983. Road access from the Parks Highway would be deferred until after award of a federal license for the project. The pioneer road would be rendered impassable if the project did not proceed.

The selected transmission line route associated with the Susitna project would roughly parallel, but not be adjacent to, the access route between Gold Creek and the Watana dam site. At Gold Creek, the line would connect with the Railbelt Intertie. Between Willow and Anchorage, the route would extend in a southerly direction to a point west of Anchorage, where undersea cables would cross Knik Arm. Between Willow and Healy, the route would utilize the transmission corridor previously selected by the Alaska Power Authority for the Railbelt Intertie.

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1 - INTRODUCTION

The bird and non-game or small mammal studies of the upper Susitna River Basin were undertaken to aid in determining the potential effect that the proposed Susitna Hydroelectric Project might have on the fauna of the region. More specifically, we learned what species of birds and small mammals were present in the upper Susitna River Basin and, on a seasonal basis, the manner and extent of their use of the region, including the general habitats in which they occurred. These data, while not definitive after only 1½ field seasons, can be used with care to 1) evaluate habitat potential in the area, 2) provide a basis for predicting faunal changes based on habitat changes caused by environmental alterations, including changes in water level, and 3) evaluate possible mitigative measures.

The bird and small mammal studies were composed of three interrelated work packages: 1) Bird community-habitat study, 2) Avifaunal survey, and 3) Small mammal studies. Field studies were conducted during the following periods: 6 July-4 October 1980, 8-10 February 1981, and 17 April-23 October 1981.

1.1 - Historical Literature Review

Prior to the initiation of this study, almost nothing was known about the birds and small (non-game) mammals of the upper Susitna River Basin. The only published bird information from the region was a report of birds seen by Hinckley (1900) while he was with a U.S. Geological Survey party in the Susitna Valley in 1898. In the surrounding regions, Abercrombie (1899) in summer and Bailey (1926) in winter both visited the upper Copper River Basin and provided sketchy accounts of birds seen. More recently, Williamson and Peyton (1959) reported inland breeding of Double-crested Cormorants (*Phalacrocorax auritus*) at Lake Louise, and Schaller (1954) reported on summer birds seen in the

Talkeetna Mountains. More data were available from the vicinity of Denali (Mt. McKinley) National Park, where O. J. Murie (1923, 1924), A. Murie (1946, 1956), Dixon (1927a, 1927b, 1933a, 1933b, 1933c, 1938), and Sheldon (1909, 1930) spent extended periods of time.

A. Murie (1963) prepared a generalized summary of occurrence of birds in Denali National Park, and a recent checklist of the birds of the Park was compiled by Kertell (1981). In the Alaska Range, directly north of the Susitna study area, a study of the nesting and hunting behavior of the Gyrfalcon* has just been completed (Bente 1981). All pertinent pre-1978 data from the above citations have been consolidated and summarized by Gabrielson and Lincoln (1959) and Kessel and Gibson (1978).

Between 10 and 15 June 1974, White (1974) carried out a raptor survey on the Susitna River upstream of the proposed Devil Canyon dam site; and, between 12 and 15 July 1975 and on 18 July 1975, White and Cade (1975) conducted a raptor survey on the proposed Susitna powerline corridors, but not in the current study area.

The small mammals of the upper Susitna River Basin had never been surveyed prior to this study and hence were essentially unknown except by inference. Published species lists for nearby areas of central Alaska came from a small number of studies and surveys: Denali National Park area (Sheldon 1930, Dixon 1938, Viereck 1959, A. Murie 1962), several collecting sites on the Denali and Richardson highways (Baker 1951, Strecker et al. 1952, Baker and Findley 1954, Pruitt 1968), and the upper Cook Inlet area (Osgood 1901, Wilber 1946, Hock and Cottini 1966). General distributional information has been summarized by Manville and Young (1965) and Hall (1980).

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*See Annotated List of Species (Section 3.7) for scientific names of birds, Table 22 for scientific names of small mammals.

Historically, little attention has been paid to bird and mammal species-habitat relationships in Alaska, although generalized, descriptive accounts of species habitats can be found scattered throughout the literature.

1.2 - Objectives

Over the two-year period of this study, the general objectives of the three work packages were as follows:

(a) Bird community-habitat study

(i) Determine, for as many of the major upland avian habitats of the region as feasible, the type and degree of use by birds, and compare these habitats relative to species composition, density, etc.

(ii) Obtain data relative to species habitat use that can be used in later analyses on habitat selection by specific species (1982).

(b) Avifaunal survey

(i) Determine all species of birds using the region.

(ii) Determine, on a seasonal basis, each species' relative abundance and general habitat use.

(iii) Determine spring and fall migration dates (earliest, latest, peak) and, insofar as time permits, the seasonal chronologies of each species.

(iv) Determine the extent and type of use of the area by the Peregrine Falcon, Bald Eagle, and Osprey.

(v) Determine, generally, the use of the region by waterbirds, including shorebirds and waterfowl.

(c) Small (non-game) mammal studies

(i) Determine all species of small and medium-sized mammals occurring in the region.

(ii) Determine, for the major vegetation types of the region, species composition, relative abundance, and habitat use.

1.3 - Study Area

Geographically, the overall study area extended from near Sherman, adjacent to the Alaska Railroad, up the Susitna River to the mouth of the MacLaren River, and out to approximately 15 km (10 miles) on either side of the river. Survey work included habitats throughout this vast area, but intensive work was located within a few kilometers of the present river channel. Except for the Cottonwood Forest plot at Sherman, the intensive sites are located between the Devil Canyon dam site and the southeast-facing slopes east of Kosina Creek (Fig. 1 and 2).

1.4 - Acknowledgments

A project of the scope of these bird and small mammal studies could not be conducted without the assistance of many competent field and laboratory personnel, and we are pleased to acknowledge and express appreciation for all such help we have received. Kevin C. Cooper participated

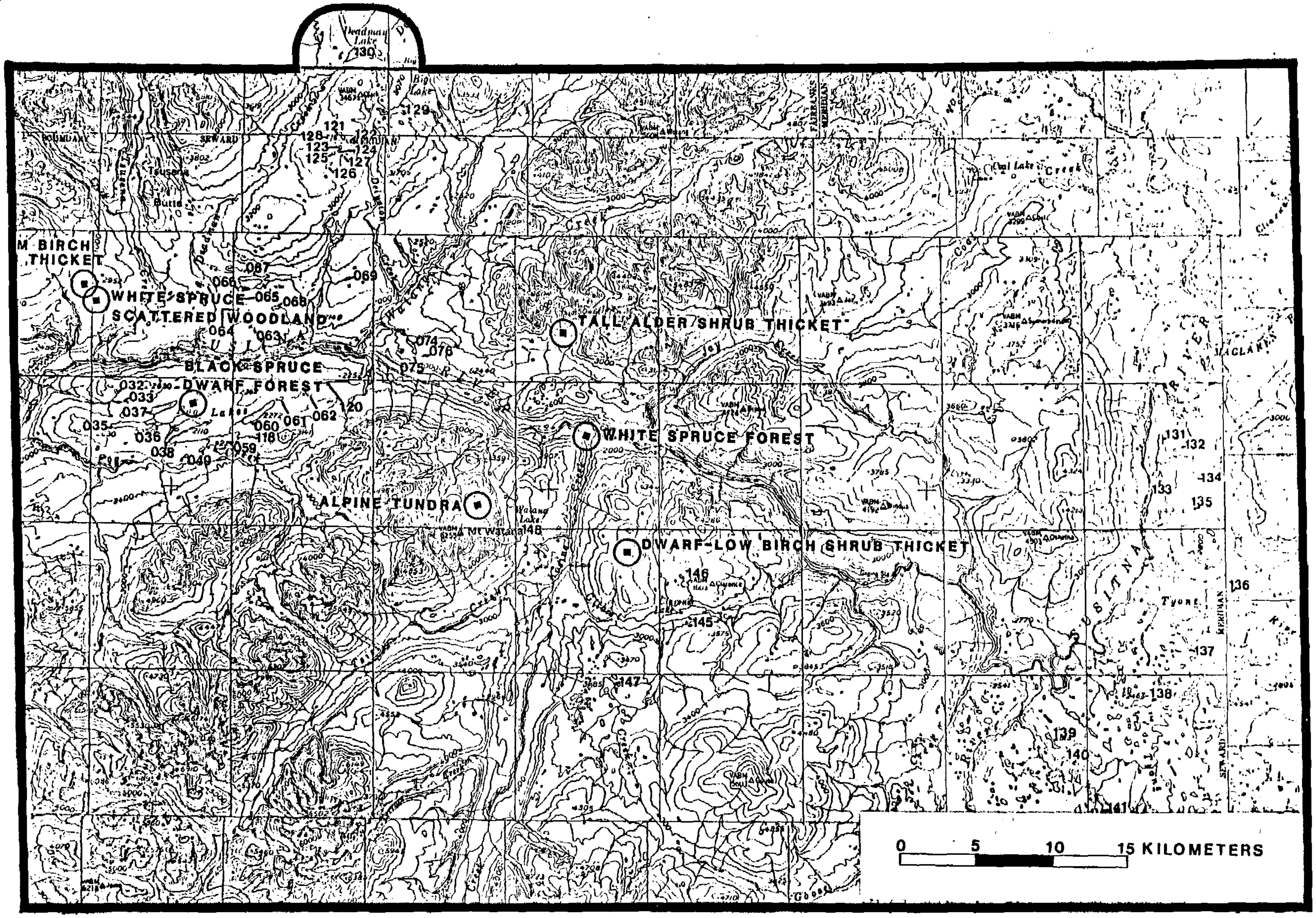

FIGURE 1

Map of the upper Susitna River Basin, Alaska, showing locations of the 12 bird census plots (⊡) and the waterbodies (numbers) included in the waterfowl surveys.

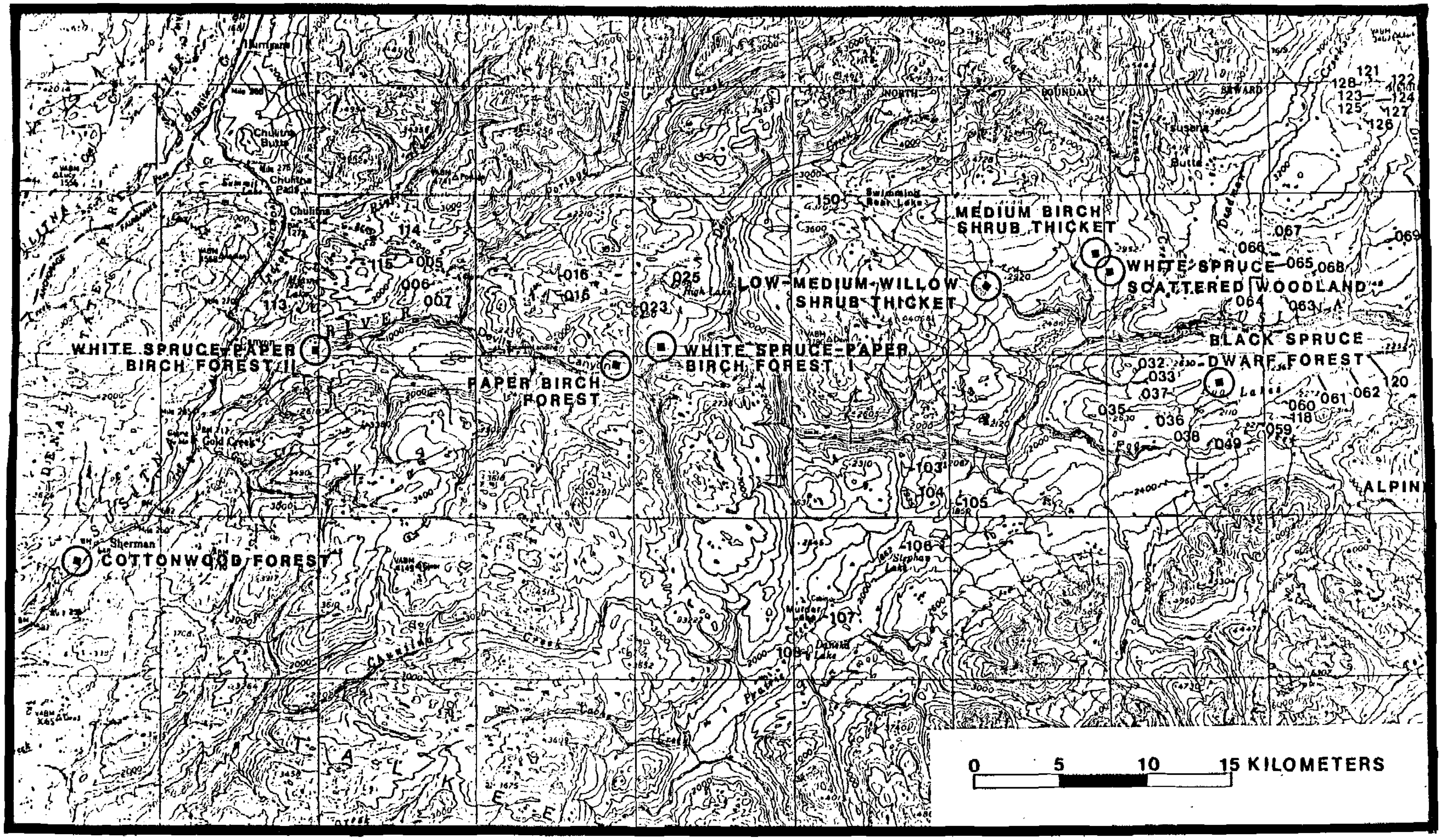

FIGURE 1 (Continued)

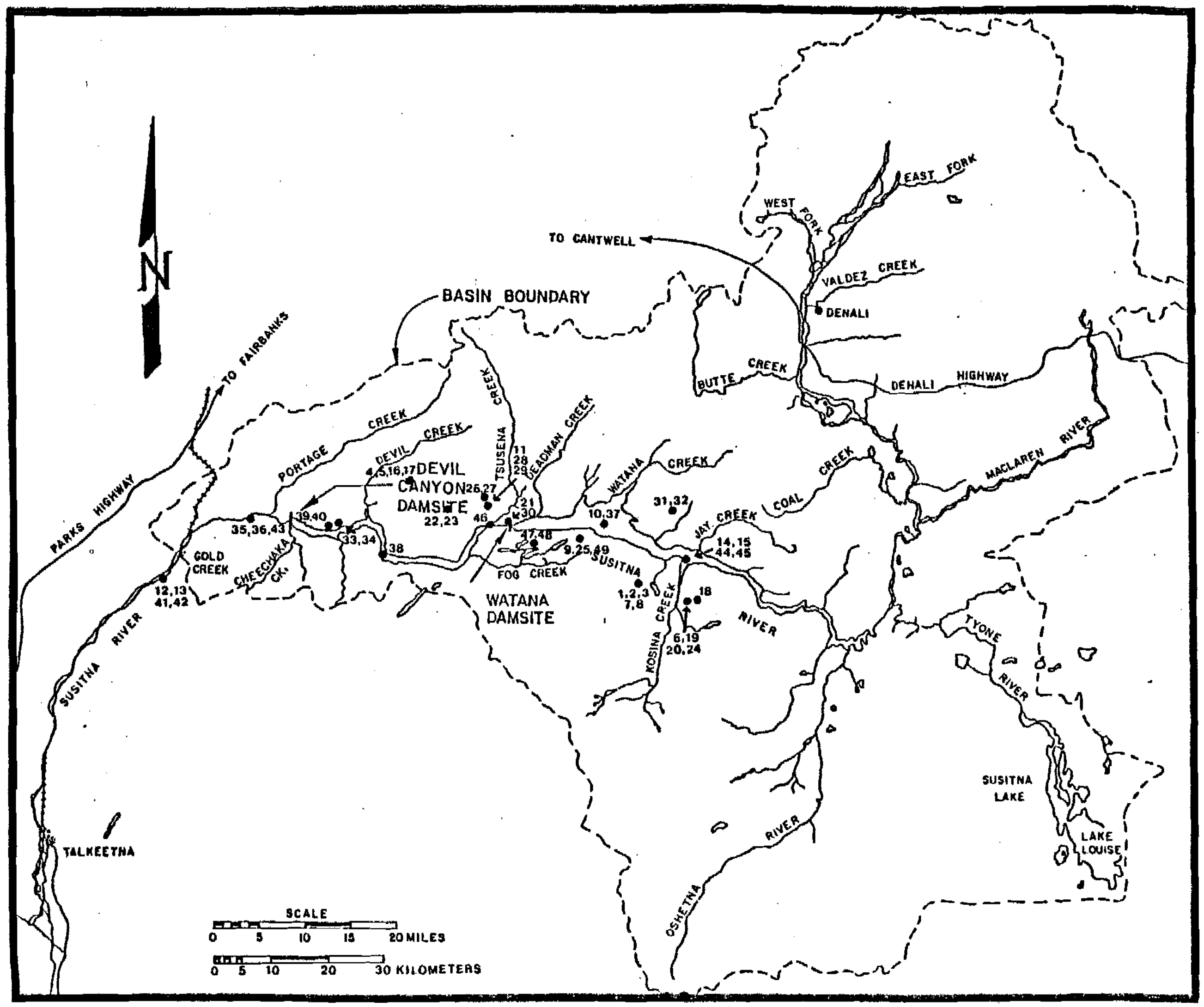

FIGURE 2

Locations of small mammal trapline sites in the upper Susitna River Basin, Alaska, 1980-81.

in all field aspects of the study during 1981 and shouldered the major responsibilities for all the 1981 waterfowl surveys. Alan M. Springer in 1980 and David G. Roseneau in 1981 shared their raptor-hunting expertise with us by participating in aerial raptor surveys. Brian E. Lawhead, in 1980, helped monitor fall bird migration and flew all of the fall waterfowl surveys. A number of other field assistants also made significant contributions to our data-gathering efforts, including Susan R. Lucachick, Michael K. MacDonald, Donald A. Williamson, Jan Overturf, and Maurice L. Ward. Edward C. Murphy and Douglas P. Pengilly provided statistical advice and assistance, and Catherine H. Curby compiled and manipulated all of our massive habitat and animal computer data files.

We also appreciated all the contributions made to our studies by various members of the Furbearer study group: Philip S. Gipson, Steven W. Buskirk, T. Winston Hobgood, David P. Volsen, William H. Busher, and Richard F. Morse. We thank John Ireland, resident at Murder Lake, for his hospitality and for sharing his many bird observations with us. And we laud the fine logistics provided by all the field support personnel at Watana and High Lake, especially Onnalie Logsdon of Terrestrial Environmental Specialists and the helicopter pilots from ERA Helicopters, Akland Air, and Air Logistics.

Our studies were conducted under a contract between the University of Alaska and Terrestrial Environmental Specialists, Inc., for Acres American, Inc., and the Alaska Power Authority.

2 - METHODS

2.1 - Selection and Configuration of Bird Census Plots

Twelve square 10 ha (25 acres) bird census plots were established in the study area. This plot size is above the minimum recommended by the International Bird Census Committee (1970) and is one that can be adequately censused in 4 h, the approximate period of maximum bird activity each morning. Except for the Alpine Tundra plot, sites were selected in relatively uniform patches of vegetation that represented each of the major woody avian habitats (after Kessel 1979) present in the region. The Alpine Tundra plot was selected to include several of the widespread avian habitats found at the higher elevations of the study area. Each of the 10-ha plots was divided by a 7 x 7 grid to aid in animal censusing procedures and in analysis of habitat variables.

2.2 - Measurement of Habitat Variables

The variables chosen to describe the habitats (Table 1) were those judged most likely to affect, either directly or indirectly, the animal community structure, species composition, and habitat occupancy levels of these habitats. Some of these variables had already been tested in central Alaska by Spindler (1976), Wolff (1977), West (1979), MacDonald (1980), and Spindler and Kessel (1980).

The gridded subplots and small mammal trap stations were used as sample units in vegetation analyses. Systematically located points were sampled, using the point-centered quarter method of Cottam and Curtis (1956), but including more detailed sampling of ground cover, understory, and shrub vegetation. Sampling was vertically stratified into six layers (after Kessel 1979): ground cover (<0.25 m), dwarf shrub (<0.4 m), low shrub (0.4-1.1 m), medium shrub (1.2-2.4 m), tall shrub (2.5-4.9 m), and tree (≥5.0 m).

Non-vegetative variables measured included litter depth, microrelief, distance to nearest standing water, if any, in subplot, and characteristics of that water (fluviatile or lacustrine, depth, surface area), distance to habitat edge and the length of that edge if any, in a subplot, and the slope and aspect of the 10-ha study plot (Table 1). Age of stands was determined by taking 10-20 auger core samples from the largest trees on a plot, or, in the case of the tall shrub plot, by cutting the largest stems from alder shrubs and counting the growth rings.

TABLE 1

MEASURED HABITAT VARIABLES USED TO DESCRIBE BIRD AND SMALL MAMMAL INTENSIVE STUDY PLOTS, UPPER SUSITNA RIVER BASIN, ALASKA, JULY-AUGUST 1980-81.

Habitat Variable	Method
Distance between trees	Average distance to nearest tree (≥5 m height), in quarters (Cottam and Curtis 1956)
Distance between shrubs/shrub clumps*	Average distance to center of nearest shrub/shrub clump (1.2-4.9 m high), in quarters (Cottam and Curtis 1956)
Canopy area of shrub/shrub clump	Average area of shrub/shrub clump canopy, in quarters (Cottam and Curtis 1956). Calculated as area of ellipse from length and width measurements)
Height of trees and shrubs	Average height of nearest tree and nearest shrub, in quarters (Cottam and Curtis 1956)
Diameter of tree trunk	Average diameter (dbh) of trunk of nearest tree, in quarters (Cottam and Curtis 1956)
Canopy thickness of tree layer and shrub layer	Average canopy thickness of nearest tree and nearest shrub, in quarters (Cottam and Curtis 1956). Derived from distance between lowest live branch and top of tree or shrub.
Foliage height density profile	Average number of 64 5.0 x 5.0 cm coverboard squares contacted, 3 m from centerpoint in quarters (Cottam and Curtis 1956), at heights 0-0.4 m, 0.6-1.0 m, 1.6-2.0 m, 3.5-3.9 m
Canopy coverage	Percent of 20 sightings (10 at 1 m intervals along each of two perpendicular lines centered on centerpoint) showing vegetation contact at cross-hairs of a vertical ocular tube. Tree and shrub as well as total canopy coverage obtained.
Ground cover	Percent each of sedge, grass, forb, microshrub (<0.25 m), litter, moss, lichen, water, and bare soil in a 1.0 x 1.0 m plot with corner on centerpoint.
Species frequency in ground cover	Occurrence of specific plant species in the 1.0 x 1.0 m plot at small mammal trap stations.
Dwarf shrub cover	Percent of shrub cover <0.4 m high in 3.0 x 3.0 m plot with corner on centerpoint.
Low shrub cover	Percent of shrub cover 0.4-1.1 m high in the 3.0 x 3.0 m plot.
Tree and shrub importance values	Sum of relative frequency, relative density, and relative dominance of species, nearest tree and nearest shrub species in quarters (Curtis and McIntosh 1951)
Litter depth	Average depth of five random samples in the 1.0 x 1.0 m plot, using calibrated probe
Microrelief	Maximum vertical range of topography in the 3.0 x 3.0 m plot
Distance to water	Distance to nearest perennial water, if any, on subplot from centerpoint

TABLE 1 (Continued)

Habitat Variable	Method
Size and type of waterbody	Area and edge of waterbody within a subplot, calculated as area and circumference of an ellipse, respectively, from length and width measurements. Type differentiated as lacustrine or fluviatile
Depth of waterbody	Maximum depth of water
Distance to habitat edge	Distance to nearest edge, if any, on subplot from centerpoint. Defined as edge of forest opening at least 30 m x 30 m, or edge of shrub thicket opening at least 15 m x 15 m.
Length of habitat edge	Length of edge within a subplot
Slope	Degree of slope of 10-ha plot as measured with Abney level
Aspect	Direction of slope exposure of 10-ha plot measured with a compass
Age of stand	Number of growth rings obtained from cut stems or with tree auger

*Clumps of intertwining shrubs were treated as a single shrub for the purposes of habitat analyses

2.3 - Bird Censusing

A modification of the territory mapping census method (International Bird Census Committee 1970) was used to determine the densities of breeding birds on each of the twelve 10-ha bird census plots. The 7 x 7 gridding of each plot resulted in forty-nine 0.2-ha subplots, which were used in censusing and in the subsequent plotting of territories and analyses of avian-habitat relationships. In all, 588 subplots were censused in 1981.

Three field parties conducted a total of eight censuses on each 10-ha plot between 20 May and 3 July 1981. Each census took approximately 4 h, usually between 03:00 and 08:00 (Alaska Standard Time), which is generally within the time of greatest singing activity. Censuses were conducted in pairs of two consecutive days at each plot, partly to minimize the effects of changing territorial boundaries and partly to alleviate transportation problems between plots. During a census, the observer stopped at the center of each subplot for 2-7 minutes, depending upon avian activity, and recorded on a field map of the plot all birds seen or heard. For birds seen, sex and age, activity, spatial location (height above ground and positioning within a shrub or tree), and substrate used (including plant species) were also recorded.

2.4 - Waterbird Surveys

Data on the use of wetlands by waterbirds were obtained primarily from two types of surveys of the lacustrine waterbodies of the region: ground censuses during the breeding season and aerial surveys during migration. Generally, we examined most of the large lakes near the proposed impoundments, plus a number of smaller lakes and ponds that were near proposed access routes or that were efficiently examined because they were either near the large lakes or were located on the route between two of the larger lakes.

Ground censuses of 28 waterbodies, involving 53 party-hours of field work, were conducted between 8 and 29 July 1981. Each waterbody was censused once. A census consisted of two or more people either walking around the shoreline of a waterbody or paddling the edges in an inflatable Sea Eagle canoe, or sometimes both simultaneously, and enumerating all waterbirds and broods present. The efficacy of this method of censusing individual waterbodies and its usefulness for comparing waterbird population characteristics over time and for determining the relative importance of different waterbodies to waterbirds is discussed by Spindler et al. (1981).

Aerial surveys to monitor waterbody use during migration were also based on counts from individual waterbodies. Surveys were conducted 7 September-4 October 1980, 3-26 May 1981, and 15 September-23 October 1981. We began aerial surveys earlier and conducted more of them in fall 1980 than in 1981, because it was necessary to familiarize ourselves with the use patterns in the region during the first year. In fall 1981 the surveys were not as extensive or intensive. We began them later in September, but continued them until most of the waterbodies were frozen. We tried to time our first survey in 1981 to catch the peak of waterfowl migration, but apparently missed it because of a somewhat earlier movement of wigeon, Pintail, and scaup in 1981. The pattern of migration and waterbody use during both fall periods was similar, however.

An average of 34 waterbodies was included in each survey, but the number varied as we developed our sampling scheme and in response to 100% ice cover. Brian E. Lawhead flew all the surveys during fall 1980, and Kevin C. Cooper flew them all during 1981. All but the 3 October 1980 survey were made from a Bell 206B "Jet Ranger" helicopter, with the observer seated in the left front seat beside the pilot. The other survey was made in an Aerospatiale AS350 "A-Star."

In searching for birds, usually a single pass was made over small waterbodies. With larger waterbodies, the helicopter followed the shoreline, usually in a counterclockwise direction so that the observer was on the water side. Diving ducks in particular were less disturbed when the helicopter flew over the shore instead of over water. Large lakes containing scattered birds were surveyed in sections. Flights during counts were at about 80 km/h (50 mph) and between 30 and 75 m (100-250 ft) above ground level. When flocks of birds were encountered, the helicopter circled widely and slowly around the birds while the observer counted and identified them, sometimes with the aid of 7X,35 binoculars. Hovering or circling directly over waterfowl was avoided, because it unnecessarily disturbed the birds, causing them to scatter and dive and making enumeration difficult.

As with most aerial surveying, accuracy of results was subject to many foibles, including weather-caused factors (sun glare, choppy water), bird behavior (diving, flushing, hiding in vegetation), differences in helicopter performance and pilots' flying styles, etc. Generally, however, we feel that results were a reasonably accurate indication of the species and numbers present on the respective waterbodies at the time of the surveys.

2.5 - Raptor Surveys

Information on use of the region by breeding raptors and ravens was derived from 1) helicopter surveys on 6 July 1980 and 16 and 17 May 1981 of all cliff habitat along the Susitna River and its tributaries (but not the upland cliffs and tors), from Portage (1980) and Indian (1981) creeks to the mouth of the Tyone River, and, on 3 and 5 July 1981, of habitats along the proposed access routes, 2) ground visits to all 1980 and 1981 active nest sites, 3) special ground and aerial searches of vegetated cliff habitat (potential Peregrine habitat?), 4) supplemental observations made whenever flying over or working near raptor habitat, and 5) from miscellaneous observations made throughout the study period.

Aerial surveys of raptor cliff-nesting habitat were conducted from Bell 206B "Jet Ranger" helicopters. Three observers in addition to the pilot took part in each survey. Brian A. Cooper participated in all surveys; he was accompanied in July 1980 by A. M. Springer and O. Logsdon, in May 1981 by D. G. Roseneau and K. C. Cooper, and in July 1981 by K. C. Cooper and S. R. Lucachick. Because of the ability and accumulated experience of the observers, we feel that our surveys were as accurate as most aerial surveys of this type.

During the surveys, the helicopter moved slowly past cliff faces as close as the pilot deemed safe, usually at a distance of about 30-40 m. When necessary for better observation, the helicopter hovered for short periods or made more than one pass past a site. All active and inactive nest sites were recorded and briefly described on 1:63,000 USGS quadrangle maps. All nest sites found in earlier surveys, including those by White (1974), were relocated and checked for activity.

Between 20 May and 13 July 1981, we visited all 1980 and 1981 active cliff sites from the ground, taking photographs of each site and recording data on nest site characteristics and cliff habitat in proximity of each site (data on file at University of Alaska Museum). Several times during early summer and at least once from the ground in June 1981, we examined all potential Peregrine-type habitat (vegetated cliffs). In all, some 44 party-hours were spent in these ground examinations of raptor habitat.

Over the course of the summer, we roughly delineated all cliffs in or near the impoundment area on 1:63,000 USGS quadrangle maps and classified cliffs according to their structure and apparent quality for nest sites. "A" cliff habitat had cliffs large enough to support a nest, had ledges and nooks for nest placement, and had little loose material; "B" cliffs had these same attributes, but were smaller and perhaps not large enough to support a nest; and "C" cliffs had loose substrates (dirt and rock banks or loose talus) and probably would not have been used by raptors.

2.6 - Avifaunal Survey

In addition to data gathered during the intensive activities described above, we accumulated general data on the avifauna through several other means:

(a) A daily checklist enumerating all independent individuals (as opposed to dependent broods) of all species observed was maintained while we were in stationary camps.

(b) Whenever time permitted, we walked cross-country at various locations throughout the upper basin, recording all individuals of all species seen and, whenever feasible, the habitats utilized. Hours in the field and distance traveled were recorded, broken down by habitat when possible. In all, over 630 party-hours were spent in this form of survey.

(c) All observations related to breeding chronologies were recorded, e.g., nests and their contents, and age and activity of dependent broods.

(d) Observations were solicited, either verbally or through posted data sheets, from others working in the region.

2.7 - Small Mammal Sampling

(a) Shrews and Voles

To sample shrew and vole populations, we used a modification of the North American Census of Small Mammals (Calhoun 1948). Trapline transects consisted of 20 trap stations, spaced every 15.2 m. Two "Museum Special" snap-traps and one pitfall trap (primarily for shrews) were set within a 1-m radius of each trap station centerpoint for three consecutive nights. Snap-traps were baited with a mixture of peanut butter, rolled oats, and ground walnuts or sunflower seeds. Pitfalls, which were heavy galvanized sheetmetal cones measuring 155 mm in diameter and 260 mm in depth, were pressed into the ground so that the cone opening was flush or slightly lower than ground level; they were not baited. Two trapline transects, treated as independent samples in analyses, were set up along grid lines number three and five of each 10-ha bird census plot (except on the multihabitat Alpine Tundra plot). In addition, we established a number of traplines at other locations in the study area, on vegetationally-homogeneous sites that represented the wide range of vegetation types present in the upper Susitna River Basin. By fall 1981, the number of trapline transects in operation totaled 49.

During each sampling period we recorded the following data for each animal trapped: date, location, trap type (snap-trap or pitfall), species, sex, weight (using 10 g, 50 g, and 100 g Pesola scales), and reproductive condition (males--testes abdominal or scrotal; females--pregnant, number and size of embryos, lactating). Representative samples of study skins and skeletal material were preserved and deposited in the University of Alaska Museum.

(b) Other Small Mammals

Systematic enumeration of small mammals other than shrews and voles proved to be impractical, largely because each species required a different, time-consuming census technique, the application of which was impossible within time and manpower constraints. Also, some of these other small mammals, while common and widespread throughout central Alaska, were present in relatively low densities in the upper Susitna River Basin (snowshoe hare and porcupine) or were in locations unlikely to be impacted by activities related to the Susitna Hydroelectric Project (collared pika and hoary marmot).

Attempts to census ground squirrels in 1981 failed, largely because of inconsistencies among inexperienced observers in the recording of squirrel sign and habitat variables. With four observers, we conducted transect censuses at eight fox den sites and 20 non-fox den sites above treeline between 9 August and 17 September 1981. Each census consisted of an observer walking a north-south transect and then an adjoining east-west transect, each 500 paces long (approx. 365 m), and stopping to record at every 20 paces (approx. 15 m) the number of ground squirrel burrow holes encompassed by a 2 m-radius circle centered at the recorder's feet. Also recorded at each stop were vegetation type, slope, aspect, and one of three substrate moisture categories--wet, moist, dry. In addition, the number of squirrel calls heard during a census was tallied.

Red Squirrel counts are still to be made. These will be done in conjunction with bird censusing in 1982, when observers will map active squirrel middens on the bird census plots. Densities will be determined by assuming one squirrel per midden (after Wolff and Zasada 1975).

Lacking more concrete data, relative abundance information given in discussions below on these other small mammals is based on general survey information gathered by our field parties and from observations contributed by others.

2.8 - Analytical Techniques

(a) Importance Values

In an attempt to identify the waterbodies most significant to waterbirds (loons, grebes, and waterfowl), we derived a relative "Importance Value" for each season for each waterbody surveyed, i.e., we calculated an Importance Value of a waterbody to breeding waterbirds compared to all others surveyed during July 1981 (a total of 28 waterbodies), another for 20 waterbodies surveyed during fall 1980, and another for 34 waterbodies surveyed during spring 1981. The importance value of each waterbody at a given season was the sum of relative mean abundance (number of birds) from the several censuses, the relative mean density (birds/km^2), and the relative mean species richness (number of species) (after Curtis and McIntosh 1951):

$$\text{IMPORTANCE VALUE of a waterbody} = \frac{\text{mean number of birds per census on waterbody}}{\text{sum of mean number of birds per census on all waterbodies}} + \frac{\text{mean density of birds per census on waterbody}}{\text{sum of mean densities of birds per census on all waterbodies}} + \frac{\text{mean number of species per census on waterbody}}{\text{sum of number of species per census on all waterbodies}}$$

(b) Avian Communities

The avian communities in the major terrestrial habitats of the region, represented by the 12 bird census plots, were compared relative to species composition, species richness (number of species), breeding density, breeding biomass, and species diversity (H').

Breeding density was determined by estimating the number of territories of each species, based on repeated observations of territorial males, females, or breeding pairs (International Bird Census Committee 1970). Partial territories were also determined and added to the number of whole territories. Species that had only a small fraction of a territory on a plot were given a "+," which was counted as 0.1 territory in calculations of breeding density, species diversity, and breeding biomass. The breeding densities of early season nesters, such as Gray Jay and chickadees, were estimated, based on repeated observations of adults or immatures on the plot.

Species diversity was calculated using the diversity index, H' (Pielou 1975). Species diversity has two components: number of species (species richness) and the evenness (species equitability) with which the individuals of the community are apportioned among these species (Pielou 1975). H' reaches its maximum value in communities with many species of nearly equal abundance. A community with many species distributed evenly may have the same diversity index as a community with fewer species that are distributed evenly.

Breeding biomass was calculated for each plot as the sum of breeding biomass for each species breeding on the plot. Breeding biomass for each species was calculated as the product of the density of breeding birds and average weight of the species. Species weights used were an average weight for all adult specimens in the University of Alaska Museum that had been collected in Alaska during the breeding season. If the sample size in the museum was too small, or variability too high, we consulted published literature (Carbyn 1971, West and DeWolfe 1974) for values determined from northern populations. Large-bodied breeding birds, such as grouse or ptarmigan, were omitted from biomass calculations, because they tended to skew the total biomass disproportionately. Breeding biomass was expressed as grams breeding birds per 10 ha.

(c) Statistical Procedures and Data Presentation

Two procedures were used to organize the small mammal trapline sites into groups, based on their similarities: cluster analysis and principal component analysis (PCA). Variables used in the analyses were our measurements of ground-level habitat structure and plant taxa frequencies, thus emphasizing the stratum used by small mammals and allowing expression of variation among sites. The resultant groups of trapline sites corresponded to vegetation types (see Section 4.2), which were used to document patterns of small mammal habitat distribution, abundance, and coexistence.

The cluster analysis (Biomedical Computer Program BMDP2M: Chi-Square Procedure [Dixon and Brown 1979]) was performed using the plant taxa frequencies. This technique is a method for organizing a data array, based on a measure of similarity among variables, into groups or clusters that are more similar within groups than among groups. In this instance, trapline sites with the most similar composition of plant taxa were clustered first (subgroups), and those less similar clustered progressively later (major groups).

The principal component analysis (Biomedical Computer Program BMDP4M [Dixon and Brown 1979]) was performed using measured structural habitat variables. PCA is a statistical technique that reduces multivariate data into a few dimensions, uncorrelated with each other, that are linear combinations ("principal components") of the original variables

(Morrison 1976). The first new composite set of linear variables (PC I) accounts for more of the variance (information) in the data set than any other linear combination and thus provides the best summary of linear relationships exhibited in the data. PC II accounts for the most variance in the data set not accounted for by PC I, and each successive component or dimension accounts for successively less variance. From our PCA analysis of habitat variables, we used PC I and PC II as axes on which to ordinate the trapline sites (using mean factor scores), in order to examine their interrelationships and to provide a base from which to look at habitat occupancy patterns.

A PCA, based on measured habitat variables, was also used to ordinate the breeding distribution of bird species relative to habitat characteristics. A mean PCA factor score from all subplots on which a given species was recorded at least once during censuses was calculated for species that occurred on 10 or more subplots. These scores were plotted on a three-dimensional diagram, using the first three principal components of habitat characteristics as axes.

Distribution patterns of small mammals relative to groupings of vegetation types were further shown through the use of a three-dimensional display technique (Surface II Graphics System Programs [Sampson 1978]). The percentage of total number of captures of a given small mammal species per trapping site was added as a vertical axis to the two-dimensional PCA ordination of trapline sites. Block or "fishnet" diagrams of each species, created by connecting contours of equal abundance, give three-dimensional illustrations of a species' distributional "topography."

To quantify the variation in range of habitat use by small mammals, we calculated values for habitat niche breadth for each species, using the formula (after Krebs and Wingate 1976)

$$B = \frac{1}{\Sigma p_i^2}$$

where B=habitat niche breadth and p_i = proportion of species total density at trapline site i; p is defined from average density estimates:

$$p_i = \frac{d_i}{\Sigma d_i}$$

where d_i = number of individuals per 100 trap nights at trapline site i. Habitat niche breadth was then standardized by dividing by the total number of sites.

3 - BIRDS - RESULTS AND DISCUSSION

3.1 - Habitat Descriptions of Census Plots

Twelve intensive study plots were established in the shrub and forest vegetation types of the upper Susitna River Basin (Fig. 1). Plot sites within these vegetation types were chosen to represent each of the major woody avian habitats (Kessel 1979) present in the region in sufficient size and uniformity to accommodate a square 10-ha (25-acre) study plot. Below, in capital letters, are listed the avian habitats represented by our plots, followed in parentheses by their most distinguishing habitat characteristics and in brackets by the approximate vegetative equivalents of Viereck and Dyrness (1980). Classified thereunder are the twelve bird census plots.

DWARF SHRUB MAT (<0.4 m high), DWARF SHRUB MEADOW, AND BLOCK-FIELD [Mat and Cushion Tundra, Mesic Sedge-grass]

Alpine Tundra

LOW (0.4-1.1 m high) AND/OR MEDIUM (1.2-2.4 m high) SHRUB THICKETS [Low and/or Tall Shrubland, separated at 1.5 m]

Dwarf-Low Birch Shrub Thicket
Medium Birch Shrub Thicket
Low-Medium Willow Shrub Thicket

TALL (2.5-4.9 m high) SHRUB THICKET [Tall Shrubland, >1.5 m]

Tall Alder Thicket

DECIDUOUS (90% of canopy) FOREST [Deciduous Forest, 75% of canopy]

Cottonwood Forest
Paper Birch Forest

MIXED (10-90% of Canopy) DECIDUOUS-CONIFEROUS FOREST [Mixed Conifer and Deciduous Forest, 25-75% of canopy]

White Spruce-Paper Birch Forest I
White Spruce-Paper Birch Forest II

CONIFEROUS (90% of Canopy) FOREST [Conifer Forest, 75% of canopy]

White Spruce Forest

SCATTERED WOODLAND (≥5 m high) AND DWARF FOREST (<5 m high)
(Stunted growth of 0.2-20% canopy)
[Conifer and Deciduous Woodlands,
10-24% tree canopy]

White Spruce Scattered Woodland
Black Spruce Dwarf Forest

There are two problems in the upper Susitna River Basin studies in using the vegetative classification of Viereck and Dyrness (1980) to describe avian habitats. One is the fact that their Tall Shrubland supports two more or less distinct bird communities (medium and tall shrub birds of Kessel [1979]). The other is that their definition of coniferous and deciduous forests is not restricted enough for birds, since only about 10% of either vegetation type will attract the respective bird species into these forests.

A brief description of each of the 10-ha study plots is provided below. Table 2 presents a summary of the various habitat variables measured on each of the 10-ha plots, and Table 3 gives the frequencies of shrub and herb species in the ground cover of these plots. Generally, we have used common names for the most important tree and shrub species (Table 2) and major plant groups (e.g., sedges, lichens), but only scientific names for the less common species and ground cover plants. Nomenclature follows Hultén (1968), except for willows, which follow Argus (1973).

(a) Alpine Tundra

The Alpine Tundra plot contained three distinct avian habitats, all typical of and widespread in the high country of the region: Dwarf Shrub Meadow, Dwarf Shrub Mat, and Block-field (rock scree). Vegetation was all less than 0.4 m high, mostly less than 0.25 m. The Dwarf Shrub

TABLE 2

SUMMARY OF VALUES OF HABITAT VARIABLES FROM EACH 10-HA INTENSIVE STUDY PLOT, UPPER SUSITNA RIVER BASIN, JULY-AUGUST 1980-81. SEE TABLE 1 FOR DESCRIPTION OF METHODS.

Habitat variable	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
GROUND COVER (%)												
Grass	3.4	22.0	4.1	16.0	21.1	19.3	12.5	28.7	8.2	2.5	4.8	3.4
Sedge	34.6	3.3	7.3	37.7	0.1	0.7	0.0	0.0	0.7	0.0	1.0	8.9
Forb	3.5	3.0	0.7	35.2	15.4	45.8	30.0	40.2	43.7	1.9	2.7	11.7
Microshrub (<0.25 m)	47.7	49.9	57.7	34.6	16.0	0.8	32.2	26.3	55.9	47.2	79.5	54.0
Litter	9.9	4.3	4.7	39.6	81.8	97.5	88.3	73.3	57.4	5.3	5.5	3.1
Moss	34.5	53.4	85.7	59.4	9.6	4.1	13.8	17.0	41.8	82.5	74.3	79.2
Lichen	41.9	47.3	9.8	0.0	0.2	0.0	0.6	0.5	0.4	25.7	3.1	9.6
Water	3.0	0.0	0.8	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.9
Bare soil	16.3	2.3	1.1	0.0	6.4	9.4	6.2	7.7	0.0	0.1	0.2	1.1
MICRORELIEF (m)	0.23	0.27	0.37	0.25	0.13	0.22	0.32	0.28	0.30	0.24	0.32	0.33
LITTER DEPTH (cm)	0.05	0.04	0.9	7.8	8.6	10.6	10.5	9.5	4.7	0.4	0.9	7.0
DWARF SHRUB COVER (<0.4 m) (%)	53.4	54.0	61.8	44.4	27.7	1.7	38.4	7.5	58.2	60.6	81.5	64.3
LOW SHRUB COVER (0.4-1.1 m) (%)	0.0	28.2	22.3	47.7	19.9	28.1	3.9	33.4	12.0	19.8	34.0	34.5
MEDIUM-TALL SHRUBS/SHRUB CLUMPS (1.2-4.9 m)												
Distance between shrubs (m)	--	(1.1)*	1.5	4.6	3.6	1.4	5.1	2.7	3.7	5.9	2.0	2.5
Shrub height (m)	--	(0.5)	1.4	1.3	3.8	2.6	3.7	3.2	2.4	2.8	1.5	2.9
Height to canopy bottom (m)	--	--	0.1	0.3	0.2	0.6	0.2	0.1	0.4	0.2	0.2	0.2
Canopy thickness (m)	--	--	1.3	1.1	3.6	2.0	3.5	3.1	2.0	2.6	1.4	2.7
Canopy area (m^2 horizontal plane)	--	--	1.3	0.9	12.3	2.6	8.3	7.5	1.8	0.9	1.8	1.4
Shrub heterogeneity (100 SD/$\bar{x}$)	--	(61.4)	37.1	101.3	47.8	29.4	45.4	50.0	39.1	56.1	50.1	60.2

TABLE 2 (Continued)

Habitat variable	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
TREES (≥5.0 m)												
Distance between trees (m)	--	--	--	--	--	6.2	5.6	8.0	3.8	4.6	20.6	--
Tree height (m)	--	--	--	--	--	17.6	13.5	13.5	12.9	10.4	9.0	--
Height to canopy bottom (m)	--	--	--	--	--	7.4	4.2	1.3	1.5	0.6	0.1	--
Canopy thickness (m)	--	--	--	--	--	10.1	9.3	12.2	11.4	9.8	8.9	--
Tree diameter (m dbh)	--	--	--	--	--	0.34	0.21	0.23	0.18	0.16	0.22	--
Tree heterogeneity (100 SD/$\bar{x}$)	--	--	--	--	--	54.0	57.7	30.3	29.4	34.0	44.4	--
CANOPY COVERAGE (%)												
Trees	0.0	0.0	0.0	0.0	0.0	56.5	55.0	25.5	57.5	19.5	3.0	1.5
Medium-tall shrubs	0.0	0.0	18.0	5.0	74.5	70.0	30.0	64.5	9.5	3.5	14.5	15.0
Total (trees & shrubs)	0.0	0.0	18.0	5.0	74.5	87.5	74.0	79.5	62.5	21.5	17.5	16.5
FOLIAGE DENSITY PROFILE (number of coverboard squares contacted)												
Woody stems:												
0.0-0.4 m	5.6	44.7	62.3	57.8	46.1	53.0	35.7	43.1	38.5	53.2	59.8	54.1
0.6-1.0 m	0.0	5.3	58.0	40.0	34.0	47.7	27.0	38.7	16.5	20.9	51.5	29.6
1.6-2.0 m	0.0	0.0	2.7	0.0	44.1	37.0	27.0	42.9	16.9	15.0	8.7	15.3
3.5-3.9 m	0.0	0.0	0.1	0.0	40.5	42.3	29.4	36.1	21.3	15.5	2.5	7.7
Graminoid stems:												
0.0-0.4 m	10.0	18.9	12.1	40.1	33.1	41.0	42.5	50.3	25.5	6.2	12.1	16.7
0.6-1.0 m	0.0	0.2	1.7	7.2	7.2	13.5	14.5	18.6	2.8	0.3	1.0	0.7
1.6-2.0 m	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.3	0.3	0.0	0.0	0.2

TABLE 2 (Continued)

Habitat variable	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
Forb stems:												
0.0-0.4 m	0.6	1.1	0.4	20.2	22.7	42.4	24.7	33.4	24.9	3.4	5.3	10.5
0.6-1.0 m	0.0	0.2	0.0	0.0	1.0	16.8	5.2	3.0	2.4	0.0	0.0	0.1
1.6-2.0 m	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0
TREE IMPORTANCE VALUES												
White spruce, *Picea glauca*	0	0	0	0	0	15	61	163	129	202	293	0
Black spruce, *Picea mariana*	0	0	0	0	0	0	0	0	2	90	7	0
Cottonwood, *Populus balsamifera*	0	0	0	0	0	220	0	0	0	2	0	0
Quaking aspen, *Populus tremuloides*	0	0	0	0	0	0	9	0	0	0	0	0
Willow, *Salix* spp.	0	0	0	0	0	1	0	0	0	4	0	0
Paper birch, *Betula papyrifera*	0	0	0	0	0	2	223	135	169	2	0	0
Alder, *Alnus* spp.	0	0	0	0	0	62	7	2	0	0	0	0
MEDIUM-TALL SHRUB IMPORTANCE VALUES												
White spruce, *Picea glauca*	0	0	0	0	0	0	37	18	91	118	0	8
Black spruce, *Picea mariana*	0	0	0	0	0	0	0	0	2	141	4	284
Willow, *Salix* spp.	0	0	0	124	5	13	5	0	14	2	3	8
Shrub birch, *Betula glandulosa*/hybrids	0	0	300	164	5	0	0	0	0	13	289	0
Paper birch, *Betula papyrifera*	0	0	0	0	0	0	30	37	54	13	0	0
Alder, *Alnus* spp.	0	0	0	12	289	195	211	240	95	13	4	0
Raspberry, *Rubus idaeus*	0	0	0	0	0	2	0	0	0	0	0	0

TABLE 2 (Continued)

Habitat variable	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
Alaska spiraea, *Spiraea beauverdiana*	0	0	0	0	0	0	0	5	1	0	0	0
Greene mountain ash, *Sorbus scopulina*	0	0	0	0	0	0	16	0	24	0	0	0
Prickly rose, *Rosa acicularis*	0	0	0	0	0	0	0	0	5	2	0	0
Devil's club, *Echinopanax horridum*	0	0	0	0	0	20	0	0	0	0	0	0
High bush cranberry, *Viburnum edule*	0	0	0	0	0	71	0	0	13	0	0	0
TOTAL LENGTH OF EDGE (m)	--	160	90	233	180	0	0	0	0	90	79	0
AVERAGE SLOPE (degrees)	7.1	2.2	5.4	6.0	22.2	0	21.8	20.8	0	1.0	5.0	1.0
MEAN ASPECT (degrees)	311	150	215	356	143	0	159	144	0	276	195	168
ELEVATION (m)	1300	1100	900	880	1200	180	600	600	260	520	820	730

*Low Shrubs

TABLE 3

FREQUENCIES (%) OF SHRUB AND HERB SPECIES IN THE GROUND COVER OF INTENSIVE STUDY PLOTS, UPPER SUSITNA RIVER BASIN, ALASKA, JULY-AUGUST 1980-81. BASED ON OCCURRENCE IN 40 1.0 m x 1.0 m SAMPLE PLOTS LOCATED AT THE MAMMAL TRAPSITES ON LINES THREE AND FIVE OF THE 10-HA STUDY PLOTS, EXCEPT ON THE ALPINE TUNDRA AND DWARF-LOW BIRCH SHRUB THICKET PLOTS, WHERE THE 1.0 m x 1.0 m PLOTS WERE LOCATED AT THE SINGLE VEGETATION SAMPLING SITE IN EACH OF THE 49 SUBPLOTS OF THE 10-HA PLOT.

Plant species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
<u>SHRUB</u>												
Alnus crispa					13		3					
Andromeda polifolia			3									
Arctostaphylos rubra				13						10	5	
Betula glandulosa/hybrids		88	100	97	17					63	85	95
Cassiope tetragona	63											
Cornus suecica/canadensis			70	95	33		93	73	100	53	100	15
Diapensia lapponica	43											
Dryas octopetala	53											
Echinopanax horridum						33						
Empetrum nigrum		94	100	67	3		7		40	37	100	97
Ledum palustre	6	29	97	20	16		6			85	97	93
Linnaea borealis				7	37		90	85	97	40	43	
Loiseleuria procumbens	4	6										
Oxycoccos microcarpus			3	3								45
Potentilla fruticosa				10						3	3	
Ribes glandulosum							7	55				
Ribes triste						57		27	10			
Ribes spp.					25							
Rosa acicularis				10	27	33	3	10	55	27	17	
Rubus idaeus					5	30	5	40				
Salix arctica	73	45										
Salix bebbiana										3		
S. myrtillifolia										3		
S. novae-angliae										3		
S. planifolia	10	18		97	3							20
S. reticulata	28	2		40	3					3		
Salix spp.	14		15		5			3		5	33	

TABLE 3 (Continued)

Plant species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest.
Sorbus scopulina									2			
Spiraea beauverdiana		8	85	27	33		55	27	65		60	17
Vaccinium ovalifolium								3				
Vaccinium uliginosum	55	96	40	63	27		17		55	50	97	100
Vaccinium vitis-idaea	33	94	100	57	35		43	13	92	100	97	100
Viburnum edule				10	3	55		7	10			
<u>FORB</u>												
Achillea spp.			40	3							5	
Aconitum delphinifolium				30	13			5				
Actaea rubra						17						
Anemone spp.	45	82		35								
Antennaria sp.		6										
Arnica latifolia				3								
Artemisia arctica	2	24	20	20								
Artemisia sp.		33										
Boykinia richardsonii	12											
Campanula lasiocarpa		2										
Circaea alpina						3						
Delphinium glaucum						5						
Dodecatheon frigidum		2										
Epilobium angustifolium				23	93	47	13	50	47	7	17	
Erigeron peregrinus				10								
Galium boreale				23		3				3		
Galium trifidum						90						
Gentiana spp.	12	29		23								
Geocaulon lividum									5	20		
Geranium erianthum				3								
Geum rossii	6											
Hedysarum alpinum										10		
Heracleum lanatum						10						

TABLE 3 (Continued)

Plant species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
Hieracium gracile				35								
Listera cordata				10					17			
Lloydia serotina	10											
Lupinus nootkatensis			7									
Mertensia paniculata				55	35	20		10		15		
Oxytropis nigrescens	10											
Parrya nudicaulis	22	10										
Pedicularis spp.	36	12	3	33							5	5
Petasites hyperboreus				27	10					3		43
Platanthera dilitata				3								
Polemonium acutiflorum				57	23			3			7	
Polygonum bistorta	24	6										
Potentilla palustris				20								3
Pyrola spp.	4	2	5	27		83	10	7	50	3	15	3
Ranunculus sp.												3
Rubus arcticus				17	30			5		5	10	
Rubus chamaemorus			47	83		5	17	7			35	75
Rubus pedatus							83	70	95			
Rumex arcticus			10									7
Sanguisorba stipulata			3	73			10	45			10	
Saussurea angustifolia										7		
Saxifraga spp.	10											
Sedum rosea				7								
Senecio spp.	8			13							3	
Solidago multiradiata		2		5	10						3	
Stellaria spp				10	7	10						5
Streptopus amplexifolius				3		60	5		7			
Thalictrum sparsiflorum						3						
Thalictrum alpinum				40								
Trientalis europaea			3	10	17	27	90	80	65		3	
Valeriana capitata	2			15								

TABLE 3 (Continued)

Plant species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
GRASS												
Calamagrostis canadensis					83	87	80	95	95	15	23	7
Deschampsia spp.						7				57		
Festuca altaica	2	51										
Hierochloe alpina	59	53										
Grass, unidentified	6		77	93							57	10
SEDGE												
Carex microchaeta	88	59										
Carex spp.		6	65		5		5	5		5	15	85
Eriophorum callatrix	6											
Eriophorum sp.				3								
Sedge, unidentified	6			100							12	
HORSETAIL												
Equisetum spp.			7	95	17	70	20	73	50	27	43	40
FERN												
Dryopteris dilatata						47	17	40	2			
Gymnocarpium dryopteris						55	33	60	67			
Matteuccia struthiopteris						7						
Thelypteris phegopteris								7				
CLUB MOSS												
Lycopodium spp.		10	17	20	3		50	33	100	7	20	3
Selaginella sibirica	8											
MOSS	98	98	100	100	77	83	97	95	97	100	100	100
LICHEN	90	100	100	15	63	3	35	35	7	97	100	83

Meadow was dominated by *Carex microchaeta* and contained significant quantities of dwarf shrub (up to 50% of ground cover), primarily *Cassiope tetragona*, *Dryas octopetala*, *Salix arctica*, *S. reticulata*, *Vaccinium uliginosum*, and some *S. planifolia*. The drier Dwarf Shrub Mat habitat was dominated by mosses (*Pleurozium schreberi* and *Polytrichum commune*), fruticose lichens, and *Cassiope tetragona*, with considerable *Carex microchaeta* and *Dryas octopetala* and some *Vaccinium uliginosum*. The block-field habitat was predominantly rock detritus, with varying amounts of crustose and fruticose lichens (20-40% cover) and mosses (up to 60% cover). The plot was on a northwest-facing terrace, sloping an average of 7°, on a north shoulder of Mt. Watana at 62°44'37" N, 148°05'42" W, and at about 1300 m (4300 ft) elevation.

The vegetation reflected the harsh environmental conditions at this plot. In 1981, an extensive snowbank still covered the southern edge of the plot on 15 May and lasted most of the summer. Vegetation began to turn green rapidly on 29 May, after a rain, although a few plants were in bloom earlier. High winds were frequent, and a cold snap during the second week of June brought nightly temperatures to -4°C. Fresh snow blanketed the plot with a 10 cm layer on 9 June, and about 7 cm fell again 28-30 June and may have been responsible for nesting failures. By late July, vegetation was already browning again; and, beginning on 14 August, regional precipitation fell mostly as autumnal snows at this high elevation.

(b) Dwarf-Low Birch Shrub Thicket

The plot consisted of a relatively uniform stand of shrub birch (*Betula glandulosa/nana*), with interspersed open patches where snow lingered in spring. Average shrub height was 0.5 m. The ground cover was fairly uniform throughout, even in the open patches; it was dominated by micro-shrubs (*Empetrum nigrum*, *Vaccinium vitis-idaea*, *V. uliginosum*), moss, and fruticose lichens. Birch and moss generally contributed less and grass (Hierochloe alpina and Festuca altaica) more to the ground cover in the open patches than in the shrubby areas. The plot was located on a 4° south-southeast-facing slope near the top of a dry, broad knoll east of Kosina Creek, at 62°42'47" N, 147°53'50" W, and at 1100 m (3600 ft) elevation.

(c) Medium Birch Shrub Thicket

A dense, homogeneous stand of 1.4 m-high shrub birch characterized this plot. Ground cover consisted of thick moss and a dense mat of microshrubs, especially Empetrum nigrum, Vaccinium vitis-idaea, Ledum palustre, and lesser amounts of Spiraea beauverdiana. The plot was along a broad, relatively dry ridge that sloped slightly to the southwest. It was located west of Tsusena Creek, at 62°52'17" N, 148°37'05" W, and at 900 m (3000 ft) elevation.

(d) Low-Medium Willow Shrub Thicket

Although a rather heterogeneous plot, the vegetation was dominated by willow, primarily Salix planifolia pulchra and S. barclayi. Dense low shrubs, predominantly willow, occurred throughout the plot, with interspersed wet sedge meadow openings present on the upper third of the plot. Medium-height shrubs of shrub birch and willow grew on the lower two-thirds of the plot. Ground cover consisted of about equal percentages of microshrubs (especially Cornus sp., Empetrum nigrum, Vaccinium uliginosum, and V. vitis-idaea, with lesser amounts of Salix reticulata), sedges, many species of forbs (including relatively high frequencies of Equisetum arvense, Rubus chamaemorus, Sanguisorba stipulata, Polemonium acutifolium, and Mertensia paniculata), and litter. The substrate was moist to wet, and the above-mentioned ground cover vegetation was underlain by moss. The plot was on the north-facing 6° slope of a draw west of Tsusena Creek, at 62°51'10" N, 148°45'50" W, and at 880 m (2900 ft) elevation.

(e) Tall Alder Shrub Thicket

The plot was dominated by dense, tall Sitka alder (Alnus crispa sinuata), averaging 88 yr old (oldest 158 yr) and 3.6 m in height. The upper half to two-thirds of the plot was dense alder, whereas the lower portion had some openings and intrusions of small groups of white spruce trees ($\bar{x}$=60 yr; oldest 134 yr). Ground cover was predominantly leaf and grass litter, with moderate amounts of dwarf and microshrubs (Linnaea borealis, Vaccinium vitis-idaea, Spiraea beauverdiana, Cornus sp., V. uliginosum, Rosa acicularis, and Ribes spp.), grass, and forbs. The plot was on a steep, southeast-facing slope east of Watana Creek, at 62°50'40" N, 147°59'00" W, at approximately 1200 m (4000 ft) elevation.

(f) Cottonwood Forest

A dense stand of tall, mature cottonwoods or balsam poplar (Populus balsamifera), averaging 133 yr old (oldest 176 yr), 17.6 m tall, and 34 cm dbh, dominated this plot. The forest was homogeneous, except for an old, overgrown river channel that intruded into the northern edge, resulting in a narrow strip of only dense alder and no trees. There was a two-level understory--an alder (Alnus spp.) layer with a canopy top at about 6 m, and a medium shrub layer of high bush cranberry (Viburnum edule) and devil's club (Echinopanax horridum). A 28% low shrub cover consisted primarily of Ribes triste, Rosa acicularis, and Rubus idaeus; and the ground cover was composed of more than 97% litter and many forbs, most commonly Galium trifidum, Pyrola spp., Streptopus amplexifolius, and Epilobium angustifolium. Equisetum spp. and the ferns Dryopteris dilatata, Gymnocarpium dryopteris, and Matteuccia struthiopteris were frequent, and there were many fallen logs. The plot was located on the Susitna River floodplain near Sherman, at 62°42'10" N, 149°49'45" W, and at 180 m (600 ft) elevation.

(g) Paper Birch Forest

The plot was composed predominantly of mature paper birch (*Betula papyrifera*) that averaged 66 yr old (oldest 90 yr), 13.5 m tall, and 21 cm dbh, although patches of white spruce ($\bar{x}$=101 yr, oldest 194 yr) intruded into the southwest corner. There were patches of heavy undergrowth of tall alder, and this was one of only two plots in which Greene mountain ash (*Sorbus scopulina*) occurred. The forest floor had a high cover (88%) of litter, and a moderate cover (30 and 38%, respectively) of forbs and of dwarf and microshrubs, including *Cornus* sp., *Linnaea borealis*, *Spiraea beauverdiana*, and *Vaccinium vitis-idaea*. The plot was on a steep south-southeast-facing, rocky, terraced slope, with rock cliffs 3 m to 6 m high. It was located on the north wall of the Susitna River canyon 8 km downstream from Devil Creek, at 62°48'46" N, 149°11'30" W, and at 600 m (2000 ft) elevation.

(h) White Spruce-Paper Birch Forest I

An open, uniform stand of mature white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) dominated this mixed deciduous-coniferous forest. The spruce trees were older and larger than the birch, the former averaging 139 yr old (oldest 185 yr), 14.3 m tall, and 24 cm dbh and the latter averaging 103 yr old (oldest 145 yr), 11.3 m tall, and 20 cm dbh. Similar to the deciduous forest plots, this one had a dense undergrowth of tall alder. There was a moderate cover (33%) of low shrubs (especially *Ribes* spp., *Rubus idaea*, and *Spiraea beauverdiana*) and microshrubs (*Cornus* sp., *Linnaea borealis*, and *Vaccinium vitis-idaea*). Ground cover was dominated by litter, with lesser amounts of forbs, especially, as in the paper birch forest, *Trientalis europaea* and *Rubus pedatus*. The ground cover had the highest percentage of grass of any 10-ha plot, 28.7%. The plot was located a little northeast of the Paper Birch Forest plot and was on a steep slope of a tributary drainage on the north side of the Susitna River (62°49'10" N, 149°08'25" W, 600 m [2000 ft] elevation).

(i) White Spruce-Paper Birch Forest II

Paper birch and white spruce dominated this mature mixed forest also, but in this stand the birch, even though younger, were larger than the spruce. The birches averaged 73 yr old (oldest 98 yr), 14.0 m tall, and 22 cm dbh, and the spruce averaged 126 yr old (oldest 140 yr), 12.2 m tall, and 16 cm dbh. Tree density and canopy coverage were twice those in Mixed Forest I and, concomitantly, the heavy understory of alder found in Mixed Forest I was absent in Mixed II. In fact, except for the dwarf shrub layer (<0.4 m), which exceeded that of Mixed I, other shrub layers lacked the coverage and density of Mixed I. The dominant ground cover species, both woody and herbaceous, were similar in the two mixed plots, although Mixed II had a higher moss cover and higher frequencies of *Cornus* sp., *Vaccinium* spp., *Pyrola secunda*, *Rubus pedatus*, and *Lycopodium annotinum*. The plot was located on a flat terrace on the south bank of the Susitna River, at 63°49'05" N, 149°32'26" W, and at 260 m (850 ft) elevation.

(j) White Spruce Forest

Mature white spruce trees (*Picea glauca*) dominated this plot, but a few black spruce (*Picea mariana*) were scattered throughout and increased in frequency toward the southwest corner. The white spruce averaged 127 yr old (oldest 145 yr), 10.1 m tall, and 19 cm dbh, whereas the black spruce averaged 83 yr old (oldest 122 yr), 8.1 m tall, and 12 cm dbh. There were many dead spruce snags of both species standing on the plot, with an average distance between snags of 11.3 m. Thirteen snags with complete tops and identifiable as white spruce averaged 13.3 m tall, and six identifiable as black spruce averaged 10.8 m tall. Many small spruce indicated continued regeneration by both species. The deciduous shrub understory consisted primarily of shrub birch, paper birch, and alder. Ground cover was predominantly moss, with considerable interlacing of lichens and of dwarf and microshrubs, especially *Vaccinium vitis-idaea*, Ledum palustre, Cornus sp., and V. uliginosum. Litter was essentially absent. The plot was located on an old outwash plain at the mouth of Kosina Creek, at 62°47'00" N, 147°57'16" W, and at 520 m (1700 ft) elevation.

(k) White Spruce Scattered Woodland

The dominant trees on the plot were mature, but relatively short, white spruce (Picea glauca), averaging 146 yr old (oldest 310 yr), 9.0 m tall, and 22 cm dbh. They were widely scattered throughout the plot, becoming somewhat denser toward the southeast corner; average distance between trees was 20.6 m. Amid the spruce was a relatively dense medium and low shrub cover of shrub birch, averaging about 1.5 m high. Beneath this layer was a dense cover (80%) of dwarf and microshrubs, especially Cornus sp., Empetrum nigrum, Ledum palustre, Vaccinium uliginosum, and V. vitis-idaea, and a relatively high ground cover of moss. The plot was located on a south-southwest-facing slope just north of the mouth of Tsusena Creek, at 62°51'47" N, 148°35'50" W, and at 820 m (2700 ft) elevation.

(l) Black Spruce Dwarf Forest

An open stand of stunted black spruce (Picea mariana) composed this plot. The spruce averaged 80 yr old (oldest 98 yr), but averaged only 2.9 m high and 4 cm dbh (and hence are treated as "shrubs" in Table 2). They were somewhat clumped in distribution and became more dense toward the west edge of the plot. There was a moderate cover (35%) of low shrubs, composed mostly of shrub birch and black spruce, and a denser cover (64%) of dwarf shrubs, primarily Vaccinium uliginosum, V. vitis-idaea, Empetrum nigrum, Ledum palustre, and shrub birch. The predominant ground cover was moss (79%). There was an extensive area of water seepage through this slightly sloping plot and some hummocky ground. The plot was located in the Fog Lakes area, at 62°47'48" N, 148°28'15" W, at 730 m (2400 ft) elevation.

3.2 - Species Composition and Relative Abundance

To date, 135 species of birds have been recorded in the upper Susitna River Basin study area. A complete annotated list of these species is included in Section 3.7. The relative abundance of these species (see Tables 4-7) is largely a function of habitat availability, with Common Redpoll, Savannah Sparrow, White-crowned Sparrow, Lapland Longspur, and Tree Sparrow being the most abundant species. Redpolls are habitat generalists, while the other abundant species are birds of the shrublands (dwarf, low, and medium shrubs), vegetation types that cover 70% of the region (Plant Ecology report, APA 1982).

Fifteen species are ranked as rare in the region on the basis of current information: four raptors (Osprey, American Kestrel, Snowy Owl, Boreal Owl), three species of prairie ducks (Gadwall, Blue-winged Teal, Ring-necked Duck), four shorebirds (Upland Sandpiper, turnstone sp., Surfbird, Sanderling), three small land birds (Black-backed Three-toed Woodpecker, Western Wood Pewee, Yellow Warbler), and Ruffed Grouse. Most of these birds are at the periphery of their geographic ranges, although lack of appropriate habitat may limit a few. All are represented, however, by larger populations in other portions of Alaska.

An Eastern Kingbird on 11 July 1980 is considered accidental in the region. In Alaska this species is a regular visitant only in Southeastern; it is casual elsewhere in the state (Kessel and Gibson 1978).

3.3 - Breeding Bird Densities

Avian population levels varied greatly among the different habitats (Table 8), as, of course, did the level of use of each habitat by different species (Table 9). The presence or absence of a given species in a habitat is largely a function of species' habitat preferences, but habitat occupancy levels are affected by a number of factors, including, in interior Alaska, habitat structural complexity and primary productivity (Spindler and Kessel 1980).

TABLE 4

RELATIVE ABUNDANCE OF LOONS, GREBES, AND WATERFOWL, UPPER SUSITNA RIVER BASIN, ALASKA. BASED PRIMARILY ON TOTAL NUMBER OBSERVED ON 1980 AND 1981 AERIAL SURVEYS AND 1981 GROUND SURVEYS.

Spring Migration (Aerial & Ground, 1981) No.	Species		Fall Migration (Aerial: 7 Sept-3 Oct 80, 15 Sept-23 Oct 81) No.	Species		Summer (Ground, 1981) No.	Species	
802	Scaup spp.	COMMON	2658	Scaup spp.	COMMON	94	Scaup (incl. 41 L, 27 G)	FAIRLY COMMON
394	Mallard	COMMON				81	White-winged Scoter	FAIRLY COMMON
366	Pintail	COMMON	905	Mallard	FAIRLY COMMON		(incl. flock of 65)	
			874	American Wigeon	FAIRLY COMMON	60	Pintail	FAIRLY COMMON
262	American Wigeon	FAIRLY COMMON	718	Goldeneye spp.	FAIRLY COMMON	59	Trumpeter Swan*	FAIRLY COMMON
215	Green-winged Teal	FAIRLY COMMON	551	Scoter spp.	FAIRLY COMMON	55	Oldsquaw	FAIRLY COMMON
210	Scoter spp.	FAIRLY COMMON	514	Bufflehead	FAIRLY COMMON	47	Mallard	FAIRLY COMMON
140	Goldeneye spp.	FAIRLY COMMON				33	Surf Scoter	FAIRLY COMMON
102	Oldsquaw	FAIRLY COMMON	299	Merganser spp.	UNCOMMON	32	American Wigeon	FAIRLY COMMON
			277	Swan spp.	UNCOMMON	28	Green-winged Teal	FAIRLY COMMON
52	Merganser spp.	UNCOMMON	233	Pintail	UNCOMMON	26	Black Scoter	FAIRLY COMMON
51	Snow Goose (=1 flock)	UNCOMMON	142	Green-winged Teal	UNCOMMON	25	Common Loon	FAIRLY COMMON
46	Canada Goose	UNCOMMON	111	Oldsquaw	UNCOMMON	24	Harlequin Duck	FAIRLY COMMON
43	Northern Shoveler	UNCOMMON	71	Canada Goose	UNCOMMON			
43	Swan spp.	UNCOMMON	35	Horned Grebe (1980)	UNCOMMON	16	Northern Shoveler	UNCOMMON
31	Redhead	UNCOMMON	33	Red-necked Grebe	UNCOMMON	11	Red-breasted Merganser	UNCOMMON
23	Bufflehead	UNCOMMON	28	Northern Shoveler	UNCOMMON	8	Red-throated Loon	UNCOMMON
11	Common Loon	UNCOMMON	17	Common Loon	UNCOMMON	8	Barrow's Goldeneye	UNCOMMON
8	Arctic Loon	UNCOMMON				7	Red-necked Grebe	UNCOMMON
6	White-fronted Goose	UNCOMMON	14	Ring-necked Duck (1980)	RARE	7	Common Goldeneye	UNCOMMON
5	Red-necked Grebe	UNCOMMON	1	Blue-winged Teal (1980)	RARE	5	Horned Grebe	UNCOMMON
4	Canvasback	UNCOMMON				5	Common Merganser	UNCOMMON
3	Red-throated Loon	UNCOMMON				4	Arctic Loon	UNCOMMON
3	Horned Grebe	UNCOMMON						
3	Blue-winged Teal	RARE						
3	Gadwall	RARE						
2	Ring-necked Duck	RARE						

*40 from aerial survey

TABLE 5

RELATIVE ABUNDANCE OF LARGE LANDBIRDS AND CRANES, UPPER SUSITNA RIVER BASIN, ALASKA. BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, EXCLUDING OBSERVATIONS FROM AIRCRAFT.

No.	Species	
182	Rock Ptarmigan	COMMON
139	Common Raven	COMMON
137	Willow Ptarmigan	COMMON
71	Golden Eagle	FAIRLY COMMON
52	Spruce Grouse	FAIRLY COMMON
40	Marsh Hawk	FAIRLY COMMON
27	Bald Eagle	UNCOMMON
21	White-tailed Ptarmigan	UNCOMMON
16	Goshawk	UNCOMMON
15	Sandhill Crane	UNCOMMON
07	Great Horned Owl	UNCOMMON
07	Gyrfalcon	UNCOMMON
07	Short-eared Owl	UNCOMMON
06	Red-tailed Hawk	UNCOMMON
03	Merlin	UNCOMMON
02	Sharp-shinned Hawk	UNCOMMON
02	Hawk Owl	UNCOMMON
02	Snowy Owl	RARE
01	Osprey	RARE
01	American Kestrel (1980)	RARE
01	Ruffed Grouse	RARE
01	Boreal Owl	RARE

TABLE 6

RELATIVE ABUNDANCE OF SHOREBIRDS AND GULLS, UPPER SUSITNA RIVER BASIN, ALASKA. BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, BUT SUPPLEMENTED BY DATA FROM LATE SUMMER AND FALL 1980 FOR RARE SPECIES.

No.	Species	
163	Mew Gull	COMMON
146	American Golden Plover	COMMON
114	Common Snipe	COMMON
103	Spotted Sandpiper	COMMON
78	Northern Phalarope	FAIRLY COMMON
69	Arctic Tern	FAIRLY COMMON
58	Lesser Yellowlegs	FAIRLY COMMON
55	Long-tailed Jaeger	FAIRLY COMMON
51	Least Sandpiper	FAIRLY COMMON
44	Bonaparte's Gull	UNCOMMON
34	Baird's Sandpiper	UNCOMMON
22	Semipalmated Plover	UNCOMMON
20	Herring Gull	UNCOMMON
19	Greater Yellowlegs	UNCOMMON
17	Whimbrel	UNCOMMON
12	Semipalmated Sandpiper	UNCOMMON
09	Wandering Tattler	UNCOMMON
09	Pectoral Sandpiper	UNCOMMON
06	Solitary Sandpiper	UNCOMMON
03	Long-billed Dowitcher	UNCOMMON
06	Upland Sandpiper (1980)	RARE
02	Turnstone sp.	RARE
01	Surfbird (1980	RARE
01	Sanderling (1980)	RARE

TABLE 7

RELATIVE ABUNDANCE OF SMALL LANDBIRDS, UPPER SUSITNA RIVER BASIN, ALASKA. BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, SUPPLEMENTED BY DATA FROM LATE SUMMER AND FALL 1980 FOR THE LESS NUMEROUS SPECIES.

No.	Species	
1161	Common Redpoll	
669	Savannah Sparrow	
631	White-crowned Sparrow	ABUNDANT
588	Lapland Longspur	
583	Tree Sparrow	
420	Horned Lark	
398	Dark-eyed Junco	
343	Ruby-crowned Kinglet	
316	Yellow-rumped Warbler	
288	Water Pipit	
258	Varied Thrush	COMMON
257	Gray Jay	
249	Wilson's Warbler	
225	Bohemian Waxwing	
211	American Robin	
195	Hermit Thrush	
179	White-winged Crossbill	
163	Fox Sparrow	
146	Swainson's Thrush	
145	Blackpoll Warbler	
129	Boreal Chickadee	
98	Snow Bunting	FAIRLY COMMON
71	Arctic Warbler	
64	Tree Swallow	
62	Violet-green Swallow	
55	Northern Waterthrush	
54	Gray-cheeked Thrush	

No.	Species	
53	Bank Swallow	
46	Cliff Swallow	
45	Gray-crowned Rosy Finch	
42	Black-capped Chickadee	
41	Golden-crowned Sparrow	
35	Lincoln's Sparrow	
33	Rusty Blackbird	
29	Dipper	
26	Pine Siskin	
23	Northern Three-toed Woodpecker	
23	Wheatear	
22	Black-billed Magpie	
16	Belted Kingfisher	UNCOMMON
16	Olive-sided Flycatcher	
14	Alder Flycatcher	
13	Common Flicker	
11	Brown Creeper	
10	Hairy Woodpecker	
10	Orange-crowned Warbler	
09	Pine Grosbeak	
05	Say's Phoebe	
02	Townsend's Solitaire (+4 in 1980)	
03	Northern Shrike (+27 in 1980)	
02	Smith's Longspur (+5 in 1980)	
01	Downy Woodpecker (+8 in 1980)	
01	Golden-crowned Kinglet (+11 in 1980)	

No.	Species	
1	Black-backed Three-toed Woodpecker (1980)	
4	Western Wood Pewee (1980)	RARE
2	Yellow Warbler (+3 in 1980)	
1	Eastern Kingbird (1980)	ACCIDENTAL

TABLE 8

AVIAN HABITAT OCCUPANCY LEVELS, UPPER SUSITNA RIVER BASIN, BREEDING SEASON, 1981

Avian Census Plot	No. species (No. breeding species)	Density (No. territories/ 10 ha)	Biomass (Grams/ 10 ha)	Species diversity (H')
Cottonwood Forest	21(16)	60.9	3653	2.55
White Spruce-Paper Birch Forest II	22(13)	34.6	1836	2.07
White Spruce-Paper Birch Forest I	18(14)	41.8	1709	2.47
Paper Birch Forest	18(10)	38.1	1814	2.05
White Spruce Scattered Woodland	23(16)	43.8	1775	2.29
Black Spruce Dwarf Forest	23(13)	24.8	1166	2.43
Low-Medium Willow Shrub	14(6)	45.4	1413	1.56
White Spruce Forest	18(8)	15.7	1059	1.83
Medium Birch Shrub	10(5)	32.5	952	1.48
Tall Alder Shrub	15(10)	12.5	888	2.05
Dwarf-Low Birch Shrub	11(6)	10.6	355	1.29
Alpine Tundra	8(7)	3.9	211	1.73

TABLE 9

NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON EACH 10-HECTARE CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, 1981. (+ = SMALL PORTION OF A BREEDING TERRITORY ON CENSUS PLOT, COUNTED AS 0.1 IN DENSITY AND DIVERSITY CALCULATIONS; V = VISITOR TO PLOT.)

Species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cottonwood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce-Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
Pintail				v								
Goshawk					v					v		
Marsh Hawk												v
Spruce Grouse					v	v	v	1.0	1.0	v	v	
Ruffed Grouse										+		
Willow Ptarmigan		0.5		v								v
Rock Ptarmigan		0.7										
White-tailed Ptarmigan	+											
American Golden Plover	v											
Greater Yellowlegs											+	
Common Snipe			v	v							0.5	1.0
Baird's Sandpiper	0.8	v										
Long-tailed Jaeger		v										
Short-eared Owl		v		v								
Common Flicker									v			
Hairy Woodpecker						1.0			1.0			
Downy Woodpecker						0.5						
N. Three-toed Woodpecker								v	0.3	1.0	v	v
Alder Flycatcher						1.0						
Olive-sided Flycatcher									v	v		
Horned Lark	0.3	v										
Tree Swallow			v	v		v						
Gray Jay					1.0		v	0.5	0.5	1.0	+	v
Black-billed Magpie					v							
Common Raven												v
Black-capped Chickadee						1.8	v	v	v			
Boreal Chickadee							v	1.7	1.0	v	v	1.0
Brown Creeper						2.0			1.0			
American Robin					0.5		v			v	0.5	0.5
Varied Thrush					1.5	10.0	3.5	2.5	3.3	2.9	v	v
Hermit Thrush					2.2	v	6.1	3.8	v			
Swainson's Thrush						6.9	5.5	5.4	8.0	3.0	v	v
Gray-cheeked Thrush						3.8	v	v			3.9	2.5
Arctic Warbler			4.8	3.6							2.8	
Ruby-crowned Kinglet						v	v	3.3	1.0	4.2	0.8	4.0
Water Pipit	0.5											
Bohemian Waxwing												v
Orange-crowned Warbler											v	
Yellow-rumped Warbler					+	7.0	9.8	7.5	9.5	1.0	0.8	2.5
Blackpoll Warbler			v			4.4	3.9	1.8	0.5		2.0	1.5
Northern Waterthrush						6.1	+	2.5	v			
Wilson's Warbler			8.8	9.2	1.2	4.0	3.8	4.0			9.4	
Rusty Blackbird												v
Common Redpoll		v	v	1.5	v	2.5	2.0	2.0	3.0	v	0.5	1.0
Pine Siskin							v			v		
White-winged Crossbill					v	v		v	v	v	v	v
Savannah Sparrow	1.0	5.8	3.0	12.3						v	2.5	0.8
Dark-eyed Junco					2.8	1.8	2.5	3.9	4.5	2.5	2.0	2.0
Tree Sparrow		2.5	11.8	15.0	1.5						7.9	2.6
White-crowned Sparrow		0.3	4.1	3.8	+	3.5					6.5	2.5
Fox Sparrow				v	1.6	4.6	1.0	1.9	v		3.5	2.9
Lincoln's Sparrow				v								
Lapland Longspur	1.0	0.8										
Snow Bunting	0.2											

Generally, in the upper Susitna River Basin, the forest and woodland habitats supported higher densities and/or biomasses of birds than the shrub communities. Highest densities in forests were found at the downstream (Sherman) Cottonwood Forest plot, which supported 60.9 bird territories/10 ha, and lowest densities were found in the White Spruce Forest plot at the mouth of Kosina Creek (15.7 territories/10 ha). Of the shrub habitats, Low-Medium Willow Shrub had the highest densities (45.4 territories/10 ha) and Dwarf Shrub-Alpine Tundra the lowest (11 territories/10 ha). Bird density was also low in Tall Alder Shrub (12.5 territories/10 ha). Alpine tundra areas of upland cliffs and block-fields and of mat and cushion tundra had the lowest bird usage, but supported some bird species generally not found in other habitats, e.g., White-tailed Ptarmigan, Horned Lark, Wheatear, Water Pipit, Gray-crowned Rosy Finch, and Snow Bunting.

Preliminary comparisons between occupancy levels in habitats of the upper Susitna River Basin and those in similar habitats in the upper Tanana River Valley (Spindler and Kessel 1980) show many parallels. In both regions Paper Birch Forest and the Mixed Deciduous-Coniferous Forest supported intermediate levels of bird populations and Coniferous Forest the lowest. The Scattered Woodland and Dwarf Forest habitats, with their openness and added shrub components, also supported intermediate occupancy levels, however, even with major coniferous components. The lower-height shrub thickets had low numbers of species, apparently because of relatively simple habitat structure, and there were differences in occupancy levels between plots with a dry substrate and ones with high substrate moisture. Habitat diversity and a wet substrate probably allowed higher occupancy levels on the Susitna Low-Medium Willow Shrub plot compared to other shrub plots.

The most conspicuous difference between the upper Susitna and Tanana valleys was in the Tall Shrub Thickets. Tall shrubs in interior Alaska supported the highest avian occupancy levels of any habitat (Spindler and Kessel 1980), but, unlike in the Susitna study area, these thickets were dominated by willow, thinleaf alder (Alnus tenuifolia), and balsam poplar (Populus balsamifera), which have average to above average levels of primary productivity. The tall shrub thickets of the Susitna study area were composed almost entirely of Alnus crispa, which has relatively low levels of primary productivity (Spindler and Kessel 1980) and which, in interior Alaska and on the Seward Peninsula, also supports relatively few birds (Kessel, pers. obs.).

3.4 - Waterbird Use of Wetlands

(a) Summer Populations

The wetlands of the region supported relatively few waterbirds during the summer, both in respect to number of species and number of individuals. The relative abundance of loons, grebes, and waterfowl as determined from all observations is shown in Table 4. The number and density of adults and broods of waterbirds observed during the intensive ground surveys of 28 ponds and lakes during July 1981 are shown in Table 10.

The density of adult birds derived from the intensive ground survey of 20.5 km^2 of wetlands was 23.8 adults/km^2. By comparison, a similar census of 13 of the more productive waterbodies of the upper Tanana River Valley, east-central Alaska, in 1977 and 1979 showed, respectively, 183.3 and 110.9 adults/km^2 of wetlands (Spindler et al. 1981)*. The number of broods was correspondingly low, with 2.9 broods/km^2 of wetlands in the upper Susitna River Basin in 1981,

*Regional comparisons of densities obtained by the waterbody census method can only be made if the distribution of waterbody size classes is similar between regions (Spindler et al. 1981), which was the case for the sets of sampled waterbodies used here.

TABLE 10

NUMBER OF ADULT WATERBIRDS (OR INDEPENDENT YOUNG) AND BROODS FOUND ON 28 WATERBODIES (TOTAL = 20.5 KM^2 OF WETLANDS), UPPER SUSITNA RIVER BASIN, ALASKA, JULY 1981. ARRANGED IN DECREASING ORDER OF ADULT NUMBERS.

Species	No. adults	No. broods
White-winged Scoter	81 (incl. flock 65)	0
Arctic Tern	48	0
Oldsquaw	47	11
Mew Gull	43	7
Lesser Scaup	36	4
scaup sp.	9	1
Surf Scoter	33	2
Black Scoter	26	11
scoter sp.	6	1
Greater Scaup	25	0
Northern Phalarope	23	0
Common Loon	22	3
Trumpeter Swan	16	1
Mallard	10	1
Red-throated Loon	8	0
American Wigeon	8	6
Red-necked Grebe	7	1
Pintail	7	2
Northern Shoveler	7	1
Goldeneye sp.	6	1 (= Common)
Horned Grebe	5	5
Bonaparte's Gull	5	0
Bald Eagle	3	0
Arctic Loon	2	0
Green-winged Teal	2	1
Red-breasted Merganser	1	1
Merganser sp.	1	0
TOTAL	487	60
No./km^2	23.8	2.9

compared to an average of 6.2 broods/km^2 in the upper Tanana River Valley (ibid.). Productivity in the eastern portion of the upper Tanana River Valley study area in 1979 was 30-40% lower than historically at Minto Lakes and the Yukon Flats (Kessel et al. 1980). Minto Lakes, Tetlin Lakes, and portions of the Yukon Flats are considered among the most productive wetlands in Alaska (J. G. King, U. S. Fish and Wildlife Service, pers. comm.). Thus, the waterbodies of the upper Susitna River Basin appear to support a relatively impoverished population of waterfowl during the summer.

The species composition of waterfowl in the region showed some differences from that of central Alaska as a whole, in part reflecting the subalpine nature of much of the study area. Oldsquaw and Black Scoter were the most productive of the waterfowl in 1981 (Table 10). Both species are primarily tundra nesters, and the Alaska Range is the only inland nesting location known for the Black Scoter in Alaska (Gabrielson and Lincoln 1959). On the other hand, the Pintail, which is one of the most numerous ducks in central Alaska, occurred in relatively small numbers in the study area, in spite of the fact that both 1980 and 1981 were high population years for Pintails in Alaska, due to severe drought in the Canadian prairie provinces (King and Conant 1980, Conant and King 1981).

Trumpeter Swans bred commonly at the eastern end of the study area, from the vicinity of the Oshetna River at least to the MacLaren River. On a random flight over the ponds of this area on 4 August 1981, we had 19 observations of Trumpeter Swans. We counted 40 adult birds, including 9 pairs with broods, totaling 28 cygnets. This area is the western edge of the Gulkana Basin Trumpeter Swan population, which has more than doubled during the past five years (King and Conant 1981).

(b) Populations During Migration

Summaries of the numbers and species composition of loons, grebes, and waterfowl enumerated during aerial surveys in fall 1980 and 1981 and spring 1981 are given in Tables 11-13, and relative abundance rankings for species in fall and spring are given in Table 4. Based on these data, the upper Susitna River Basin, which is on a high plateau between the Alaska Range and the Talkeetna Mountains, does not appear to be a major migration route for waterbirds (contra U. S. Corps of Engineers 1977).

Scaup, including both Lesser and Greater scaup, were the most numerous species group during both spring and fall. Relatively large numbers of Mallards and American Wigeon also moved through during both seasons (although we missed peak wigeon numbers in fall 1981 surveys). Pintails were common during spring migration but uncommon in fall. Few geese or cranes were seen at either season.

The upper Susitna River Basin was less important to migratory waterfowl in spring than fall. The difference was probably due largely to the time of ice breakup, which occurred after the main spring migratory movement of many species, especially the dabbling ducks and Common Goldeneye. Early migrants used the Susitna River itself and the thawed edges of lakes. Use of the region's waterbodies increased toward the end of May, concurrent with the availability of more open water and the influx of the later-arriving loons, grebes, scaup, Oldsquaw, scoters, and mergansers. The relatively high Importance Values (see below) of the large lakes of the region in spring reflect their use after thaw by these later-arriving species.

The pattern of fall movement in the region was similar to that known for the rest of central Alaska. That is, peak numbers of American Wigeon, Pintail, and Green-winged Teal occurred during the first half of

TABLE 11

SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, FALL 1980

	DATE OF SURVEY						
Species	7 Sept	11 Sept	16 Sept	20 Sept	26 Sept	3 Oct	TOTAL
Loon spp.				4	1		5
Common Loon		3	2	3			8
Red-necked Grebe	2	3	4		5	3	17
Horned Grebe	1	4	17	9	2	2	35
Swan spp.		34	29	9	12	20	104
Canada Goose				1	20		21
American Wigeon		155	325	97	88	56	721
Green-winged Teal		30	83	9	1	2	125
Mallard	10	64	14	116	110	124	438
Pintail	60	60	53	21	3	4	201
Blue-winged Teal		1					1
Northern Shoveler		8	20				28
Ring-necked Duck			2	12			14
Scaup spp.	165	347	499	370	293	180	1854
Oldsquaw	7	4	13	13	16	4	57
Black Scoter		8	38	25	24	10	105
Scoter spp.*				6	56	72	134
Surf Scoter		5	4	2			11
White-winged Scoter	10			1	6	1	18
Bufflehead		33	40	95	127	101	396
Goldeneye spp.	15	36	68	124	95	133	471
Merganser spp.		8	30	36	68	19	161
TOTAL BIRDS	270	803	1241	953	927	731	4925
Total wetland area surveyed (km^2)	13.11	22.08	25.76	27.53	29.00	24.25	
Density (birds/km^2 of wetlands)	20.6	36.4	48.2	34.6	32.0	30.1	

* Surf or White-winged scoter

TABLE 12

SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, FALL 1981

	DATE OF SURVEY					
Species	15-16 Sept	26 Sept	26 Sept-9 Oct	12-19 Oct	20-23 Oct	TOTAL
Common Loon	2	3	3	1		9
Arctic Loon						
Red-throated Loon						
Loon spp.						
Red-necked Grebe	12	3	1			16
Horned Grebe						
Whistling Swan		18	24			42
Trumpeter Swan	6		10	14		30
Swan spp.		41	25	22	13	101
Canada Goose				50		50
Mallard	41	153	131	142		467
Pintail	32					32
Green-winged Teal	13	3				16
Northern Shoveler						
American Wigeon	133		14	5		152
Canvasback						
Redhead						
Scaup, Greater and Lesser	479	166	51	90		786
Goldeneye, Common and Barrow's	18	125	68	36		247
Bufflehead	17	20	29	52		118
Oldsquaw	15	31	7	1		54
White-winged Scoter			69	13		82
Surf Scoter				29		29
Black Scoter	1	6	2	1		10
Scoter spp.	69		1	92		162
Common Merganser			1	2		3
Red-breasted Merganser						
Merganser spp.	77	38		18		133
TOTAL BIRDS	915	607	436	568	13	2539
Total wetland area surveyed (km^2)	25.68	25.68	21.31	11.57	6.62	
Km^2 of 100% frozen waterbodies surveyed*	0	1.41	3.91	3.76**	2.00	
Density (birds/km^2 of wetlands)	35.6	23.6	20.5	49.1	1.96	

* Other waterbodies had at least some open water.

** An additional 9.22 km^2 of 100% frozen waterbodies were not surveyed in mid-October because they were known to be frozen. By late October only Stephan and Murder lakes still had some open water.

TABLE 13

SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, SPRING 1981

	DATE OF SURVEY			
Species	3 May	10 May	26 May	TOTAL
Common Loon			4	4
Arctic Loon			5	5
Red-throated Loon			2	2
Loon spp.		3	4	7
Red-necked Grebe			4	4
Horned Grebe		1	1	2
Whistling Swan				
Trumpeter Swan	2		6	8
Swan spp.		11	10	21
Canada Goose				
Mallard	97	78	121	296
Pintail	71	70	116	257
Green-winged Teal	67	47	38	152
Northern Shoveler		12	28	40
American Wigeon	5	94	99	198
Canvasback		1		1
Redhead			28	28
Scaup, Greater and Lesser		103	513	616
Goldeneye, Common and Barrow's		51	38	89
Bufflehead		2	10	12
Oldsquaw		2	84	86
White-winged Scoter			16	16
Surf Scoter		4	35	39
Black Scoter		1	42	43
Scoter spp.		12	74	86
Common Merganser			7	7
Red-breasted Merganser			2	2
Merganser spp.			25	25
TOTAL BIRDS	242	492	1312	2046
Total wetland area surveyed (km^2)	25.68	25.68	25.68	
Km^2 of 100% frozen waterbodies surveyed*	14.31	1.97	0	
Density (birds/km^2 of wetlands)	9.4	19.2	51.1	

* Other waterbodies had at least some open water.

September; of loons, grebes, and scaup during the second and third weeks of September; of Oldsquaw and mergansers during the last half of September; and of Mallards, scoters, Buffleheads, and goldeneyes from the last third of September to mid-October. Swan migration, which included both Trumpeter and Whistling swans, occurred between the last week of September and the end of October.

(c) Relative Importance of Waterbodies

Use by birds of the various waterbodies* of the region differed considerably. Waterbodies included among the six highest Importance Value (I.V.) ratings (see Section 2.8) for at least one season are listed with seasonal population statistics in Table 14.

Of these more important waterbodies, WB 106 and 107, Stephan and Murder lakes, respectively, were among the top three in Importance Values for all seasons. Stephan Lake received twice the use in fall as in spring, but both waterbodies consistently had relatively high levels of species richness, while large Stephan Lake had high numbers of birds and smaller Murder Lake, high densities. These lakes assumed additional importance in early spring and late fall because of ice conditions. Murder Lake, which reportedly has some open water all winter, provided some of the first open water for early spring migrants, as did the inlet of Stephan Lake; Green-winged Teal, Mallard, and Pintail were using this open water on 3 May 1981. Likewise, these lakes provided the last open water in fall and were used by the late migrants. Swans used these lakes during October as other lakes in the region became ice-covered. Between 9 and 11 Trumpeter Swans frequented Murder Lake between 10 and 18 October 1981 (J. Ireland, pers. comm.), 11-22 unidentified swans were on Stephan Lake from 9 to 23 October 1981, and 120 swans were there on 10 October 1980.

*See Figure 1 for location of specific waterbodies.

TABLE 14

SEASONAL POPULATION STATISTICS FOR THE MORE IMPORTANT OF SURVEYED WATERBODIES OF THE UPPER SUSITNA RIVER BASIN, 1980-81. INCLUDED ARE WATERBODIES THAT WERE AMONG THE SIX HIGHEST IMPORTANCE VALUE RATINGS IN AT LEAST ONE SEASON.

		Fall 1980**			Fall 1981**			Spring 1981++			Summer 1981			
Waterbody	Size (km^2)	Mean no. birds	Mean density (no./km^2)	Mean no. species	Mean no. birds	Mean density (no./km^2)	Mean no. species	Mean no. birds	Mean density (no./km^2)	Mean no. species	No. adults	Density of adults	No. species	No. broods
WB 107 (Murder Lake)	0.15	39.0	260.0	4.3	38.0	253.3	3.0	51.3	342.2	5.0	23	153.3	5	1
WB 106 (Stephan Lake)	3.55	156.0	43.9	9.5	168.5	47.5	5.0	99.7	28.1	7.3	87	24.5	9	2
WB 140	0.90	53.5	59.4	5.0	30.5	33.9	2.5	48.3+	53.7+	3.7+	75	83.3	11	4
WB 131	1.04	212.8	204.6	6.5	123.0	118.3	5.0	54.7+	52.6+	3.7+	--	--	--	--
WB 145 Clarence L.	1.60	103.8	64.8	7.0	42.5	26.6	4.5	58.7	36.7	7.0	35	21.9	8	6
WB 059	1.44	72.8	50.5	6.5	55.0	38.2	3.0	21.3	14.8	4.7	54	37.5	11	5
WB 148 (Watana Lake)	1.25	95.8	76.6	3.8	34.5	27.6	2.0	21.3+	17.1+	3.0+	8	6.4	3	0
WB 067 (Pistol Lake)	0.76	19.0*	17.9*	4.0*	4.0+	5.3	1.5+	85.0	111.8	6.0	15	19.7	8	5
WB 032	0.07	--	--	--	--	--	--	--	--	--	8	114.3	4	6
WB 150 (Swimming Bear Lake)	0.57	--	--	--	11.5	20.2	0.5	4.7+	8.2+	0.7+	33	57.9	5	4

* Combines WB 064-067

** 11, 16, 20, and 26 September 1980; 15 and 26 September 1981

\+ 100% frozen on at least one survey

++ 3, 10, and 26 May 1981

-- Not surveyed

WB 131, near the mouth of the MacLaren River, was another of the most important lakes on the study area, because it consistently supported high levels of waterfowl abundance, density, and species richness. Its I.V. in spring was lessened by the fact that it was still frozen during two (3 and 10 May) of the three spring surveys. Because it was so far from the main proposed construction sites, we did not census it for breeding birds in July, but a flight over the lake on 4 August 1981 revealed a flock of some 100 molting ducks, mostly scaup, as well as a pair of Trumpeter Swans. This and WB 134 were the only duck-molting lakes we found in the basin. A flock of 22-42 Trumpeter Swans congregated to feed on this lake throughout the first half of September 1980.

WB 140, east of the Oshetna River, had the highest I.V. of the 28 waterbodies censused during the breeding season. Not only did it have a high species richness (11 species), but it also supported a large number of birds and an above average density. It was also of above average importance during migration, although it thawed late and froze early.

WB 145, Clarence Lake, had the fourth highest I.V. during spring and fall migration, but was less important during the summer. It had a relatively high species richness at all seasons, being used by both diving and dabbling ducks during migration, but primarily by divers in summer. A flock of 51 migrant Snow Geese flew west over this lake on 30 April 1981 (T. W. Hobgood, pers. comm.).

WB 148, Watana Lake, was used in fall, especially in 1980, by migrant scaup, goldeneyes, and mergansers during the last half of September. Otherwise it was of little importance to birds.

WB 067, Pistol Lake, had a relatively high I.V. in spring because of the number and diversity of birds it contained after it began to thaw toward the end of the first week of May. This relatively large lake was only of average importance during summer, however, and was little used in fall.

WB 059, the southernmost Fog Lake, supported high levels of abundance and species richness at all seasons. It received less use in spring than at other seasons, probably because of ice cover, which was still extensive as late as 17 May 1981. On this date, ducks were heavily concentrated in the open water at the inlet end of the lake. This lake and WB 140 had the highest species richness (11 species) during summer.

WB 032, a small lake at the west end of the Fog Lakes, supported a high density of birds in summer and showed high productivity (at least four broods of Horned Grebe and two of American Wigeon seen on 28 July 1981). It was not monitored during migration.

WB 150, Swimming Bear Lake, an alpine lake, received its primary use during summer. After it thawed in late May, it was occupied by at least five species of waterbirds (scaup, Oldsquaw, scoter, Mew Gull, and Arctic Tern), three of which had broods on 29 July 1981. Flocks of scaup and White-winged Scoters were seen on the lake during the last half of September 1981.

None of the waterbodies in the upper Susitna River Basin had Importance Values as high as those calculated for some of the better wetland sites of eastern interior Alaska from data obtained during fall 1980 by Ritchie and Hawkings (1981) (Fig. 3) and during spring 1980 by Ritchie (1980) (Fig. 4).

3.5 Breeding by Cliff-nesting Raptors, Ravens, and Eagles

(a) Summer Populations

In all, 43 raptor/raven nest sites were located during 1980 and 1981, 20 of which were inactive in both years. Presumably these inactive sites

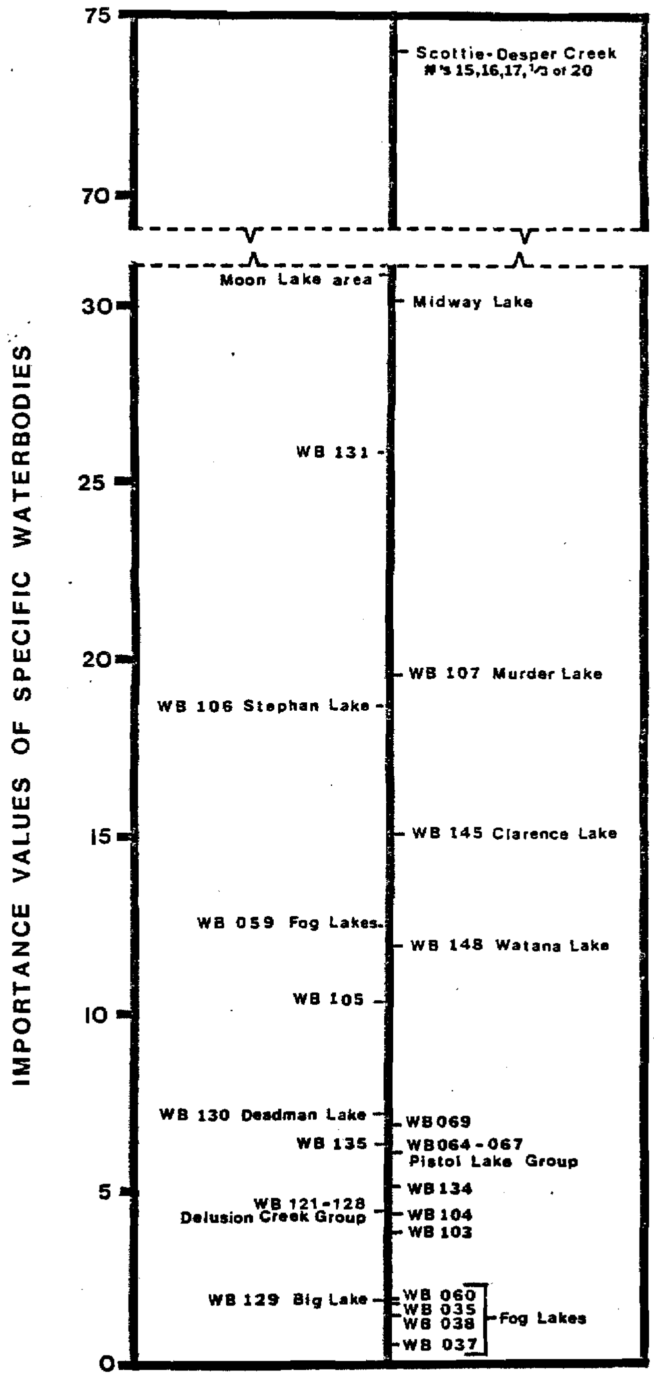

FIGURE 3

Relative importance of 20 waterbodies for migrant loons, grebes, and waterfowl in the upper Susitna River Basin, Alaska, compared to 3 waterbodies in the upper Tanana River-Scottie Creek area of eastern Alaska in fall 1980.

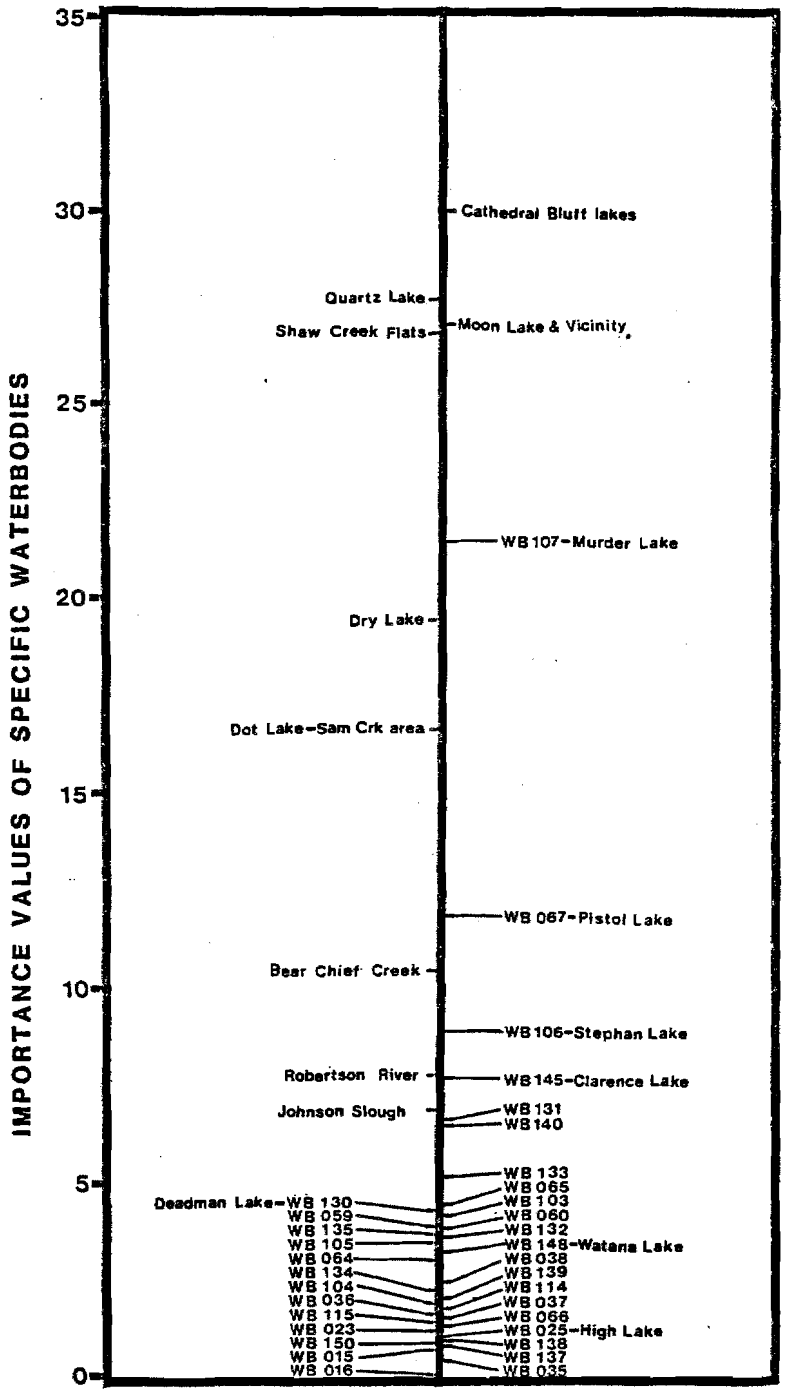

FIGURE 4

Relative importance of 34 waterbodies for migrant loons, grebes, and waterfowl in the upper Susitna River Basin, Alaska, in spring 1981 compared to 9 waterbodies in the upper Tanana River Valley of eastern Alaska in spring 1980.

function either as alternative sites or are used in years of higher population levels. Of the 23 nests that were active in at least one year, at least 5 were used both years, each by the same species (Table 15). Active sites during the two years of study included ten of Golden Eagle, six of Bald Eagle, four of Common Raven, one, perhaps two, of Gyrfalcon, and one of Goshawk.

In 1974, White (1974) found ten active nests within this same geographic area: two Gyrfalcon, one Bald Eagle, and seven Common Raven. He reported 14 inactive nests, ascribing 8 to ravens and 3 each to Golden and Bald eagles. The reason for the substantially different species composition between the two sets of surveys, i.e., more ravens and fewer eagles in 1974, is unknown.

The concentration of active Golden Eagle nests in both 1980 and 1981 (one pair per 14.8 km [9.2 miles]) was similar to that along the Dalton Highway through the Brooks Range in 1979 (one active nest per 15.7 km [9.7 miles]) (D. G. Roseneau, pers. comm.)--the Brooks Range having one of the largest populations of Golden Eagles in Alaska. A. Murie (1944), in Denali (Mt. McKinley) National Park, found active nests as close as 1.6 and 2.4 km (1-1.5 miles) to each other in 1941 and 1939, respectively. Pairs of Golden Eagles regularly build and maintain a number of simultaneous nests, which they use as alternative sites in various years (Brown and Amadon 1968), some several kilometers apart (D. G. Roseneau, pers. comm.). It has been suggested (White et al. 1977) that local populations increase during years of high hare populations, but hares were relatively scarce on the upper Susitna in 1980 and 1981. A. Murie (1944) found that ground squirrels were a major prey of Golden Eagles in Denali National Park in 1939-1941, and this species was abundant in the Susitna area during our study.

Bald Eagle densities found in the upper Susitna River drainage appear slightly lower than those of interior Alaska, where Roseneau et al. (1981)

TABLE 15

LOCATION OF ACTIVE RAPTOR AND RAVEN NEST SITES, UPPER SUSITNA RIVER BASIN, ALASKA, 1980 AND 1981, AND THEIR PROXIMITY TO POTENTIAL ADVERSE DISTURBANCE FROM CONSTRUCTION ACTIVITIES

Nest	Species	Substrate elevation m (feet)	Active 1980	Active 1981	Nest location	Potential disturbance
A	Bald Eagle	490 (1600)	X	0	8.0 km up Susitna River from the mouth of Watana Creek. On wooded island in live, 15 m white spruce.	Inundation
B	Bald Eagle	690 (2260)	X	X	4.5 km up Oshetna River from its confluence with the Susitna River. Nest 4 m from edge of west river bank in a 22 m white spruce.	--
C	Golden Eagle	750 (2450)	X	0	3.5 km upriver from V-Canyon and 0.7 km up a narrow canyon on the north side of the Susitna River. Nest 26 m up a 33 m cliff, 100 m back from and 6.7 m above unnamed creek.	--
D	Golden Eagle	700 (2300)	X	0	4.0 km up the Susitna River from the mouth of Jay Creek and in canyon on north side of the Susitna. Nest 5 m up 13 m cliff, 10 m back from and 18 m above unnamed creek.	--
E	Golden Eagle	640 (2100)	X	X	2.5 km up Jay Creek from its junction with Susitna River. Nest 5 m up 30 m cliff, 150 m from west bank and 115 m above Jay Creek.	Inundation
F	Golden Eagle	550 (1800)	X	0	1.0 km down Susitna River from the mouth of Kosina Creek. Nest 32 m up 38 m cliff on north riverbank.	Inundation
G	Golden Eagle	490 (1600)	X	0	4.0 km down Susitna River from the mouth of Watana Creek. Nest 13 m up 23 m cliff, 40 m back from and 34 m above the north bank of the river.	Inundation
H	Unknown	490 (1600)	X	0	6.8 km down Susitna River from mouth of Devil Creek and 4.0 km up a gorge on south side of the Susitna. Nest 100 m up 105 m cliff of creek canyon. Occupied by a Gyrfalcon in 1974 (White 1974).	0.5 km from road and rail-road, east end Corridor 2*
I	Golden Eagle	365 (1200)	X	X	0.5 km up Devil Creek from its mouth. Nest 30 m up 45 m vegetated cliff, 100 m back from and 120 m above Devil Creek, on west bank.	Inundation
J	Raven	520 (1700)	X	?	1.0 km up Devil Creek from its mouth. Nest near top of cliff of west bank. Could not relocate nest in 1981.	--
K	Bald Eagle	(2500)	X	X	9.0 km up Deadman Creek from its mouth. Nest on top of 15 m broken-topped cottonwood, 25 m from north side of Deadman Creek.	Approximately 50 m from Corridor 3
L	Bald Eagle	275 (900)	X	X	1.0 km up Susitna River from confluence with Indian River. Nest on top of 23 m broken-topped Cottonwood, 4 m from north river bank.	0.5 km from road and rail-road, west end Corridor 2*

TABLE 15 (Continued)

Nest	Species	Substrate elevation m (feet)	Active 1980	Active 1981	Nest location	Potential disturbance
M	Golden Eagle	305 (1000)	-	X	2.0 km up Susitna River from the mouth of Portage Creek. Nest on moderate-sized cliff on north bank, but not relocated on ground check.	--
N	Bald Eagle	580 (1900)	-	X	On south shore of WB 105, 1.0 km east of NE end of Stephan Lake. Nest on top of 13 m broken-topped cottonwood.	On alternate b of road and railroad, east end Corridor 2
O	Raven	470 (1550)	-	X	2.0 km up Fog Creek from mouth. Nest 9 m up 23 m cliff on west bank, 17 m back from and 23 m above creek.	0.7 km from alternate b of road and railroad, east end Corridor 2
P	Raven	550 (1800)	-	X	5.0 km up Tsusena Creek from mouth. Nest on cliff on east bank of creek.	0.5 km from road, east end Corridor 1
Q	Raven	625 (2050)	-	X	1.0 km up Deadman Creek from mouth. Nest 13 m up 32 m cliff on east bank of creek.	Inundation
R	Golden Eagle	975 (3200)	-	X	8.0 km down Susitna River from the mouth of Kosina Creek. Nest 7 m up 12 m cliff on tor above south bank of river.	--
S	Bald Eagle	540 (1775)	0	X	2.0 km up Susitna River from the mouth of Kosina Creek. Nest 25 m up 33 m cliff on north bank of river.	Inundation
T	Golden Eagle	685 (2250)	0	X	4.0 km up Susitna River from the mouth of Jay Creek, in canyon on north side of river. Nest 1 m up 5 m vegetated cliff, 14 m back from and 33 m above unnamed creek.	Inundation
U	Gyrfalcon	715 (2350)	-	X	At V-Canyon. Nest 100 m up 113 m cliff at south bank of Susitna River.	--
V	Golden Eagle	750 (2450)	0	X	3.5 km up Susitna River from V-Canyon and 0.7 km up narrow canyon on north side of Susitna River. Nest 8 m up 12 m cliff, 81 m back from and 67 m above unnamed creek.	--
OO	Goshawk	550 (1800)	-	X	2.0 km southeast of Devil Canyon Dam site.	100 m from road and 200 m from railroad, east end of Corridor 2

0 = inactive
- = site not located in 1980
* = east and west ends of Corridor 2 divided at Devil Canyon dam site

reported 44 nests, 25 active in 1980, in the vicinity of the Alaska Highway and Tanana River between Fairbanks and the U. S.-Canada border, a distance of approximately 480 km (300 miles).

Compared to eagles, Gyrfalcons are uncommon in central Alaska, but they nest throughout the Alaska Range. Cade (1960) estimated the total Alaska population at about 200-300 pairs, whereas Roseneau et al. (1981) thought there were more, but fewer than 500 pairs. Numbers in a given area may vary considerably between years (Cade 1960, Roseneau 1972), but probably not over large geographic regions (Roseneau 1972). Gyrfalcons in northern and western Alaska have low site fidelity from year to year (Cade 1960, Roseneau 1972), but in the Alaska Range most sites are used every year (Bente 1981).

There were no confirmed sightings of Peregrine Falcons in the region during our study, in spite of the many hours spent in ornithological field work and in raptor habitat. White (1974), however, saw two individual Peregrines during his 10-15 June 1974 survey, but found no sign of nesting. One bird was a "single adult male...roosting on a cliff about 4 miles upriver from the Devil Canyon Dam axis," and the other was "a sub-adult...about 15 miles upriver from the Devil Canyon Dam axis." White (ibid.) stated that the Yentna-Chulitna-Susitna-Matanuska drainage basin "seemingly represents an hiatus in the breeding range of breeding peregrines...," and Roseneau et al. (1981) stated that "The Susitna and Copper rivers both provide...[very few]...potential nesting areas for Peregrines."

A single observation of an Osprey was reported during the two seasons of study, a bird seen on 23 May 1981 by J. Ireland at Murder Lake (pers. comm.).

(b) Breeding Chronologies

No special effort was made to obtain data on the breeding biology of raptors and ravens on the Susitna study area. Because the breeding season is a period when most birds are relatively sensitive to disturbance, however, we show in Table 16 the breeding chronologies of eagles, Gyrfalcon, and Common Raven in interior Alaska.

(c) Potential Disturbance Factors

The general types of impacts on raptors that can result from development activities have been well-described by Roseneau et al. (1981), and Tables 17-19, which summarize disturbance factors, are taken from their report.

Inundation is an additional potential impact from hydroelectric projects. In the upper Susitna River Basin, the total length of good potential raptor cliffs (type "A") that would be inundated by the proposed reservoirs is 42.5 km (26.4 miles) (Table 20). Almost all "A" quality habitat in the Watana reservoir will be inundated, but only about half of that in the Devil Canyon reservoir. Currently, however, the number of raptor nests (active and inactive) is considerably greater in the proposed Watana reservoir area than in that for Devil Canyon dam (Table 21), with densities of 0.6 nest sites/km and 0.1/km, respectively. For some reason, in spite of cliffs with good structural characteristics, Devil Canyon is little used for raptor nesting. Possibly the deep, narrow canyon, with its often strong and buffeting winds, makes this area undesirable for raptors.

3.6 - Avifauna/Habitat Relationships

A general overview of bird habitat preferences in the upper Susitna River Basin can be obtained by examining the density of territories of

TABLE 16

BREEDING CHRONOLOGIES OF EAGLES, GYRFALCON, AND COMMON RAVEN IN INTERIOR ALASKA

		DATES OF PHASES OF BREEDING CYCLE				
Species	Status+	Arrival/courtship	Egg-laying	Incubation	Nestlings	Fledging/dispersal
Golden Eagle*	M	5 Mar-30 Apr	1 Apr-10 May	15 Apr-20 June	1 June-1 Sept	1 Aug-25 Sept
Bald Eagle*	M/R	10 Mar-1 May	20 Mar-10 May	31 Apr-30 June	20 May-15 Sept	1 Aug-30 Sept
Gyrfalcon*	R	1 Mar-10 Apr	1 Apr-20 May	5 Apr-25 June	15 May-15 Aug	10 July-30 Sept
Raven**	R	1 Mar-15 Apr	1 Apr-5 May	5 Apr-25 May	25 Apr-25 June	25 May-15 July

\+ M = migrant, R = resident

* Data summarized from Roseneau et al. (1981)

** Based on calculations from Kessel (unpubl. data) and Brown (1974)

TABLE 17

GENERAL TYPES OF IMPACTS TO RAPTORS (FROM ROSENEAU ET AL. 1981)

Disturbance

Construction and Operation Activities

- sudden loud noises (e.g., blasting, gas venting, etc.) can lead to panic flights and damage to nest contents
- noise, human presence, etc. can lead to disruption of daily activities

Aircraft Passage

- sudden appearance and noise can lead to panic flights and damage to nest contents

Human Presence Near Nests

- inadvertent - chance occurrence of people (and dogs) near nests; people may be unaware of nest, raptors, or raptor alarm behavior

- deliberate - curious passersby, naturalists, photographers, researchers can have impacts if safeguards are not taken

Direct Impacts

Intentionally Destructive Acts (as a result of increased public access)

- shooting
- legal or illegal removal of eggs, young, or adults
- rolling of rocks off cliff tops
- cutting of nest trees

Man-made Structures and Obstructions

- raptors may be struck on roads where they may perch or feed
- may strike wires, fences, etc.
- may be electrocuted on power poles
- raptors sometimes attack aircraft, or may accidentally strike aircraft

Environmental Contaminants

- deliberate application and accidental release of insecticides, herbicides, petrochemicals, and toxic industrial materials can affect raptors and prey by affecting hormones, enzymes, shell thickness, bird behavior, egg fertility and viability, and survival rates of nestlings, fledglings, immatures and adults

Changes in Prey Availability

- decrease in prey abundance or loss of nearby hunting areas may affect territory size, efficiency of hunting, nest occupancy, nesting success, condition of adults and young

- changes may result from aircraft overflights, construction and maintenance activities, public access, etc.

Habitat Loss

Abandonment of area due to destruction of nest, perch or important hunting habitat

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TABLE 18

FACTORS THAT AFFECT THE SENSITIVITY OF RAPTORS TO DISTURBANCES (FROM ROSENEAU ET AL. 1981)

<u>Characteristics of the disturbance</u>

- type of disturbance
- severity (speed, loudness, suddenness, persistence, etc.)
- frequency of occurrence

<u>Characteristics of the bird</u>

- the individual (individual differences in response)
- sex
- age
- 'mood' (a factor of recent activities, weather)
- territorial status (breeder, territorial non-breeder, or non-territorial floater)
- stage of annual life cycle (winter, migration, courtship, egg-laying, rearing young, etc.)
- occurrence of other disturbances or natural stresses at the same time
- previous experience with this type of disturbance (habituation may occur)

<u>Topography</u>

- nearness of disturbance to raptor or nest
- relative elevations (is nest or raptor above or below the disturbance? by what distance?)
- presence of screening features (trees, intervening hill)
- direction faced by nest relative to sun, wind, disturbance
- type of nest (exposed ledge, overhung ledge, cave)
- distance of nest above foot of cliff and below lip of cliff (i.e., 'security' of nest)

<u>Time of day</u>

<u>Weather at time of disturbance</u>

<u>Potential predators nearby</u>

<u>Type of prey utilized by the bird</u> (species, location, abundance)

TABLE 19

INFLUENCE OF TIMING OF DISTURBANCE ON THE POSSIBLE EFFECTS ON RAPTORS (FROM ROSENEAU ET AL. 1981)

Timing	Possible effects of disturbance
Winter	Raptor may abandon nest, roosting cliff, or hunting area (e.g., Gyrfalcon)
Arrival and courtship	Migrant raptor may be forced to use alternative nest site (if available), may remain but refuse to breed or may abandon nest site
Egg-laying	Partial clutch may be abandoned and remainder (or full clutch) laid at alternative nest; breeding effort may cease or site may be abandoned
Incubation	Eggs may be chilled, overheated, or preyed upon if parents are kept off nest too long; sudden flushing from nest may destroy eggs; male may cease incubating; clutch or site may be abandoned
Nestling phase	Chilling, overheating, or predation of young may occur if adults are kept off nest; sudden flushing of parent may injure or kill nestlings; malnutrition and death may result from missed feedings; premature flying of nestlings from nest may cause injury or death; adults may abandon nest or site
Fledgling phase	Missed feedings may result in malnutrition or death; fledglings may become lost if disturbed in high winds; increased chance of injury due to extra moving about; parents may abandon brood or site
Night	Panic flight may occur and birds may become lost or suffer injury or death
General	Undue expense of energy; increased risk of injury to alarmed or defending birds; missed hunting opportunities

TABLE 20

LINEAR DISTANCES OF CLIFFS IN VICINITY OF PROPOSED IMPOUNDMENTS, AND DISTANCES THAT WOULD BE INUNDATED, SUSITNA HYDROELECTRIC PROJECT

	Type of cliff	Length inundated (km)	Length above waterline (km)
Devil Canyon Reservoir			
	A	27.4	24.9
	B	8.3	7.9
	C	2.4	1.6
Watana Reservoir			
	A	15.1	0.9
	B	5.1	0
	C	1.6	0.3

TABLE 21

NUMBER OF KNOWN RAPTOR OR RAVEN NEST SITES IN UPPER SUSITNA RIVER BASIN, ALASKA, THAT WOULD BE INUNDATED BY DEVIL CANYON AND WATANA RESERVOIRS

Species	Total no. active nests	Total no. inactive nests	Active nests that would be flooded		Inactive nests that would be flooded		Total flooded nests
			Devil Canyon	Watana	Devil Canyon	Watana	
Golden Eagle	10	9	1	4	2	3	10
Bald Eagle	6	1	0	2	0	1	3
Gyrfalcon	1	0	0	0	0	0	0
Goshawk	1	0	0	0	0	0	0
Common Raven	4	7	1	0	1	2	4
Unknown	1	3	0	0	0	0	0
TOTALS	23	20	2	6	3	6	17

various species in the habitats represented by the bird census plots (Table 9), the assumption being that species occur in greatest densities in their preferred habitats. Similarily, some information on habitat preferences was obtained from our general surveys, in which we recorded the number of individuals of each species seen per kilometer in various habitats (data not shown).

Following, based on data from the bird censuses and the general bird surveys, is a list of the four or five most abundant species found during the summer in each of the major avian habitats of the upper Susitna River Basin:

(a) Lacustrine Waters and Shorelines: Arctic Tern, Mew Gull, Lesser and Greater scaup, Common Loon.

(b) Fluviatile Waters, shorelines, and alluvia: Spotted Sandpiper, Mew Gull, Violet-green Swallow, and Harlequin Duck.

(c) Upland Cliffs and Block-fields: Gray-crowned Rosy Finch, Common Redpoll, Horned Lark, American Golden Plover, Water Pipit.

(d) Dwarf Shrub Mat: Water Pipit, American Golden Plover, Horned Lark, Lapland Longspur, Rock Ptarmigan.

(e) Low Shrub: Savannah Sparrow, Tree Sparrow, Lapland Longspur, White-crowned Sparrow.

(f) Medium Shrub: Tree Sparrow, White-crowned Sparrow, Savannah Sparrow, Arctic Warbler, Wilson's Warbler.

(g) Tall Shrub: Hermit Thrush, Wilson's Warbler, Fox Sparrow, White-crowned Sparrow, Tree Sparrow.

(h) Scattered Woodland and Dwarf Forest: White-crowned Sparrow, American Robin, Bohemian Waxwing, Tree Sparrow, Ruby-crowned Kinglet.

(i) Mixed Deciduous-Coniferous Forest: Hermit Thrush, Dark-eyed Junco, Yellow-rumped Warbler, Swainson's Thrush, Varied Thrush.

(j) Deciduous Forest: Yellow-rumped Warbler, Common Redpoll, Swainson's Thrush, Blackpoll Warbler.

(k) Coniferous Forest: Ruby-crowned Kinglet, Varied Thrush, Dark-eyed Junco, Yellow-rumped Warbler, Swainson's Thrush.

A more detailed examination of species-specific habitat selection during the breeding season, based on the more than 60 habitat variables measured on the 588 subplots (Table 1), is still incomplete because of time constraints. A principal component analysis was performed, however, using 31 structural habitat variables that were present across the full range of the 12 bird census plots, i.e., from tundra through forests. This procedure provided statistically uncorrelated axes (principal components), each representing a combination of habitat characteristics, along which to ordinate each bird census plot (using mean factor scores from each plot's 49 subplots) (not shown) and to ordinate the habitat data for individual bird species (using mean factor scores from subplots on which the species was recorded at least once during the eight 1981 censuses) (Fig. 5).

An examination of how each habitat variable "loaded" onto each of the first four principal components allowed an interpretation of the meaning of these axes. PC I corresponded to a gradient of openness, ranging from open treeless to heavy-canopied habitats, a primarily deciduous component; it accounted for 33.8% of the total variation (information)

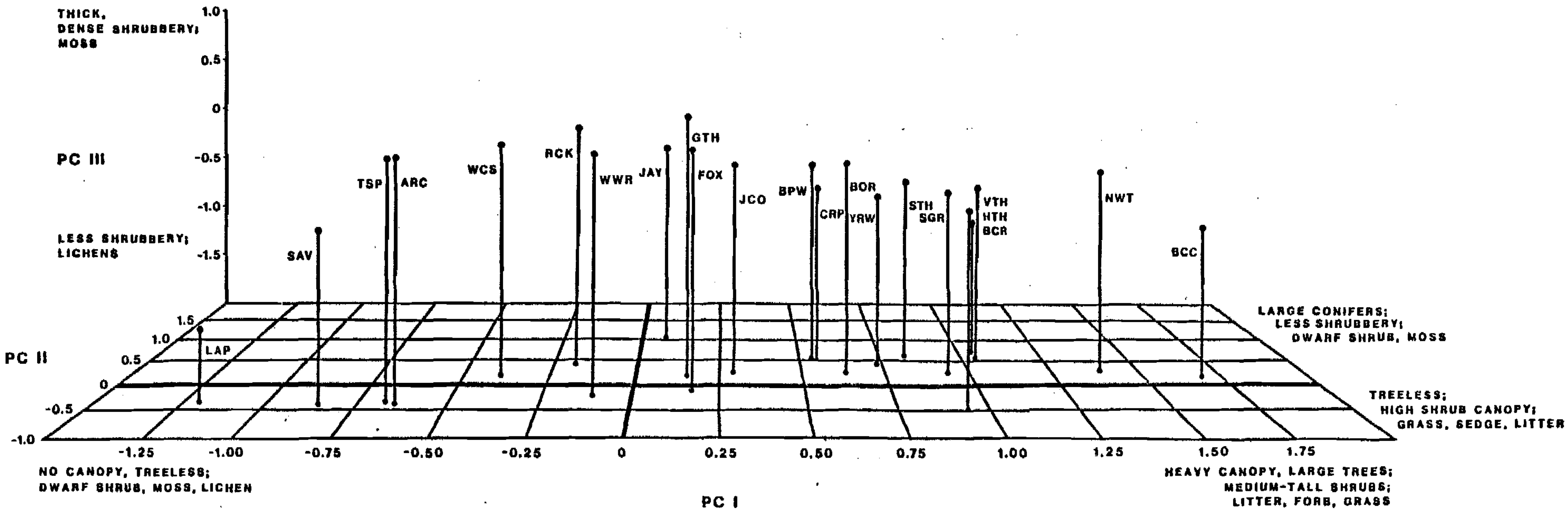

FIGURE 5

Habitat ordination of 22 bird species in the upper Susitna River Basin, Alaska, based on a three-dimensional plot of mean factor scores from subplots on which the species occurred at least once during 1981 censuses (LAP = Lapland Longspur, SAV = Savannah Sparrow, TSP = Tree Sparrow, ARC = Arctic Warbler, WCS = White-crowned Sparrow, RCK = Ruby-crowned Kinglet, WWR = Wilson's Warbler, JAY = Gray Jay, GTH = Gray-cheeked Thrush, FOX = Fox Sparrow, JCO = Dark-eyed Junco, BPW = Blackpoll Warbler, CRP = Common Redpoll, BOR = Boreal Chickadee, YRW = Yellow-rumped Warbler, STH = Swainson's Thrush, SGR = Spruce Grouse, HTH = Hermit Thrush, BCR = Brown Creeper, VTH = Varied Thrush, NWT = Northern Waterthrush, BCC = Black-capped Chickadee).

in the data set. PC II, which accounted for 10.6% of the variation, linearly combined two relatively independent habitat gradients, one ranging from treelessness to woodlands and forests with conifers, and the other from high deciduous shrub canopy (tall and medium shrubs, primarily alder) to less shrubbiness. PC III corresponded to thickness and density of shrub cover and accounted for 8.8% of the variation. PC IV represented a substrate moisture gradient, ranging from bare soil and lichens to low shrubs with a ground cover of forbs, grasses, sedges, and water, and accounted for 7.0% of the variation. In all, 60.2% of the variation in the data set was accounted for by these four principal components.

The ordination of the habitat data for 22 bird species along the first three principal components is shown in Figure 5. The height of each vertical bar represents the factor score along PC III, whereas the dot at the bottom of the bar shows the species' ordination relative to PC I and II. Although this ordination presents some problems of interpretation that have yet to be addressed, the species on the left end (-) of PC I were selecting treeless habitats with varying amounts of shrubbery; those on the right (+), forest habitats; and those in the middle, either open forests (Ruby-crowned Kinglet and Gray Jay) or medium-tall shrubbery that may or may not have a forest overstory. The Northern Waterthrush is in an anomalous position along this axis, reflecting the phytogeography of the region. Generally, the species favors tall shrub thickets near water (Kessel, pers. obs.). This habitat occurred almost entirely along the major rivers at the lower elevations of the Susitna River Basin, at the same sites where the major forests were found. Six of the nine Northern Waterthrush territories found in 1981 were on the Cottonwood Forest plot and 2.5 were on the Mixed I plot, both adjacent to fluviatile waters. Thus, habitat data from the subplots on which Northern Waterthrushes occurred manifest this riverine association in the region of tall shrub and forest habitats.

Interpretation of species' habitat ordinations along PC II is more difficult, because the two trends of habitat characteristics combined in this component influence bird distribution differently. The Hermit Thrush falls at the lower (-) end of PC II because of its apparent selection of habitats with high importance values of medium-tall alder shrubs (cf Table 9 and Table 2). Other bird species at this end of the axis were selecting treeless habitats. At the upper end (+) of PC II, Gray Jays appear to have been selecting habitats with large spruce trees. An understanding of the positioning of the other species along this composite axis must await application of further statistical procedures, however.

Along PC III, the Lapland Longspur (shortest vertical bar) shows selection of open habitats; in actuality, it often occurred where only a ground cover of prostrate, dwarf shrub was present. Species with the tallest bars (Gray-cheeked Thrush and Fox Sparrow) were birds of the tall shrubs, which in this area were primarily alders or short spruce, both of which have thick (deep) canopies and also often grow in association with shrubbery of lower-height canopies. Other species with tall bars (Arctic Warbler, Tree Sparrow, and White-crowned Sparrow) show their selection of habitats with dense, low- and medium-height shrub birch. The Wilson's Warbler occurred in both types of shrub habitats, with or without a forest canopy.

3.7 - Annotated List of Species

A list of the 135 species of birds recorded in the upper Susitna River Basin during the study, with species-specific information for the region (abundance and status, habitat, phenological data), follows. Information for these species accounts was drawn from above Sections 3.1-3.6 and from the collective field observations gathered by our group and others throughout the study. Breeding by some birds in the study area has not yet been confirmed. In the annotated list, a species is called a breeder only if we have a substantiated breeding record. Suspected breeding--based on such things as breeding or territorial behavior of adults, breeding status in closely adjacent areas, or persistent abundance of certain species in breeding habitats--is indicated as "probable" or "possible" breeding, depending on the strength of the evidence.

Common Loon. Gavia immer. Uncommon breeder on lacustrine waters. Species occurred 16 May (1981) through 19 October (1981). Four birds each on 26 May 1981 and on 20 September 1980 was maximum day count. Three broods totaling five young were seen 28-29 July 1981; the oldest chick was about two-thirds adult size, with juvenal feathering in the dorsal and scapular feather tracts.

Arctic Loon. Gavia arctica. Uncommon spring migrant and probable breeder on lacustrine waters. Species was observed from 16 May (1981), when a dead bird was found on a pond just north of Watana Camp, through 27 July (1981), when a pair was observed on WB 015. A total of 12 birds was seen in 1981.

Red-throated Loon. Gavia stellata. Uncommon probable breeder on lacustrine waters, occurring between 9 May (1981) and 21 August (1980). Few birds were seen, six in 1980 and 12 in 1981.

Red-necked Grebe. Podiceps grisegena. Uncommon breeder on lacustrine waters, occurring from 16 May (1981) through 12 October (1981), maximum eight birds on 15 September 1981. An adult flushed from a nest north of Watana Camp on 18 July 1980, and a pair with two juvenal-feathered, non-flying young was on WB 036 on 27 July 1981.

Horned Grebe. Podiceps auritus. Uncommon breeder on lacustrine waters. Species occurred 10 May (1981) through 3 October (1980), maximum 17 birds on 16 September 1980. Five broods totaling eight large downy young were seen on 28 July 1981; four broods were on WB 032 and the other was on WB 033.

Whistling Swan. Olor columbianus. Fairly common migrant. Two birds on 9 May 1981, 14 on 17 May 1981, and two on 22 May 1981 were the only records in spring. The first Whistling Swans identified in fall were 18 birds on WB 134 on 26 September 1981. Others (up to 23) were identified at WB 103 and WB 104 on 8-9 October 1981. The 144 swans reported by George Nissen, helicopter pilot, on Stephan Lake and nearby WB 105 on 10 October 1980 were probably also mostly Whistling Swans, based on the size of the aggregations and the fact that they occurred during the known period of peak movement of this species through central Alaska (Kessel, unpubl. data).

Trumpeter Swan. Olor buccinator. Common breeder on lacustrine waters, especially in the wetlands east of the Susitna, between the Oshetna and MacLaren rivers. Earliest in spring was a sighting on 29 April 1981 on Murder Lake by J. Ireland; he also reported 7-11 Trumpeters there between 10 and 18 October 1981, the latest birds identified as this species. However, small groups of swans, composed of 6-13 adults and juvenals, on Stephan Lake between 20 and 23 October 1981, were probably of this species. Maximum count was 42 Trumpeters on WB 131 on 7 September 1980. Single pairs were at their nests on WB 132 and WB 138 on 26 May 1981. Nine broods (2-5 cygnets each) were counted during a 1¼-hour random survey over the ponds of the Oshetna-MacLaren region on 4 August 1981.

Canada Goose. Branta canadensis. Uncommon migrant. In spring this species occurred from 20 April (1981) to 18 May (1981), maximum 35 birds on 1 May 1981. It was observed in fall from 16 August (1980) to 22 October (1981); high count was 27 flying over Watana Creek on 23 September 1981.

White-fronted Goose. Anser albifrons. Uncommon spring migrant. Six birds seen 1 May 1981 at Watana Camp Lake constituted the only record.

Snow Goose. Chen caerulescens. Uncommon spring migrant. The only record was of 51 birds seen flying over Clarence Lake by T. W. Hobgood on 30 April 1981.

Mallard. Anas platyrhynchos. Common spring and fairly common fall migrant and uncommon breeder on lacustrine waters. Species occurred from 23 April (1981) to 19 October (1981), with the main fall passage occurring from late September to mid-October. Maximum count in spring was 121 birds on 26 May 1981 and in fall 153 birds on 26 September 1981. Single broods were seen on 13 July 1980 and 27 July 1981, the latter of four flying juvenals.

Gadwall. Anas strepera. Rare spring migrant and summer visitant. A male at Pistol Lake and a pair at WB 059, all 17 May 1981, and a male on WB 032 on 3 July 1981 provided the only records in the study area. This species is normally scarce north of the Pacific coast of Alaska (Kessel and Gibson 1978).

Pintail. Anas acuta. Common spring and uncommon fall migrant and uncommon breeder on lacustrine waters. Pintails were recorded from 24 April (1981) to 3 October (1980), with the main fall passage over by mid-September. Spring maximum was 116 birds on

26 May 1981, and high count in fall was 60 birds on both 7 and 11 September 1980, all during aerial surveys. Two broods were found in 1981, one on 8 July and the other, of nearly-fledged juvenals, on 29 July.

Green-winged Teal. Anas crecca. Fairly common spring migrant and uncommon breeder and fall migrant on lacustrine waters. Species occurred from 29 April (1981) through 3 October (1980), although the main fall exodus occurred by mid-September. Maximum count in spring was 67 birds on 3 May 1981, in fall 83 birds on 16 September 1980. Single broods of 2- to 3-week-old chicks were recorded on 12 July 1980 and 8 July 1981.

Blue-winged Teal. Anas discors. Rare migrant. In spring two birds were seen at WB 067 on 6 May 1981, and one was seen at Murder Lake on 25 May 1981 by J. Ireland. In fall one male at Stephan Lake on 11 September 1980 was the only record.

Northern Shoveler. Anas clypeata. Uncommon migrant and breeder on lacustrine waters. Species was recorded from 9 May (1981) to 16 September (1980). Maximum count in spring was 28 birds on 26 May 1981, in fall 20 birds on 16 September 1980. A brood of six downy young seen on 12 July 1981 on Murder Lake was the only evidence of breeding.

American Wigeon. Anas americana. Fairly common migrant and breeder on lacustrine waters. Species occurred from 2 May (1981) through 19 October (1981). The main fall passage occurred during the first half of September, with a maximum single-day count of 325 wigeon on the aerial survey of 16 September 1980; maximum count in spring was 102 on the aerial survey of 26 May 1981. Six broods of downy young were seen 13-28 July 1981, and a brood of ten large young was noted on 2 September 1980.

Redhead. *Aythya americana*. Uncommon spring migrant. The only records were of 31 Redheads seen in spring 1981. Three birds were seen on 17 May on WB 059, Fog Lakes. The rest were observed during the aerial survey of 26 May: eight birds on WB 067 (Pistol Lake), seven on WB 106 (Stephan Lake), two on WB 130 (Deadman Lake), three on WB 148 (Watana Lake), and eight on WB 145 (Clarence Lake).

Ring-necked Duck. *Aythya collaris*. Rare migrant on lacustrine waters. The only records were of two birds on WB 059 on 16 September 1980, a group of seven males and five females on Clarence Lake on 20 September 1980, and two birds seen on Murder Lake in early May 1981 by J. Ireland.

Canvasback. *Aythya valisineria*. Uncommon spring migrant. One bird on WB 067 on 6 May 1981, one on WB 037 on 10 May 1981, and a pair at WB 059 on 17 May 1981 were the only records in the study area.

Greater Scaup and Lesser Scaup. *Aythya marila* and *Aythya affinis*. Common migrants and breeders on lacustrine waters. Although both species were identified, it was often impossible to separate them under many field conditions; thus they are treated together. Scaup occurred from 9 May (1981) through 19 October (1981); their main fall passage occurred during the second and third weeks of September. Maximum count in spring was 513 birds on 26 May 1981, in fall 499 on 16 September 1980. Four broods of downy Lesser Scaup, totaling 14 young, were seen between 16 and 28 July 1981; three broods totaling 29 young were seen at Stephan Lake on 21 August 1980. Although Greater Scaup were present throughout the summer, no brood- were found; they were somewhat less numerous in summer than Lesser Scaup.

Common Goldeneye and Barrow's Goldeneye. Bucephala clangula and Bucephala islandica . Fairly common spring migrants and uncommon breeders and fall migrants on lacustrine and fluviatile waters. Both species were identified and Barrow's appeared to be more numerous, but females and eclipse males were usually impossible to identify to species during summer and early fall, so the species are treated here together. Goldeneyes occurred from 29 April (1981) (Barrow's Goldeneye at mouth of Watana Creek) through 17 October (1981) (12 unidentified goldeneyes on Stephan Lake). Maximum in spring was 51 goldeneyes on 10 May 1981; maxima in fall were 133 birds on 3 October 1980, 125 on 26 September 1981, and 124 on 20 September 1980. One brood of three downy Common Goldeneyes was seen on WB 060 (Fog Lakes) on 27 July 1981.

Bufflehead. Bucephala albeola. Uncommon spring migrant and fairly common fall migrant on lacustrine waters. Species occurred in spring from 29 April (1981) to 26 May (1981) and in fall from 8 September (1981) to 19 October (1981). Maximum count in spring was 10 birds on 26 May 1981, in fall 127 birds on 26 September 1980, both during aerial surveys. None was recorded in summer.

Oldsquaw. Clangula hyemalis. Fairly common spring migrant and breeder and uncommon fall migrant on lacustrine waters. Species occurred 17 May (1981) to 12 October (1981), maximum 84 birds during the aerial survey on 26 May 1981. Oldsquaws and Black Scoters were the most productive waterfowl on the study area, with 0.54 broods/km^2 of wetlands surveyed during July 1981. Eleven broods, mostly downy young, were counted between 8 and 28 July 1981, three broods each on Pistol Lake (WB 067), Clarence Lake (WB 145), and WB 140.

Harlequin Duck. Histrionicus histrionicus. Fairly common breeder on suitable fluviatile waters. Species occurred from 13 May (1981) through 24 September 1981 and 2 October 1980; maximum single-day count was seven adults in the vicinity of Kosina Creek on 2 June 1981. A few-day-old downy was found dead on Kosina Creek on 17 July 1980, and a brood of four was seen on the Susitna River above the mouth of Watana Creek on 25 July 1980.

White-winged Scoter. Melanitta deglandi. Uncommon migrant and summer visitant on lacustrine waters. This scoter occurred from 26 May (1981) to 17 October (1981), maxima 16 birds on 26 May 1981 and 39 on 29 September 1981. A flock of up to 63 birds was present at Stephan Lake 12-16 July 1981.

Surf Scoter. Melanitta perspicillata. Uncommon migrant and breeder on lacustrine waters. Species occurred 17 May (1981) to 12 October (1981). Maximum count in spring was 37 birds on 26 May 1981, in fall 29 birds on 12 October 1981. Two broods of downy young were recorded on the Fog Lakes on 27 and 28 July 1981. A flock of 12 Surf Scoters, mostly males, was on Watana Lake on 13 July 1980.

Black Scoter. Melanitta nigra. Fairly common migrant and breeder on lacustrine waters. Species occurred 17 May (1981) to 12 October (1981). Maximum counts were during aerial surveys: 38 birds on 16 September 1980 and 30 birds on 26 May 1981. It was one of the most productive ducks on the study area (0.54 broods/km^2 of wetlands). Eleven broods totaling 55 downy young were recorded between 24 and 29 July 1981.

Common Merganser and Red-breasted Merganser. Mergus merganser and Mergus serrator. Uncommon migrants and breeders. Common Mergansers may have bred along the Susitna River proper, where we regularly saw adults off our camps at the mouth of Kosina Creek and off the Mixed II plot; Red-breasteds occupied lacustrine and smaller fluviatile waters in the study area. Because of difficulties in identification from aircraft, these species are discussed together. They occurred from 4 May 1980 and 8 May 1981 (Red-breasted Merganser) and 7 May (1981) (Common Merganser) through 12 October (1981) (Common Merganser). Maximum count was 68 mergansers (sp.) on 26 September 1980. Three broods of Red-breasted Mergansers were recorded: one of six young on Portage Creek on 23 July 1980, one of four young at High Lake on 5 August 1980, and one of ten newly-hatched young on WB 023 on 6 July 1981. Molting Red-breasted Mergansers were observed using the wetland system west of Deadman Mt. and upper Deadman Creek on 3 and 28 July and 24 August 1981.

Goshawk. Accipiter gentilis. Uncommon resident and breeder in deciduous and mixed forests. A nest with at least one large young was found 6 m up in a birch tree, in paper birch forest, 27 July 1981.

Sharp-shinned Hawk. Accipiter striatus. Uncommon probable breeder in mixed and coniferous forests. Three birds were seen in 1980 and two in 1981.

Red-tailed Hawk. Buteo jamaicensis. Uncommon migrant; uncommon breeder in coniferous or mixed forests, occurring from 26 April (1981) through 16 September (1980). A pair was seen about a nest on the Susitna River near the mouth of Portage Creek on 1 May 1981 but not subsequently. Both B.j. harlani and B.j. calurus were seen.

Golden Eagle. Aquila chrysaetos. Fairly common breeder on cliffs. Observed 20 April (1981) through 19 October (1981) in the study area, and a bird was reported in the northern foothills of the Alaska Range on 20 March 1981 (Kessel, unpubl. notes). Six pairs nested along the upper Susitna River and its tributaries each year, using a total of ten nest sites during both years. Young birds ranged from almost 3 weeks old to over 4 weeks old at the time of the aerial survey on 6 July 1980.

Bald Eagle. _Haliaeetus leucocephalus_. Uncommon breeder. Species was recorded from 10 March (1981) through 30 October (1980). A pair was observed at a cliff nest near the mouth of Kosina Creek on 28 April 1981. Four active aeries were found in the study area in both 1980 and 1981; three nests failed in 1981. One nest contained 5-week-old young on 6 July 1980. Nests were in the tops of cottonwoods and white spruce trees and on riverine cliffs.

Marsh Hawk. _Circus cyaneus_. Fairly common migrant; uncommon probable breeder in meadows, occurring as early in spring as 25 April (1981) and as late in fall as 16 September (1981).

Osprey. _Pandion haliaetus_. Rare spring migrant. One bird seen at Murder Lake on 23 May 1981 by J. Ireland was the only record in the study area.

Gyrfalcon. _Falco rusticolus_. Uncommon resident and breeder on cliffs. One aerie in V-Canyon was occupied in 1981. White (1974) found two active nests in steep draws on the south side of the Susitna River, just above the proposed Devil Canyon dam site, 10-15 June 1974. The species is known to occur in the Alaska Range during winter (Bente 1981), and two were seen near the mouth of Watana Creek on 11 March 1980.

Merlin. _Falco columbarius_. Uncommon probable breeder in scattered woodland and forest edge. Ten birds were recorded in 1980, but only three in 1981. A pair exhibited defensive behavior at Deadman Falls Canyon on 5 June 1981, and a bird was seen there again on 28 July 1981.

American Kestrel. _Falco sparverius_. Rare fall migrant. One male at Stephan Lake on 23 August 1980 was the only record.

Spruce Grouse. _Canachites canadensis_. Fairly common resident and breeder in mixed and coniferous forests throughout the study area. First chicks were seen on 23 June (1981). Maximum breeding density in 1981 was 1.0 territory/10 ha in each of two White Spruce-Paper Birch Forest plots.

Ruffed Grouse. _Bonasa umbellus_. Rare visitant. One bird observed 20 May 1981 at the edge of an open white spruce forest at Kosina Creek was the only record of the species in the study area. It is a common resident in interior Alaska.

Willow Ptarmigan. _Lagopus lagopus_. Common resident and breeder in low shrub thickets. Young were first observed on 9 July (1981). Maximum breeding density in 1981 was 0.5 territory/10 ha in the Dwarf-Low Birch Shrub plot.

Rock Ptarmigan. _Lagopus mutus_. Common resident and breeder in dwarf and low shrub and in block-fields throughout the study area. Chicks were first seen on 24 June (1981). Maximum breeding density in 1981 was 0.7 territory/10 ha in the Dwarf-Low Birch Shrub plot.

White-tailed Ptarmigan. _Lagopus leucurus_. Uncommon resident and breeder in dwarf shrub mat and block-fields. Species occurs at higher elevations than its congeners, although at least several hundred altitudinal feet of overlap was seen with Rock Ptarmigan. No nests were found, but broods were seen at Mt. Watana beginning on 10 August (1981).

Sandhill Crane. _Grus canadensis_. Uncommon migrant. Two flocks of cranes were observed on 19 September 1980, one of 30 birds flying northeast up Devil Creek and one of 105 birds flying northeast up

Tsusena Creek. Fifteen birds seen flying northwest over lower Watana Creek by W. H. Busher on 15 May 1981 provided the only additional record of the species.

Semipalmated Plover. _Charadrius semipalmatus_. Uncommon breeder on alluvial bars. Species occurred from 5 May (1981) to 8 September (1980). Two nests with full clutches of four eggs were found, one on 6 June and the other on 16 June 1981; both were along shorelines of the Susitna River.

American Golden Plover. _Pluvialis dominica_. Common breeder in dwarf shrub mat and dwarf shrub meadows. Species occurred in the study area from 15 May (1981) through 22 August (1980). Three nests with four eggs each were found in 1981, the earliest on 12 June. Maximum breeding density in 1981 was 1.5 territories/10 ha in the Alpine Tundra plot.

Whimbrel. _Numenius phaeopus_. Uncommon probable breeder in dwarf shrub meadow, occurring from 9 May (1981) to 6 August (1981).

Upland Sandpiper. _Bartramia longicauda_. Rare probable breeder in dwarf shrub meadow near scattered spruce woodlands. This shorebird was observed only in 1980, when two birds were seen near Watana Camp on 8 July, at least three birds were seen west of Kosina Creek on 13 July, and one was seen east of Kosina Creek on 19 July. It is known to breed in the Alaska Range and along the Denali Highway (Kessel and Gibson 1978).

Greater Yellowlegs. _Tringa melanoleuca_. Uncommon probable breeder in wet meadows, foraging on fluviatile and lacustrine shorelines. Species occurred from 29 April (1981) to 31 July (1980). Defensive pairs were present near High Lake in mid-July 1980 and near the White Spruce Scattered Woodland plot on 1 July 1981, but no nests or young were found.

Lesser Yellowlegs. *Tringa flavipes*. Fairly common spring migrant; rare summer visitant. In spring species occurred 6 May (1981) to 24 May (1981). Single birds were seen on 16 June 1981, 13 July 1980, and 23 July 1981.

Solitary Sandpiper. *Tringa solitaria*. Uncommon probable breeder in scattered woodland or forest edge near lacustrine waters; rare spring migrant. One migrant was seen 9 May 1981. At least one courting male was observed regularly about a beaver pond at Sherman in June 1981.

Spotted Sandpiper. *Actitis macularia*. Common breeder on alluvial shorelines, especially along the larger creeks and rivers, occurring from 19 May (1981) to 10 September (1980). Earliest nest, with full clutch of four eggs, was found on a Susitna riverbar on 6 June (1981). A brood of juvenal-plumaged young with some down was seen on Kosina Creek on 17 July 1980, and an independent juvenal was seen at Clarence Lake on 24 July 1981.

Wandering Tattler. *Heteroscelus incanus*. Uncommon possible breeder and fall migrant. The species was recorded 7-30 June 1981 and on 14 August and 8 September 1980. The June birds were in appropriate habitat for breeding, i.e., along tundra streams, but the species is secretive and we noted no breeding behavior. Tattlers breed in the Alaska Range (Kessel and Gibson 1978) and likely do so in the study area.

Turnstone. *Arenaria* sp. Rare migrant. Two unidentified turnstones were flushed from a Susitna riverbar by an approaching helicopter on 14 May 1981.

Northern Phalarope. *Phalaropus lobatus*. Fairly common probable breeder, occurring in wet meadow pond areas from 9 May (1981) to 13 July 1981 and 12 July 1980. Maximum count was 24 birds seen 17 May 1981.

Common Snipe. *Gallinago gallinago*. Common breeder in wet meadows, where it occurred from 28 April (1981) to 31 July (1981). One bird on 16 September 1981 was the only fall migrant recorded. A clutch of four eggs found on 1 June 1981 hatched on 15 June.

Long-billed Dowitcher. *Limnodromus scolopaceus*. Uncommon spring migrant. Two observations totaling three birds on 17 May 1981 constituted the only records.

Surfbird. *Aphriza virgata*. Rare possible breeder in dwarf shrub mat. One bird seen 13 July 1980 west of Kosina Creek was the only record, but the species is known to breed in the Alaska Range (Kessel and Gibson 1978).

Sanderling. *Calidris alba*. Rare fall migrant. One juvenile at the Tyone River mouth on 5 September 1980 was the only record.

Semipalmated Sandpiper. *Calidris pusilla*. Uncommon spring migrant, recorded 6-20 May 1981, and rare summer visitant, recorded 25 and 30 June and on 23 July 1981.

Least Sandpiper. *Calidris minutilla*. Fairly common probable breeder in wet and dwarf shrub meadows, occurring 9 May (1981) to 25 July (1980). Aerial courtship displays were prominent May-July.

Baird's Sandpiper. *Calidris bairdii*. Uncommon breeder in dwarf shrub mat, occurring 15 May (1981) to 18 July (1980). A nest, with full clutch of three eggs, was found 19 June 1981, and three downy young were seen the same date. In 1981, the species was last seen on the Alpine Tundra plot on 2 July, and on 7 July one individual moved through and fed at lower elevations at the Dwarf-Low Birch Shrub plot.

Pectoral Sandpiper. *Calidris melanotos*. Uncommon migrant in wet meadows and at water edges. Three birds on 12 May 1981, six on 17 May 1981, and one on 16 September 1980 were the only records.

Long-tailed Jaeger. *Stercorarius longicaudus*. Fairly common probable breeder in dwarf shrub meadow and dwarf shrub mat. Earliest seen in spring was 26 May (1981), latest 10 August (1981).

Herring Gull. *Larus argentatus*. Uncommon spring migrant and summer visitant, occurring 3 May-14 June 1981; maximum was 15 birds seen on 3 May 1981 during aerial survey.

Mew Gull. *Larus canus*. Common summer visitant and breeder about lacustrine and fluviatile waters; also flocked to refuse dump at High Lake. Species occurred 30 April (1981) through 24 August (1980). Large downy young were found at High Lake on 10 July 1980 and 6 July 1981; a brood of large, flightless chicks was on a pond south of High Lake on 12 July 1980; and seven families of fledged juvenals were enumerated 27-29 July 1981.

Bonaparte's Gull. *Larus philadelphia*. Uncommon summer visitant about fluviatile and lacustrine waters, breeding in adjacent scattered spruce woodlands. A fledged juvenal on WB 059 on 27 July 1981 was the only evidence of breeding in the region.

Arctic Tern. *Sterna paradisaea*. Fairly common probable breeder about lacustrine water shorelines. Species occurred from 6 May (1981) to 16 August (1980). Maximum was seven scattered birds seen by several field parties on 17 May 1981. No eggs or young were found, but territorialism and aggressive behavior indicated breeding.

Great Horned Owl. Bubo virginianus. Uncommon resident and probable breeder in forests and woodlands. Heard calling in the upper Basin 12 February 1981 and 6-7 March 1980. A probable family group of three birds was present near Kosina Creek at least between 20 May and 13 June 1981.

Snowy Owl. Nyctea scandiaca. Probably rare migrant. Two birds were seen about 18 November 1981 by Craig Gardiner.

Hawk Owl. Surnia ulula. Uncommon resident and probable breeder in mixed woodlands. Records of single birds were made from 22 February (1981) through early November (1981).

Short-eared Owl. Asio flammeus. Uncommon migrant, summer visitant, and possible breeder, occurring in all open habitats. Earliest in spring were one on 27 April 1980 and one on 3 May 1981, and latest in fall was on 21 October (1981).

Boreal Owl. Aegolius funereus. Rare resident and probable breeder in mixed forests. Single observations, probably of the same bird, on 18 April 1981 and 5 May 1981, were the only records.

Belted Kingfisher. Megaceryle alcyon. Uncommon probable breeder in cutbanks. Species was recorded from 13 May (1981) through 11 September 1980 and 14 September 1981, primarily along the large watercourses. A pair was observed flying regularly between Kosina Creek and a canyon across the Susitna River during July 1980, apparently to a nest site in the canyon.

Common Flicker. Colaptes auratus. Uncommon breeder at forest edge. This species was present as early as 6 May (1981) and as late as 11 September (1980). A pair was seen at a nest with young at Kosina Creek on 20 June 1981.

Yellow-bellied Sapsucker. Sphyrapicus varius. No sapsuckers were seen, but old sapwells on many of the large paper birches in the study area attested their presence in earlier years. Most of the workings were many years old, but some at the mouth of Kosina Creek were relatively fresh, perhaps no older than about five years. Similar old sapwells are numerous in the Tanana River Valley, and in recent years a few sapsuckers have been seen in extreme eastern interior Alaska (Kessel, pers. obs.).

Hairy Woodpecker. Picoides villosus. Uncommon resident and breeder in mixed and deciduous forests. Most were seen in the vicinity of Sherman or along Portage Creek. A female and fledged young were seen together on the Cottonwood Forest plot at Sherman on 13 June 1981.

Downy Woodpecker. Picoides pubescens. Uncommon resident and probable breeder in open mixed and deciduous forests. Single birds were observed at irregular intervals during the 1980 study period, and there was a portion of a breeding territory on the Cottonwood Forest plot at Sherman during June 1981.

Black-backed Three-toed Woodpecker. Picoides arcticus. Probably rare resident in coniferous forest. One male seen along Watana Creek on 29 September 1980 was the only record.

Northern Three-toed Woodpecker. Picoides tridactylus. Uncommon resident and breeder in coniferous forests. A pair at a nest with young was observed at Kosina Creek on 13 and 20 June 1981. The nest was 8 m up in a 12-m black spruce.

Eastern Kingbird. _Tyrannus tyrannus_. Accidental. One bird observed near High Lake on 11 July 1980 was the only record. In Alaska this species is a regular visitant only in Southeastern; it is casual elsewhere in the state (Kessel and Gibson 1978).

Say's Phoebe. _Sayornis saya_. Uncommon breeder on upland cliffs and in buildings. A few birds were seen, mostly at Mt. Watana and in mountains east of Watana Creek, from 28 May (1981) through 20 July (1980). A pair was feeding young at a cliff on Mt. Watana on 13 July 1980, a bird was flushed from a nest in an old cabin on Gilmore Creek on 29 June 1981, and a pair was present at V-Canyon on 5 June 1981.

Alder Flycatcher. _Empidonax alnorum_. Uncommon probable breeder in medium and tall shrub thickets. A late spring migrant, this species was recorded first on 3 June (1981), when at least four singing males were present in the vicinity of the Sherman campsite. Two juveniles at Stephan Lake on 21 August 1980 were fall migrants, the latest individuals seen.

Western Wood Pewee. _Contopus sordidulus_. Rare possible breeder in deciduous forest. Four birds at Watana Creek on 25 July 1980 provided the only record.

Olive-sided Flycatcher. _Nuttallornis borealis_. Uncommon migrant and probable breeder, occurring in open forest and scattered woodland. One singing bird at Watana Creek on 15 May 1981 was earliest seen, and one bird at Stephan Lake on 23 August 1980 was latest.

Horned Lark. _Eremophila alpestris_. Common migrant and fairly common breeder, occurring on passage in most open habitats and as a breeder in block-fields and dwarf shrub mat. Three birds at Watana Creek on 30 April 1981 were earliest in spring. Two nests were found in 1981, both in high alpine dwarf shrub mat; one had five eggs on 31 May, the other four eggs on 3 June. The first fledgling was seen 20 June 1981. Postbreeding flocks were forming 16-21 August 1981, some shifting to lower elevations; four flocks totaling 70 birds were seen at 1100 m in dwarf-low shrubs northwest of Clarence Lake on 16 August 1981. Five birds on 23 September 1981 were latest fall migrants observed.

Violet-green Swallow. Tachycineta thalassina. Fairly common spring migrant and summer visitant; probable breeder in riparian cliffs. One bird on 16 May (1981) about Watana Camp was earliest in spring, and none was seen after 25 July (1980), when two were noted over Watana Creek.

Tree Swallow. Iridoprocne bicolor. Fairly common spring migrant and probable breeder, occurring widely over lacustrine and fluviatile waters. Two on 3 May (1981) over Watana Creek were earliest in spring, and none was seen after 23 July (1980).

Bank Swallow. Riparia riparia. Uncommon local breeder and fall migrant, occurring about riparian cutbanks and over fluviatile waters. There was a nesting colony of 25 pairs along upper Watana Creek on 25 July 1980, the only evidence of breeding in the area. The species was recorded no earlier than 4 June (1981) nor later than 21 August (1980).

Cliff Swallow. Petrochelidon pyrrhonota. Uncommon local summer visitant and breeder, occurring about fluviatile and lacustrine waters. The species was recorded only in the month of July (1980, 1981). Twenty birds in two colonies of five pairs each were seen nesting under the eaves of two small cabins on the Watana Lake shore on 9 July 1981, and a colony of seven pairs was seen at Clarence Lake on 24 July 1981.

Gray Jay. Perisoreus canadensis. Common resident and breeder in coniferous and mixed forests and woodlands throughout the study area. Densities on four census plots in 1981 ranged from 0.5 to 1.0 fledged family/10 ha. One bird was observed in flight over low shrub thickets northwest of Clarence Lake on 5 September 1981, the only occurrence noted far from timber.

Black-billed Magpie. Pica pica. Uncommon visitant in spring, summer, and fall; possible resident and breeder in open tall shrubs and scattered woodlands.

Common Raven. Corvus corax. Common resident and breeder, nesting on riparian and upland cliffs. Widespread, this species foraged in or near most habitats and fed on game carcasses and about refuse dumps in winter. Nests contained downy young at the time of the aerial survey on 16-17 May 1981.

Black-capped Chickadee. Parus atricapillus. Uncommon resident and probable breeder in deciduous forests. Breeding territories were found only on the Cottonwood Forest plot, where there were 1.8 territories/10 ha in 1981.

Boreal Chickadee. Parus hudsonicus. Fairly common resident and breeder in coniferous and mixed forests. A pair was found feeding young in a nest in the hollow top of a leaning 15 cm dbh spruce snag on the Black Spruce Dwarf Forest plot on 16 June 1981. Maximum breeding density in 1981 was 1.7 territories/10 ha in mixed white spruce-paper birch forest.

Brown Creeper. Certhia familiaris. Uncommon breeder and fall visitant in deciduous and mixed forests. A singing bird on 20 May (1981) was earliest record, and one seen 21 October (1981) was latest in fall. On 3 June 1981 a pair was seen entering a vertical cleft in the bark 10 m up the trunk of an 18-m cottonwood at Sherman. This nest could not be examined, and no others were found. There were two breeding territories in 1981 on the Cottonwood Forest plot and one on the mixed White Spruce-Paper Birch Forest II plot.

Dipper. Cinclus mexicanus. Uncommon resident and probable breeder on suitable fluviatile waters throughout the study area. We have no observations from mid-winter, but between 17 and 23 April 1981, before spring thaw, birds were observed at open water sites along creeks and rivers. Most were seen along the Susitna River at the mouths of Watana, Deadman, and Tsusena creeks, and in Devil Canyon.

American Robin. Turdus migratorius. Common spring migrant and breeder and uncommon fall migrant, occurring from 25 April (1980) to 11 October (1981), although few were seen after August. Species occurred in forests and medium and tall shrub thickets. Two nests with eggs were found, one in a paper birch near Sherman on 13 June 1981 and the other in high alpine tundra southeast of the Devil Canyon dam site on 20 June 1981. The latter nest was on the ground at the base of a 1-m high rock face. Maximum breeding density in 1981 was 0.5 territory/10 ha on each of three census plots: Tall Alder Shrub Thicket, White Spruce Scattered Woodland, and Black Spruce Dwarf Forest.

Varied Thrush. Ixoreus naevius. Common spring migrant and breeder and uncommon fall migrant, occurring in all forest types and in tall alder shrub thickets. Species was recorded in spring as early as 24 April (1981) and in fall as late as 20 September 1980 and 30 September 1981. Four nests were found, the earliest, with four eggs, on 21 May (1981). Nests were located in a spruce tree, an alder shrub, and on an old stump. First nestlings were seen 13 June (1981), first fledglings on 20 June (1981). Most forest plots supported breeding densities in 1981 of 2.5-3.5 territories/ 10 ha, but there were 10 territories on the 10-ha Cottonwood Forest plot.

Hermit Thrush. Catharus guttatus. Common breeder in forests on steep slopes and in tall alder shrub thickets; uncommon fall migrant. Species was first seen in spring on 14 May (1981), last in fall on 7 September 1981 and 12 September 1980. Five nests were found in 1981, the earliest with a full clutch of four eggs on 25 May and with nestlings with closed eyes but emerging primaries on 11 June. A clumsy juvenal was seen in woods along Portage Creek on 31 July 1981. Maximum breeding density in 1981 was 6.1 territories/10 ha in the Paper Birch Forest plot.

Swainson's Thrush. Catharus ustulatus. Fairly common breeder in all forest types. Species occurred from 18 May (1981) to 27 August (1980). A bird carrying nesting material in mixed forest on 20 May 1981, an adult carrying food in spruce forest on 17 July 1980, one feeding a fledgling on 15 July 1980, and many defensive pairs observed at various times constituted breeding evidence. Maximum breeding density in 1981 was 8.0 territories/10 ha on the mixed White Spruce-Paper Birch Forest II plot.

Gray-cheeked Thrush. Catharus minimus. Fairly common breeder in scattered woodland, in dwarf black spruce, and in the Cottonwood Forest plot. Species occurred 20 May (1981) to 4 September (1980). Earliest nest, on a 0.6 m high stump in the Cottonwood Forest plot, had a full clutch of four eggs on 3 June 1981. Maximum breeding densities in 1981 of 3.9 and 3.8 territories/ 10 ha were on the White Spruce Scattered Woodland and the Cottonwood Forest plots, respectively.

Wheatear. *Oenanthe oenanthe*. Uncommon breeder in block-fields. Earliest sighting was of one male west of Tsusena Creek on 31 May (1981); none was seen after 30 August (1980), when one juvenile was seen east of Devil Creek. No nests were found, but defensive adults were encountered in mid-July (1980, 1981), and bob-tailed young were noted at the summit between Devil Creek and Watana Camp on 18 July 1980.

Townsend's Solitaire. *Myadestes townsendi*. Uncommon spring migrant; uncommon breeder on cliffs. One bird at Tsusena Butte on 17 May 1981 was our only record of a migrant. One was seen about a cliff northeast of Jay Creek on 20 June 1981, and a pair at a nest with young was observed at a rock outcrop in mountains northeast of Watana Creek on 22 July 1980. Single birds seen 13 and 23 July 1980 were the only other records of the species.

Arctic Warbler. *Phylloscopus borealis*. Fairly common breeder in scattered woodlands and medium shrub thickets as far east as the slopes northwest of Clarence Lake; not detected on passage except on 22 August 1980, when four birds were seen west of Watana Camp. Earliest record in spring was 11 June (1981). Twelve singing males were counted on 11 July 1980 at High Lake, and food-carrying adults were seen there on 1 August 1980. An adult feeding fledged young was observed at WB 023 on 29 July 1981. Maximum breeding density in 1981 was 4.8 territories/10 ha on the Medium Birch Shrub Thicket census plot.

Golden-crowned Kinglet. *Regulus satrapa*. Uncommon spring and fall visitant, occurring in coniferous and mixed forests. One bird along the Susitna River on 24 April 1981 was the only spring record; one bird was seen at Cache Creek mouth on 9 September 1980; one was seen near the mouth of Tsusena Creek on 14 September

1980; two were seen on 12 September, four on 19th, and two on 25th--all in 1980 at Portage Creek; and two were observed at Gold Creek on 4 October 1980.

Ruby-crowned Kinglet. Regulus calendula. Common migrant, and common breeder in coniferous forests. Species was recorded in spring as early as 3 May (1981), a singing male at Watana Creek, and in fall as late as 25 September (1980). Four fledglings fed and begged from their parents in the white spruce forest at Kosina Creek on 15-17 July 1980. Maximum breeding density in 1981 was 4.2 territories/10 ha in the White Spruce Forest plot.

Water Pipit. Anthus spinoletta. Common breeder about block-fields and dwarf shrub mat, and common migrant, less conspicuous in spring than in fall. Earliest sighting in spring was of eight birds along the Susitna River on 1 May (1981) and latest in fall was on 30 September (1981), except for a very late bird on 21 October 1981. Three nests were found on Mt. Watana in 1981, all in dwarf shrub mat, the earliest with six eggs on 10 June. A nest on 19 June had three nestlings. Postbreeding flocking was first noted in alpine areas on 10 August 1981, and small groups (two to five birds) began to move to lower elevations at this same time.

Bohemian Waxing. Bombycilla garrulus. Common migrant and uncommon probable breeder in scattered spruce woodland. A flock of about 25 birds at the mouth of Watana Creek on 21 March 1980 and a single bird at the same place on 22 March 1981 were the earliest seen; latest in fall was a flock of 12 birds along Watana Creek on 24 September (1980). Maximum number was 38 birds counted on a 5-km transect through scattered dwarf black spruce in the Fog Lakes area on 9 May 1981. Late summer flocks included family groups of recently fledged juvenals.

Northern Shrike. _Lanius excubitor_. Uncommon breeder in tall shrub thickets and scattered spruce woodlands. Although probably resident, species was first recorded on 25 April (1980); on passage it occurred in all open vegetated habitats. A family group of four birds, including at least two fledged young, was seen near High Lake on 9 July 1980. One immature was observed northwest of Clarence Lake on 16 September 1981, and an adult was seen near Deadman Lake on 5 October 1981.

Orange-crowned Warbler. _Vermivora celata_. Uncommon breeder in medium and tall shrub thickets and scattered woodlands. Earliest in spring was a singing male at Sherman on 21 May (1981) and latest in fall was one bird at High Lake on 7 September (1980). A nest placed in moss under a dwarf shrub contained six eggs when first found on 11 June 1981; the young hatched on 21 June.

Yellow Warbler. _Dendroica petechia_. Rare migrant and summer visitant. A male singing at 04:20 on 15 June 1981 in riparian willows along the Susitna River, between Sherman and Devil Canyon, was not present there hours later or subsequently. One male was observed at Sherman on 30 July 1981, and three juveniles were seen there on 30 August 1980. There were no other records.

Yellow-rumped Warbler. _Dendroica coronata_. Common breeder in forests. Earliest in spring was one on 8 May (1981) and latest in fall were two on 24 September (1980). No nests were found, but food-carrying adults were observed along the Susitna, below Watana Creek, on 7 July 1980. Independent juvenals were recorded on 14 July 1980. Maximum breeding densities in 1981 were 9.8 territories/10 ha on the Paper Birch Forest plot and 9.5 territories/10 ha on the mixed White Spruce-Paper Birch Forest II plot.

Blackpoll Warbler. Dendroica striata. Fairly common breeder in tall shrub thickets, scattered woodlands, and in understory within forests. Earliest in spring were two males on 18 May (1981). A nest 1 m up in a tall alder shrub of the understory of the Cottonwood Forest plot held six eggs when found on 13 June 1981; the eggs hatched sometime between 14 and 19 June. Also, adults were observed carrying food below Watana Camp on 7 July 1980. Maximum breeding densities in 1981 were in the deciduous forests: 4.4 territories/10 ha in the Cottonwood Forest plot and 3.9 territories/10 ha in the Paper Birch Forest plot. A juvenile at Gold Creek on 5 September 1980 was the latest record.

Northern Waterthrush. Seiurus noveboracensis. Fairly common probable breeder in tall shrub thickets near water, often at deciduous and mixed forest edges along the banks of the Susitna River. Earliest in spring was a singing male on 15 May (1981), and latest in fall was one bird on 6 September (1980). Maximum breeding density in 1981 was 6.1 territories/10 ha on the Cottonwood Forest plot.

Wilson's Warbler. Wilsonia pusilla. Common breeder in medium shrub thickets, with or without a forest overstory. Earliest in spring was a male on 14 May (1981). A bird on 25 September (1981) was latest in fall. A nest on the ground at the base of a willow in scattered woodland contained six eggs on 14 June 1981 and five young on 1 July. A defensive, food-carrying pair was observed on 7 July 1980. Maximum breeding densities in 1981 ranged from 8.8 to 9.4 territories/10 ha on the Low-medium Willow Shrub Thicket and Medium Birch Shrub Thicket plots.

Rusty Blackbird. Euphagus carolinus. Uncommon migrant and possible rare breeder. Earliest in spring were sightings on 27 April 1980 and 2 May 1981; none was seen in spring after 24 May (1981). In fall the species was recorded from 13 August (1980) through

25 September (1980). A bird seen on 29 July 1981 at WB 059 (Fog Lakes) was the only midsummer record.

Pine Grosbeak. Pinicola enucleator. Uncommon spring, summer, and fall visitant and possible breeder. A pair of birds on 16 May 1981, two birds on 21 May 1981, three on 3 June 1981, one on 4 June 1981, one on 18 June 1981, three on 18 September 1980, and two birds on 4 October 1980 were the only records.

Gray-crowned Rosy Finch. Leucosticte tephrocotis. Uncommon probable breeder in cliffs and block-fields. A pair on 23 May (1981) was earliest record; one bird on 23 September (1981) was latest. Large postbreeding flocks (15-35 birds) were present on alpine tundra from 10 August through 11 September 1981.

Common Redpoll. Carduelis flammea. Abundant and widely distributed at all seasons; the most numerous passerine species recorded, but bred in low densities. Four nests were found. Three pairs were building nests 7-21 m up in 21-26 m cottonwoods on the Cottonwood Forest plot on 21 and 22 May 1981. On 4 June 1981 a female incubating four eggs was found 1.2 m up in a 1.5 m alder on a river bar; the eggs hatched on 15 June. A flock of 200+ birds at High Lake on 4 September 1980 was the largest flock seen.

Pine Siskin. Carduelis pinus. Irregularly uncommon summer visitant and probable breeder; fairly common in summer 1980 and distinctly uncommon in summer 1981 (when the species was numerous from Kodiak and Anchorage to Southeastern and when it bred as far north as Fairbanks). Seen in mixed deciduous-coniferous forests and in tall alder shrub thickets. Itinerant and irruptive and near the northern limits of its range, this species probably breeds in the study area in some years.

White-winged Crossbill. Loxia leucoptera. Fairly common summer visitant and possible breeder in coniferous forests. Like those of siskins and redpolls, numbers of this species fluctuate markedly from year to year. Maximum counts were a flock of 65 crossbills that landed briefly in cottonwoods near the Mixed II plot on 2 August 1981 and 36 birds seen at the Cottonwood Forest plot on 4 June 1981.

Savannah Sparrow. Passerculus sandwichensis. Abundant breeder throughout the study area in open low shrub thickets with grass-sedge ground cover. Earliest in spring was on 2 May (1981) and latest in fall on 14 September (1981). Five nests were found, from alpine tundra to scattered woodlands. Eggs were found in nests from 7 June through 1 July 1981. First barely-fledged young was recorded on 29 June (1981). Maximum breeding density in 1981 was 12.3 territories/10 ha on the Low-Medium Willow Shrub Thicket plot. Postbreeding Savannah Sparrows did not form flocks. They began gradually to disappear from the Dwarf-Low Birch Shrub plot in mid-August 1981, and few were left by 25 August.

Dark-eyed Junco. Junco hyemalis. Common breeder, occurring throughout forest and woodland habitats. It was recorded as early as 2 May (1981) and as late as 29 September (1981), with an exceptionally late bird on 30 October 1981. Maximum breeding densities in 1981 were 3.9-4.5 territories/10 ha in the White Spruce-Paper Birch Forest plots.

Tree Sparrow. Spizella arborea. Abundant breeder in low shrub thickets. Earliest record in spring was 6 May (1981) and latest records in fall were 4 October 1980 and 6 October 1981. First observation of nesting was on 27 May (1981), when a pair was lining its nest with ptarmigan feathers. Nine nests were located, with eggs present from 7 June to 9 July. The first nestlings were found on

15 June (1981) and first fledglings on 28 June (1981). Maximum breeding densities in 1981 were 15.0 territories/10 ha on the Low-Medium Willow Shrub plot and 11.8 territories/10 ha on the Medium Birch Shrub plot. Tree Sparrows did not form postbreeding flocks, but gradually left the Dwarf-Low Birch plot from 20 to 25 August 1981. Few birds remained on this plot after 25 August 1981.

White-crowned Sparrow. Zonotrichia leucophrys. Abundant breeder, widely distributed in low and medium shrub habitats. Species occurred from 6 May (1981) to 29 September (1981). Eight nests were found, the earliest, with four eggs, on 29 May (1981). Nestlings were present in three nests on 15 June (1981), and some had fledged by 29 June (1981). Average clutch size of five completed clutches in 1981 was 4.8 eggs. Maximum breeding density in 1981 was 6.5 territories/10 ha on the White Spruce Scattered Woodland plot.

Golden-crowned Sparrow. Zonotrichia atricapilla. Uncommon probable breeder in low shrub thickets and dwarf spruce forests. Species was seen as early as 16 May (1981) and as late as 3 September 1981 and 6 September 1980.

Fox Sparrow. Passerella iliaca. Fairly common probable breeder in medium and tall shrub thickets and in forest understory. Species occurred from 8 May (1981) through 7 September (1981). Maximum breeding densities in 1981 were 4.6 territories/10 ha on the Cottonwood Forest plot and 3.5 territories/10 ha on the White Spruce Scattered Woodland plot.

Lincoln's Sparrow. Melospiza lincolnii. Uncommon probable breeder in low and medium shrub thickets near water. Species occurred from 26 May (1981) through 7 September 1981 and 9 September 1980.

Lapland Longspur. Calcarius lapponicus. Abundant breeder in dwarf shrub meadow and dwarf shrub mat. Species occurred from 24 April (1981) through 16 September (1981), with an extremely late individual seen 2 October 1981. Earliest nest, containing five eggs, was seen 26 May (1981) and had four downy nestlings on 7 June (1981). Longspurs began forming flocks on 25 July 1981 and were still moving through dwarf-low shrub habitat in large flocks (15-70 birds) on 26 August 1981.

Smith's Longspur. Calcarius pictus. Uncommon probable breeder in dwarf shrub meadow/mat. A pair north of Watana Camp on 8 July 1980, two birds near Watana Lake on 13 July 1980, one male northwest of Clarence Lake on 7 July 1981, and one male at the last location on 24 August 1981 were the only records of the species. The species is known to breed along the Denali Highway (Kessel and Gibson 1978).

Snow Bunting. Plectrophenax nivalis. Fairly common probable breeder at high elevations in cliffs and block-fields, feeding in dwarf shrub mat. Species was observed from 15 May (1981) to 19 October (1981).

4 - NON-GAME (SMALL) MAMMALS - RESULTS AND DISCUSSION

4.1 - Species Composition and Relative Abundance

During the study period we confirmed the presence of sixteen species of small mammals in the upper Susitna River Basin (Table 22). In addition, there was evidence of two other species in the region: a bat (two separate sightings of what were probably little brown bats, Myotis lucifugus, near High Lake and Tsusena Creek, August 1980, by J. Wilson

TABLE 22

SPECIES OF SMALL MAMMALS FOUND IN THE UPPER SUSITNA RIVER BASIN, ALASKA, 1980 AND 1981

Order INSECTIVORA

Family Soricidae

Sorex cinereus, masked shrew

Sorex monticolus, dusky shrew

Sorex arcticus, arctic shrew

Sorex hoyi, pygmy shrew

Order LAGOMORPHA

Family Ochotonidae

Ochotona collaris, collared pika

Family Leporidae

Lepus americanus, snowshoe hare

Order RODENTIA

Family Sciuridae

Marmota caligata, hoary marmot

Spermophilus parryii, arctic ground squirrel

Tamiasciurus hudsonicus, red squirrel

Family Cricetidae

Clethrionomys rutilus, northern red-backed vole

Microtus pennsylvanicus, meadow vole

Microtus oeconomus, tundra vole

Microtus miurus, singing vole

Lemmus sibiricus, brown lemming

Synaptomys borealis, northern bog lemming

Family Erethizontidae

Erethizon dorsatum, porcupine

and S. W. Buskirk); and water shrew, Sorex palustris (tracks of a small mammal between ice openings on Watana Creek, March 1980, by S. W. Buskirk).

Comparison of our species list with the literature and several unpublished sources shows few distributional surprises. Our discovery of arctic shrews in the study area constitutes a minor range extension; the closest previous record was from Denali National Park (Murie 1962).

To inventory the shrews and voles of the upper Susitna Basin, we conducted one spring and two fall trapline surveys, involving a total of 16,776 trap nights of effort. This effort resulted in the capture of 1752 microtine rodents (6 species) and 1747 shrews (4 species). The two most abundant animals, constituting 76% of total captures, were northern red-backed voles, represented by 1382 specimens, and masked shrews, represented by 1286 specimens. Other shrews captured were arctic shrews (297 specimens), dusky shrews (153), and pygmy shrews (11). Microtus specimens included 203 tundra voles, 68 meadow voles, and 75 singing voles. Small numbers of brown lemmings (20) and northern bog lemmings (4) were also taken.

Capture results from sites sampled during all three trapping periods indicated a pronounced temporal difference in small mammal abundance (Fig. 6). Trapping in fall 1980 resulted in 941 animal captures, compared to 125 the following May and 1231 in fall 1981. Comparison of fall numbers shows that tundra voles were twice as abundant in 1981 as in 1980, red-backed voles 1.7 times more abundant, and masked shrews 1.3 times more abundant. Fall capture numbers of meadow voles, arctic shrews, and pygmy shrews were about equal, while dusky shrews declined sharply. We captured brown lemmings (6 specimens) and bog lemmings (3) in 1981 only. Regardless of the temporal differences in population

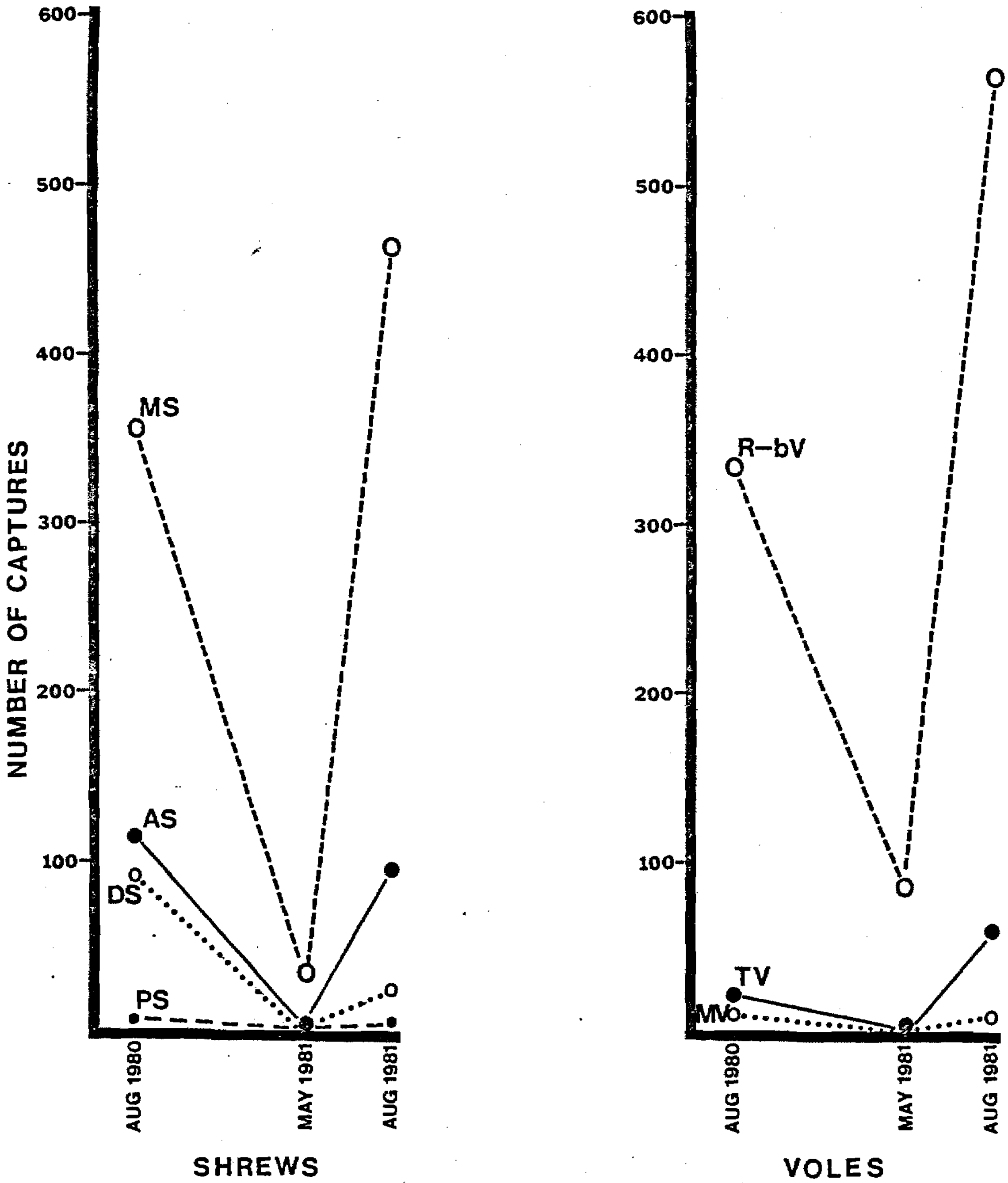

FIGURE 6

Temporal variation in numbers of small mammal captures at 22 trapline sites in the upper Susitna River Basin, Alaska, 1980-81 (MS = masked shrew, AS = arctic shrew, DS = dusky shrew, PS = pygmy shrew, R-bV = northern red-backed vole, TV = tundra vole, MV = meadow vole).

levels, the relative abundance ranking among species remained the same, i.e., the common species remained common and the rare continued to be rare.

Six small mammal species not sampled on our traplines also occurred in the study area: arctic ground squirrel, hoary marmot, collared pika, red squirrel, porcupine, and snowshoe hare.

The arctic ground squirrel was a numerous and ecologically important mammal of the region. Although the largest numbers were found on the drier slopes, knolls, and ridges above treeline, small numbers occurred at lower elevations: one near the mouth of Tsusena Creek, several along the railroad sidings at Sherman and Curry, and one 0.8 km below treeline in mixed forest near Portage Creek.

During the snow-free months ground squirrels provide an abundant, reliable food source for a number of mammalian and avian predators (Carl 1962, Murie 1962, Bente 1981, Olendorff 1976). At High Lake in 1981 the first ground squirrel emerged from hibernation the third week of April; the last squirrel seen here in fall was 4 October 1981 (E. Powell, pers. comm.). These emergence and entrance dates are essentially the same as those reported by Hock (1960) and Hock and Cottini (1966) in the Talkeetna Mountains near Anchorage, and by Carl (1962) at Ogotoruk Creek, northwestern Alaska. Seasonal chronologies (after Hock 1960) in ground squirrels in the Talkeetna Mountains, approximately 120 km south of the study area, are shown in Figure 7.

General observations indicated that the Susitna study area supports a relatively high and stable population of ground squirrels, probably comparable to densities reported elsewhere in the State. For example, in the Talkeetna Mountains to the south, Hock and Cottini (1966), on 20 June 1951, removed 27 squirrels from an area about 100 m x 50 m with little apparent decrease in numbers; the squirrel population in this

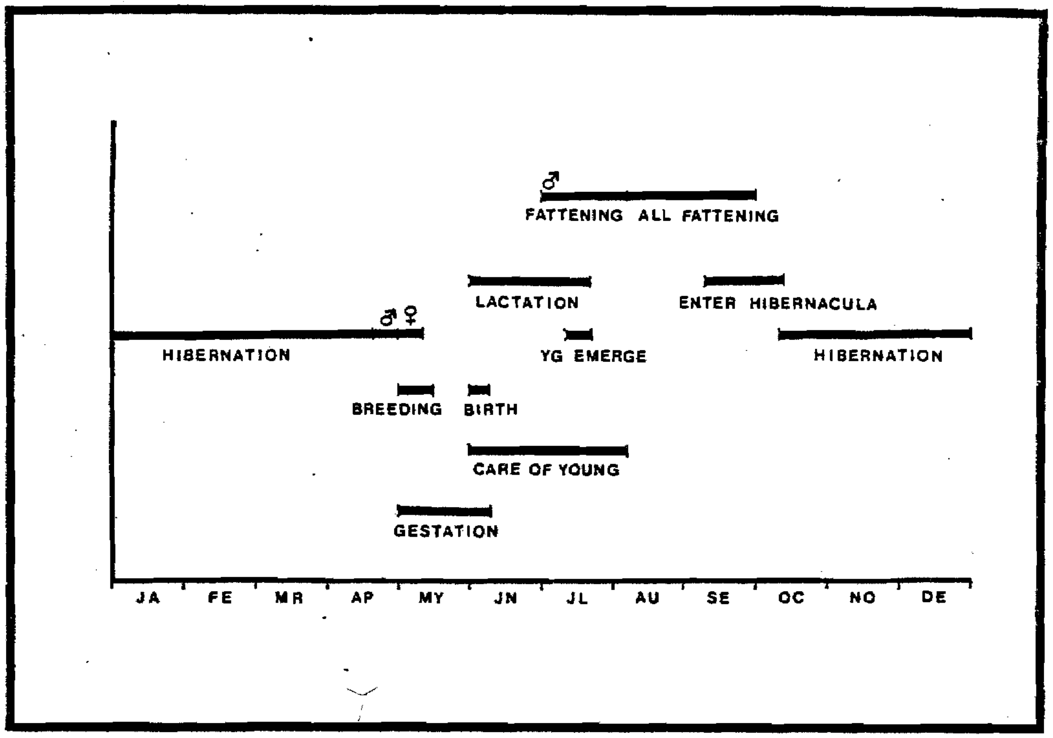

FIGURE 7

Seasonal chronologies of the arctic ground squirrel, Talkeetna Mountains near Anchorage, Alaska (after Hock and Cottini 1966).

area remained high throughout four years of study. In the eastern Brooks Range, Bee and Hall (1956) counted 175 ground squirrels along a 1-km ridge, and, in another location nearby, 70 squirrels on approximately 1.5 ha of hillside. At Ogotoruk Creek, near the extreme western end of the Brooks Range, Carl (1962, 1971) estimated a maximum number of 220 animals on his 29-ha (72-acre) study plot during the month of July 1961.

Hoary marmots were locally common residents of the alpine zone. We found scattered colonies above treeline above 1000 m. None was seen within proposed impoundment areas. Marmots hibernate longer than ground squirrels; in the Talkeetna Mountains near Anchorage, marmots emerge from hibernation during the first third of May and begin entering hibernacula in early September (Hock and Cottini 1966).

Hock and Cottini (1966) suggested that a portion of their marmot population underwent seasonal shifts in altitude, moving down from high rocky slopes in fall to sites having better soil conditions for winter denning and having an available food supply in early spring. An opposite seasonal movement apparently occurs in some Montana hoary marmot colonies (Barash 1974). The only suggestion of fall movement in the upper Susitna River Basin was the observation of several marmot trails and a single marmot traversing the 1067 m-high valley near Swimming Bear Lake (WB 150) in about 8 cm of snow on 10 October 1980 (T. W. Hobgood, pers. comm.).

Another locally common alpine species was the collared pika. It occurred regularly in talus slopes at higher elevations. As in the case of marmots, no pikas were seen below treeline.

Densities of pikas varied from five animals/ha in large rock slides, to 25/ha on small, isolated rock piles at Denali National Park in 1962 (Broadbooks 1965).

Active throughout the year (Sheldon 1930, Broadbooks 1965, Hock and Cottini 1966), pikas store large quantities of dried plant material in late summer for use during the winter months.

Evidence of avian predation on this species was our discovery of pika bones in a raptor "pellet" (bird species unknown) near the edge of montane alder thickets in fall 1981. Observations in other areas suggest that the short-tailed weasel (Mustela erminea) is an important mammalian predator of the pika (S. O. MacDonald pers. obs., Rausch 1961, Broadbooks 1965).

In contrast to the three alpine species, red squirrels, porcupines, and snowshoe hares were generally confined to the forested areas of the Basin. Within these areas red squirrels were fairly common, while porcupines and snowshoe hares were uncommon. Snowshoe hares, a major source of food for predators over much of central Alaska, were generally restricted to areas east of Watana Creek. Localized "pockets" occurred primarily in the vicinities of Jay Creek, Goose Creek, and the lower Oshetna River. Long-term information on overall hare abundance, provided by several local residents, indicated that the low number of hares during our study is a chronic situation and not just a low stage of a population cycle.

4.2 - Small Mammal/Habitat Relationships

(a) Shrews and Voles

Forty-two trapping sites were organized into floristically similar groups by using a cluster analysis of frequency counts of 81 plant taxa in the ground cover (Fig. 8). The major groups that emerged from this analysis corresponded to the following vegetation types of Viereck and Dyrness 1980: 1) herbaceous and dwarf and low shrub, 2) coniferous forest and woodland, and 3) mixed forest, deciduous forest, tall shrub, and tall grass. Within major groups, clustered subgroups roughly corresponded to sedge-grass

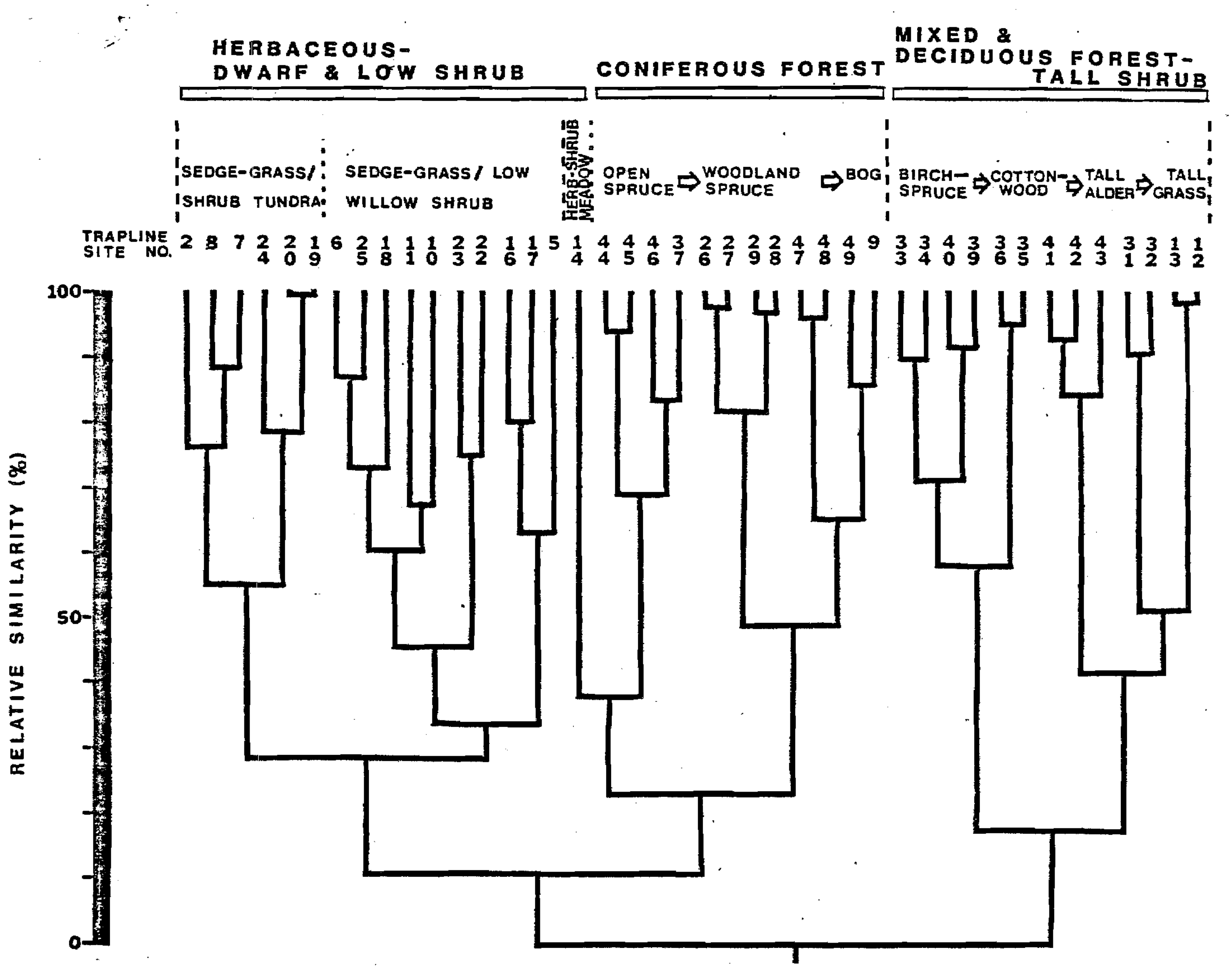

FIGURE 8

Clustering of 42 small mammal trapline sites into similar vegetative groupings, based on an analysis of frequency counts of 81 plant taxa in the ground cover.

and shrub tundra, sedge-grass and low willow shrub; herbaceous-mixed low shrub meadow, open white spruce forest to black spruce bog (low birch shrub sites also clustered with this group); and paper birch-white spruce forest, cottonwood forest, tall alder shrub, and tall grass meadow (the last with a tall shrub component). The number of captures of each small mammal species relative to these vegetation types is shown in Figure 9.

Trapline site ordination by principal component analyses (PCA) provided essentially the same general groupings as the clustering technique, despite use of structural habitat variables instead of plant taxa counts. This approach also tends to emphasize habitat continuity. The resultant ordinations of 43 trapline sites trapped in fall 1981 are shown in Figure 10, and those of 22 sites trapped during all three sampling periods are shown in Figure 12 (p. 124).

By using the relative abundance of a given small mammal species at each trapping site as a vertical axis on the PCA ordinations (see Section 2.8), a general habitat occupancy pattern becomes visible (Fig. 11). Shrews and red-backed voles in the upper Susitna River Basin displayed a relatively broad and uniform distribution pattern across the habitat landscape. Masked shrews, the numerically dominant shrew species, occurred at all trapping sites. They were most numerous in deciduous forest (particularly cottonwood), grassland, and tall shrub sites. Arctic shrews occurred at 29 trapline sites, with peaks of abundance on the drier non-forested sites, particularily grassland (at low elevations) and low shrub (above treeline). Dusky shrews were thinly distributed across the vegetation types of the study area. Although we captured them at 23 sites, no particular preferences were apparent; however, they may have avoided the wettest sites. The few captures of pygmy shrew in cottonwood forest (3 specimens), white spruce forest (1), and grassland (1) during the fall 1981 trapping, and open spruce forests (5) and cottonwood forest (1) during fall 1980, suggest a possible restriction of this species to forest.

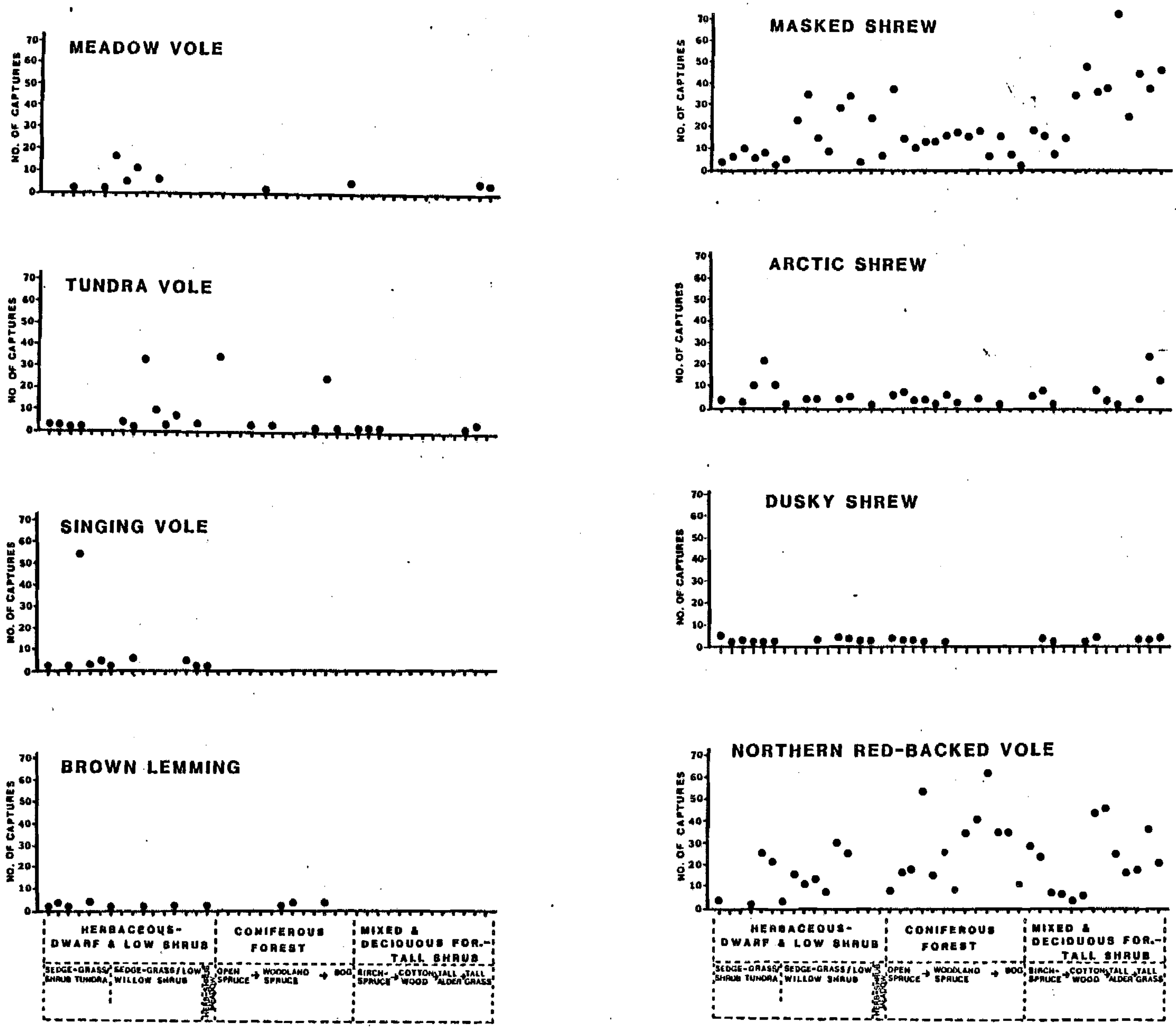

FIGURE 9

Abundance of eight small mammal species relative to vegetation types at 42 trapline sites in the upper Susitna River Basin, Alaska, 29 July-30 August 1981.

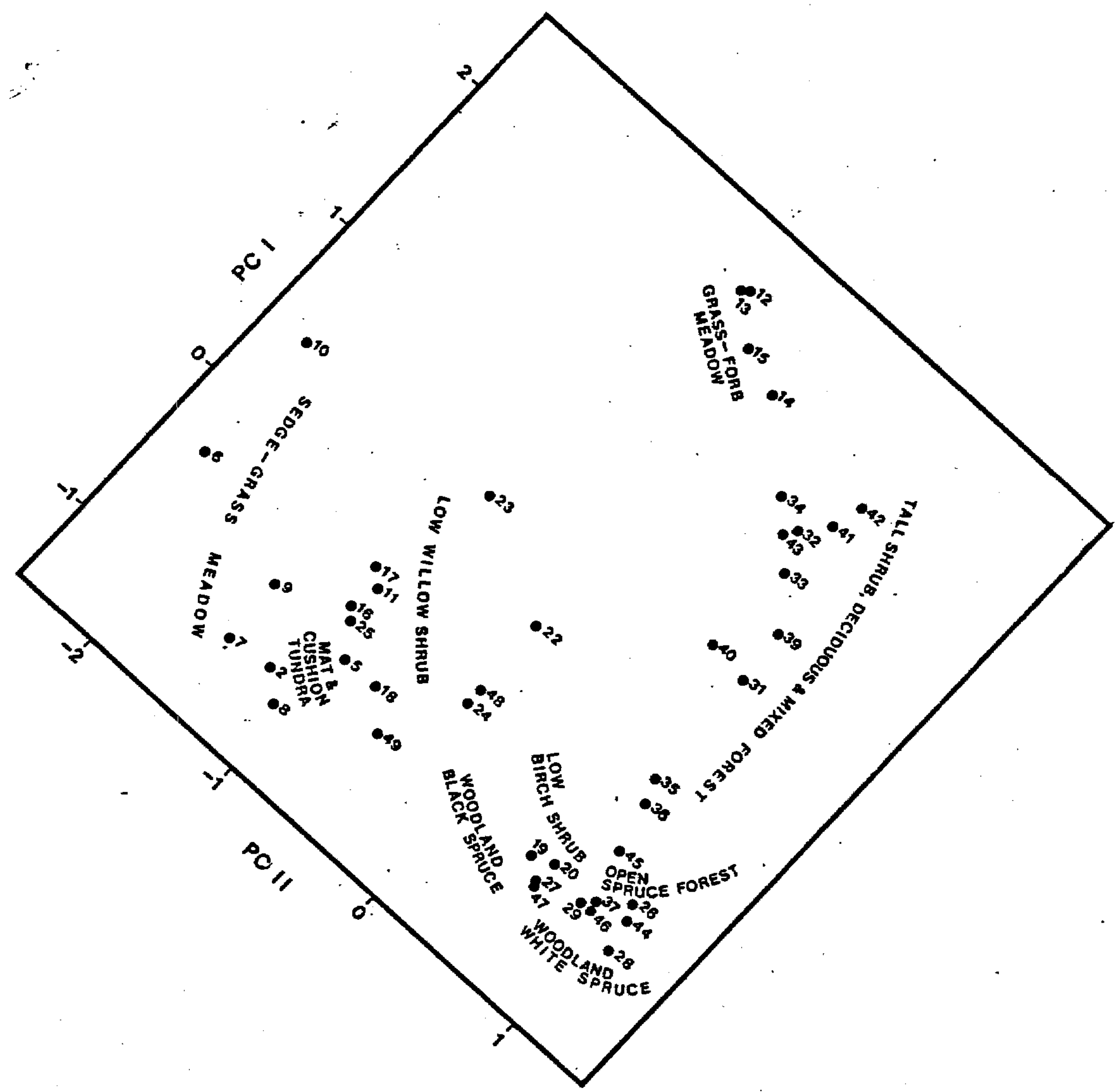

FIGURE 10

Two-dimensional ordination of 43 small mammal trapline sites trapped in fall 1981, upper Susitna River Basin, Alaska, based on principal component analyses of ground-level structural habitat variables. The two principal components accounted for 41% of total variance in measured variables among sites. Vegetation types that correspond to the groupings of mean factor score centroids are indicated.

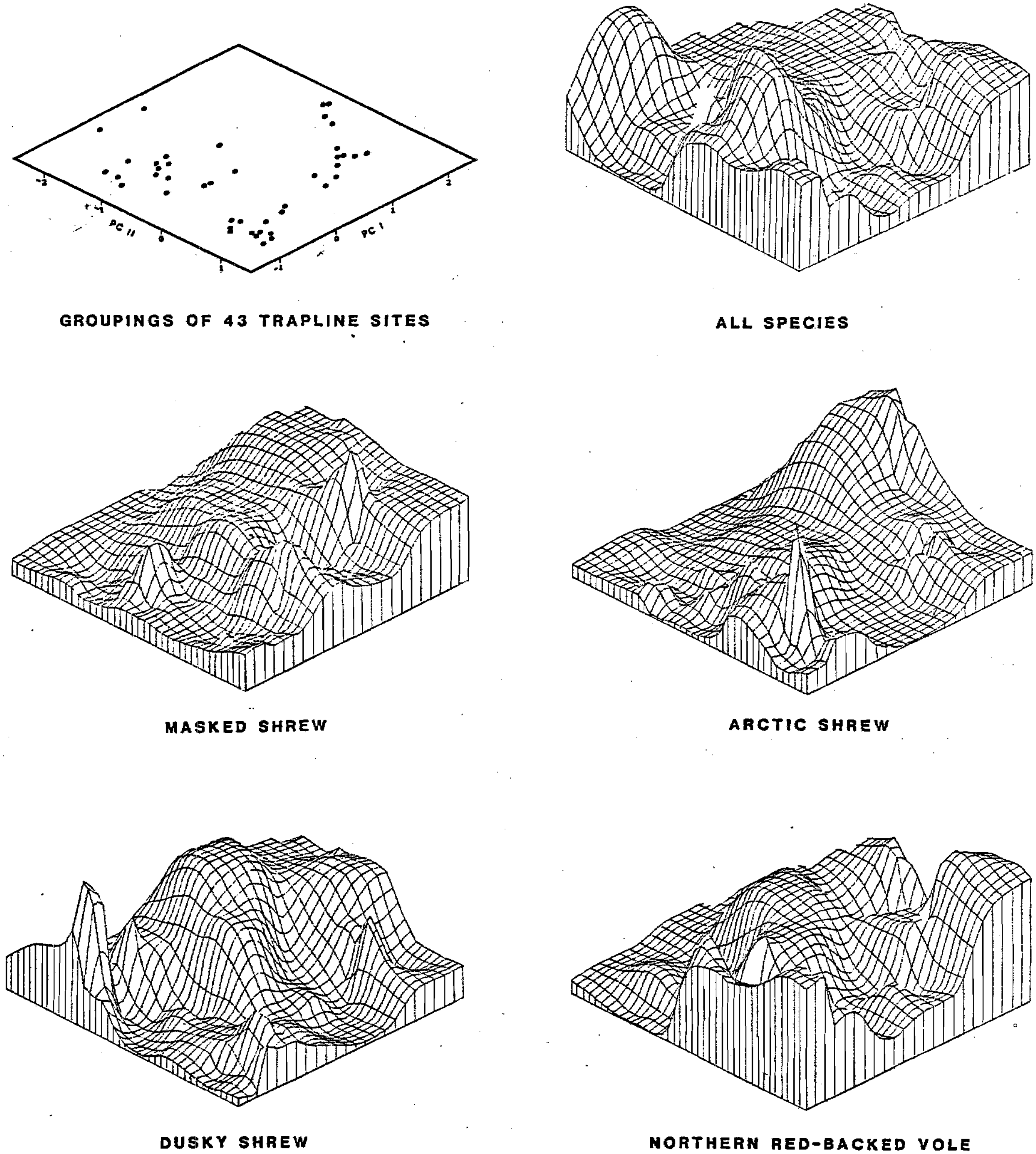

FIGURE 11

Habitat occupancy patterns of small mammals captured at 43 trapline sites, upper Susitna River Basin, Alaska, 29 July-30 August 1981. Species relative abundance has been added as a vertical axis to the two-dimensional PCA ordination shown in Figure 10 (see Methods, Section 2.8).

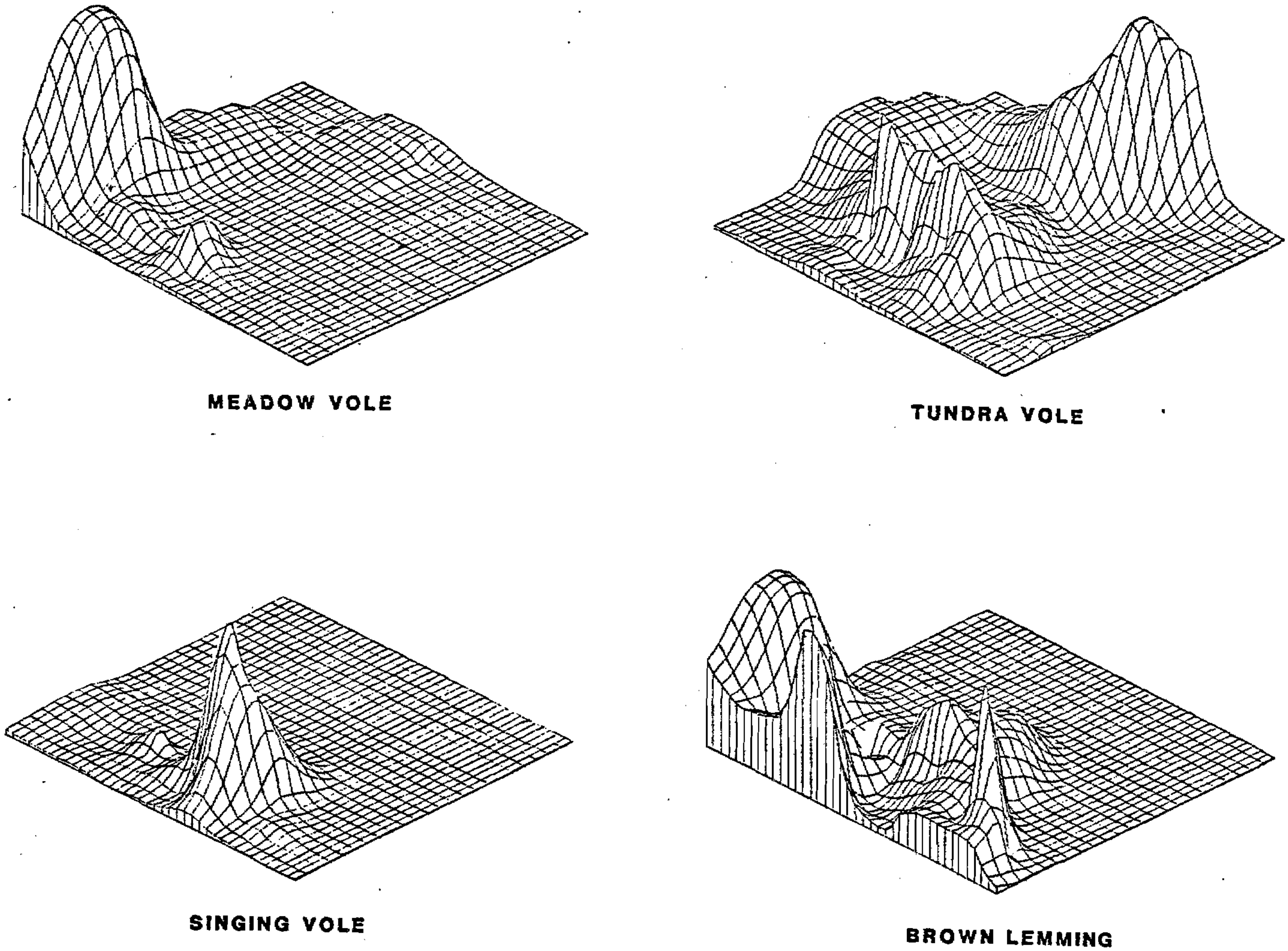

FIGURE 11 (Continued)

Red-backed voles, the dominant microtine of the region, occurred on all but five trapping sites. Although red-backed vole abundance levels were roughly similar across most forest and shrub types, greatest numbers occurred in open and woodland spruce and cottonwood forest sites. Herbaceous meadows, particularly in wet situations, harbored lower red-backed vole densities, as did paper birch forest.

In contrast to the more general habitat occupancy patterns of most shrews and of red-backed voles, the three Microtus species displayed stronger habitat specificity, as evidenced by their general restriction to open, non-forested sites (Fig. 11). Singing vole colonies were found in open low shrub, herbaceous tundra, and mat and cushion tundra above treeline. Captured on only 10 trapline transects, they were most abundant in open low willow-birch shrub on relatively dry soils. Tundra voles and meadow voles occurred primarily in sedge and grass-forb meadows and bogs. We captured tundra voles on 22 sites (primarily grass-forb, but also sedge-grass), compared to 10 for meadow voles (primarily wet sedge-grass). Small numbers of brown lemmings were captured on 11 sites at or above treeline, usually in wet herbaceous and low shrub situations. Bog lemmings were taken at lower elevations in mesic sedge-grass/low shrub meadow (2 captures), grass meadow (1), and near a seepage in white spruce forest (1).

Some of the small mammal species occupied a broad range of vegetation types, while others were more restricted. We quantified these differences by calculating a standardized habitat niche breadth measure for each species captured during fall 1981 (Table 23). The ubiquitous masked shrew and red-backed vole had the broadest habitat niche breadth, followed closely by dusky shrew and arctic shrew. Microtus species, and particularly singing voles, had the narrowest habitat niche breadths, along with the rare or uncommon pygmy shrew, bog lemming, and brown lemming.

TABLE 23

STANDARDIZED HABITAT NICHE BREADTH VALUES FOR TEN SMALL MAMMAL SPECIES SAMPLED BY SNAP AND PITFALL TRAPPING AT 43 SITES, UPPER SUSITNA RIVER BASIN, FALL 1981. (SEE SECTION 2.8 FOR CALCULATION OF Σd_i AND HABITAT NICHE BREADTH VALUES.)

Species (Sum of captures/100 TN [Σd_i])	Standardized habitat niche breadth value
Masked shrew (464.7)	0.60
Northern red-backed vole (454.8)	0.59
Dusky shrew (28.3)	0.45
Arctic shrew (96.3)	0.38
Brown lemming (10.2)	0.21
Tundra vole (87.7)	0.17
Northern bog lemming (2.2)	0.09
Meadow vole (43.8)	0.08
Pygmy shrew (2.8)	0.08
Singing vole (42.7)	0.05

As population densities fluctuate over time, a species might be expected to expand its range into suboptimal habitat during periods of high density and contract its range to optimal habitat during periods of low density (Guthrie 1968, others). Changes in habitat niche breadth for species captured in the upper Susitna River Basin generally reflect such changes (Table 24). Variation in habitat niche breadth between periods seems to parallel changes in abundance for masked shrews, red-backed voles, and dusky shrews. In masked shrews and red-backed voles, niche breadth varied little, despite large variations in abundance. Range contraction did not occur in arctic shrews, however, which increased in niche breadth despite a slight decline in abundance. The habitat niche breadth of the tundra vole remained essentially constant, despite a two-fold population increase from fall 1980 to fall 1981. The opposite occurred with the meadow vole, in which abundance levels were constant from fall to fall, yet niche breadth increased.

Interspecific interactions, particularly among ecologically similar species, can play a major role in determining intraspecific habitat utilization (MacArthur and Wilson 1967) and may help explain the apparent anomalies we witnessed in shifts of habitat niche breadth values. To avoid competing for limited resources, species may occupy different habitats, or may occupy the same habitat but exploit its resources (food, den sites, etc.) in different ways and/or at different times. Closely related species, similar in size and broadly overlapping in food requirements, should display the greatest degree of habitat segregation (Grant 1978). Discrete habitat distribution patterns among the Basin's three Microtus species (Fig. 11) supports this conjecture: Singing voles and meadow voles occupied a narrow and non-overlapping range of habitats, suggestive of species having strong and different habitat preferences. Tundra voles, in contrast, displayed a more diffuse and overlapping pattern of habitat occupancy, suggestive of a more ecologically flexible species, although their peak densities occurred on sites essentially devoid of either congener.

TABLE 24

STANDARDIZED HABITAT NICHE BREADTH VALUES FOR SIX SMALL MAMMAL SPECIES CAPTURED ON 22 TRAPPING SITES, DURING THREE SAMPLING PERIODS, UPPER SUSITNA RIVER BASIN, 1980-81. (SEE SECTION 2.8 FOR CALCULATION OF HABITAT NICHE BREADTH VALUES.)

	Standardized habitat niche breadth values (Sample size)		
Species	Fall 1980	Spring 1981	Fall 1981
Masked shrew	0.71(361)	0.34(39)	0.76(478)
Dusky shrew	0.65(96)	0.00(0)	0.47(26)
Arctic shrew	0.31(118)	0.04(3)	0.44(101)
Northern red-backed vole	0.68(333)	0.57(94)	0.78(616)
Meadow vole	0.05(13)	0.00(0)	0.13(13)
Tundra vole	0.16(24)	0.04(1)	0.17(57)

A comparison of the habitat occupancy patterns of the tundra and meadow voles between fall 1980 and fall 1981 (Fig. 13) shows that while the tundra vole population increased substantially the second year, spill-over into other meadow habitats was not evident (breadth values remained constant). Also, while meadow vole abundance was similar between years, habitat shift and expansion occurred the second year (breadth values increased)--but into habitats not occupied by its congener. Habitat segregation between two similar species was thus maintained and the possibility for overt competitive interactions reduced.

There was no clear pattern of habitat segregation between red-backed voles and Microtus species. Capture information on sites with low numbers of Microtus in fall 1980 and high numbers the following year showed an inverse relationship in red-backed vole numbers (in spite of the fact that this vole was also more abundant the second year). West (1979), noting a similar situation for red-backed voles and Microtus in the Yukon-Tanana Highlands, attributed it to competitive exclusion. Other studies (Morris 1969, Turner et al. 1975) also have shown that Microtus and red-backed voles tend to exclude each other from certain sites.

Among members of the Susitna River Basin's diverse microtine fauna, then, red-backed voles were the most abundant and widespread. A habitat generalist, the species dominated the forest and shrublands of the area. Open herbaceous-dominant habitats, left vacant by declining Microtus populations, were quickly colonized and dominated by this adaptable vole, which has a relatively unspecialized tooth structure (Guthrie 1965) and generalized feeding habits (Guthrie 1965, Grodzinski 1971, Bangs 1979, West 1979). Although red-backed vole numbers can vary considerably from year to year, the magnitude of change is usually less dramatic (and also less predictable) than that of such open country species as Microtus and Lemmus (Pitelka 1967, Whitney 1976, West 1979).

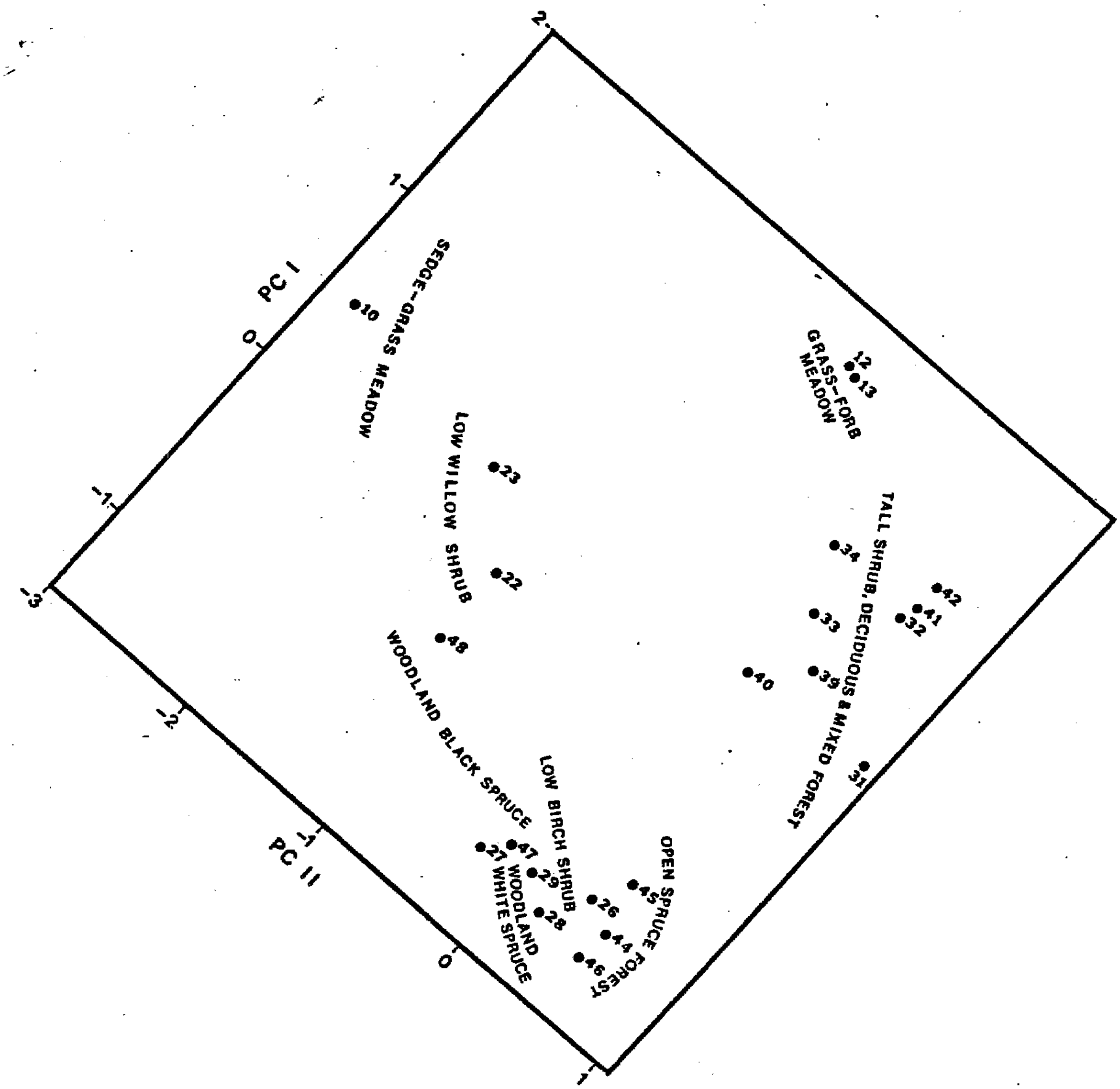

FIGURE 12

Two-dimensional ordination of 22 small mammal trapline sites trapped during all three 1980-81 sampling periods, upper Susitna River Basin, Alaska, based on principal component analyses of ground-level structural habitat variables. The two principal components accounted for 40% of total variance in measured variables among sites. Vegetation types that correspond to the groupings of mean factor score centroids are indicated.

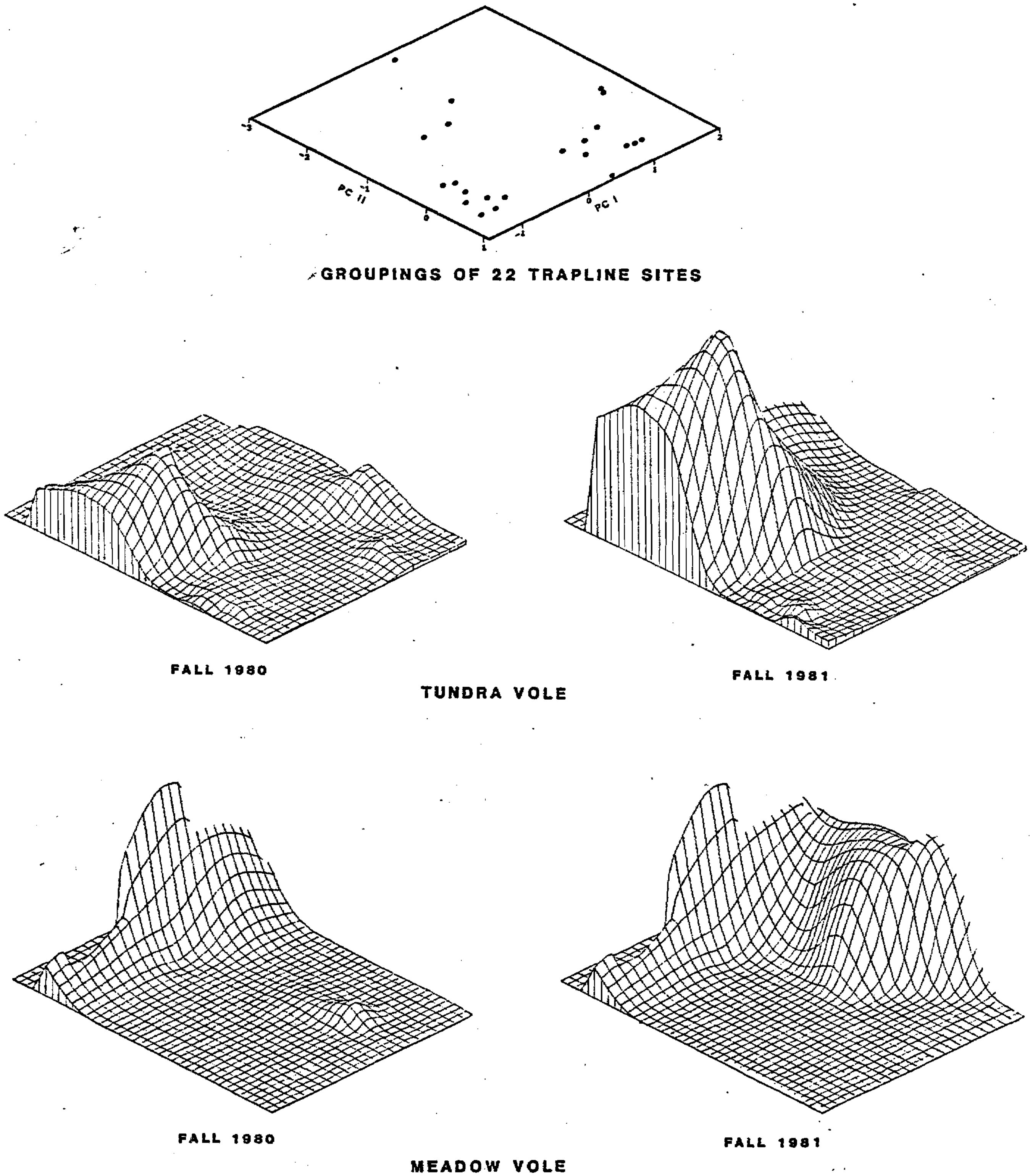

FIGURE 13

Changes in habitat occupancy patterns of tundra voles and meadow voles between fall 1980 and fall 1981, upper Susitna River Basin, Alaska. Species relative abundance has been added as a vertical axis to the two-dimensional PCA ordination shown in Figure 12 (see Methods, Section 2.8).

Members of the genus Microtus were restricted to, and specialized in, meadow and meadow/shrub habitats found scattered about the Basin's landscape. All have more specialized tooth morphologies and diets than have red-backed voles (Guthrie 1965, West 1979). The similarity of habitat and trophic requirements among Microtus is most pronounced in tundra voles and meadow voles (West 1979), and the impact of competition probably plays a major role in determining the dynamic spatial relationships between the two. Among Microtus, tundra voles appear the most ecologically flexible, in that they have a somewhat simpler tooth structure (Guthrie 1965), broader food habits (West 1979), and wider tolerance to differing vegetation types (West 1979, this study) than have their congeners. As suggested by West (1979), such flexibility probably accounts for the fact that among the three Microtus species occurring in the Susitna Basin, tundra voles seemed better able to find and exploit isolated "pockets" and border patches of suitable habitat. This flexibility might also explain why tundra voles were the only Microtus found on the two Susitna River islands sampled during 1981.

Northern bog lemmings and brown lemmings did not appear to be major microtine constituents in the study area. Bog lemmings are generally uncommon throughout their range, and little is krown of their ecological requirements (Banfield 1974, West 1979, MacDonald 1980). In other areas of the State, small numbers have been taken primarily in shrub bogs and marshes (Osgood 1900, Dice 1921, West 1979, MacDonald 1980)--not unlike the few sites where we found them during this study. Their diet is apparently restricted to sedges, grasses, some forbs (Cowan and Guiguet 1956) and mosses (West 1979).

Although the high country of the upper Susitna Basin has an apparent abundance of suitable brown lemming habitat, we captured only small, scattered numbers during our study. They have been found in fairly large numbers in other montane areas of central Alaska (R. L. Rausch pers. comm.), so perhaps we failed to sample the right habitat, or, more likely, sampled during a period of low population levels. Brown lemmings are usually associated with wet sedge-grass tundra above treeline, but are also found locally at lower elevations in spruce bogs and wet meadows (Buckley and Libby 1957, Banfield 1974). This species is almost completely dependent on a diet of sedges and grasses (Guthrie 1968), although mosses may be important at times (West 1979).

Among the insectivorous shrews, habitat occupancy patterns indicated considerable spatial overlap between species and only weak habitat preferences. Hence, competition could help explain the apparent inverse relationship of masked shrew abundance and the abundance of the other shrew species, particularly the similarly-sized dusky shrews and pygmy shrews. Confounding factors, not obvious from our data, could also be involved (Terry 1981): (1) Shrews coexist in the same habitats, and their environmental requisites are less similar than assumed (Disparity in body size between masked shrews and arctic shrews suggests the ability to coexist [see Brown 1975], which might explain why arctic shrew abundance appeared least affected by masked shrew abundance in fall 1981); (2) they occupy distinct subdivisions of the habitats (i.e., microhabitats); or (3) habitat coexistence (macro- and micro-) is occurring because critical resources are not limited.

(b) Other Species

Arctic ground squirrels inhabit herbaceous tundra and open shrub habitats above treeline (Guthrie 1967, Kurtén and Anderson 1980, this study). At lower elevations they also colonize riverbanks, lakeshores, moraines, eskers, road sidings, and other disturbed sites with subclimax vegetation (Banfield 1974, Guthrie 1968, this study). Our observations corroborate Bee and Hall's (1956) conclusion for the Brooks Range that the optimum conditions for ground squirrel colonies are (1) loose permafrost-free soils on well-drained slopes, (2) vantage points from which the surrounding terrain can be observed, and (3) bare soils surrounded by vegetation that is in an early xerosere stage of succession. Carl (1962) found ground squirrels avoided sites where tall vegetation (greater than 20 cm) impaired vision. The effects of squirrel activity--e.g., burrowing, mound building, feeding, feces deposition--within areas of established colonies tends to maintain vegetation at an early successional stage (Carl 1962, Youngman 1975).

Hoary marmots and collared pikas are generally restricted to tundra/block-field habitats at high elevations (Hoffmann et al. 1979, this study). Both are ecotone species: their homes and shelters are in one habitat (rocks of various particle size and shape) and their food in another (various herbaceous tundra types) (Broadbooks 1965). The co-occurrence of marmots, pikas, and even ground squirrels in apparently the same habitat suggests high potential for both competitive and cooperative interactions.

The arboreal red squirrel occupies a variety of forest habitats, but prefers mature coniferous forest (Cowan and Guiguet 1956). White spruce forest is generally considered the optimal habitat in interior Alaska (Nodler 1973, others). Here, red squirrels feed primarily on the seeds of spruce, particularly white spruce, but supplement their diet with fungi, fruits, and even the buds of spruce and aspen (Smith 1967, Nodler 1973). They store large quantities of spruce cones, and mushrooms when available, in "middens" for winter use (Murie 1927, Streubel 1968). Buskirk (pers. comm.) noted that, in fall 1981, red squirrel middens in his study area appeared composed only of mushrooms and spruce buds. A massive cone crop failure caused by an area-wide epidemic of white spruce needle rust (<u>Chrysomyxa ledicola</u>) during 1980 (J. H. McBeath, Univ. Alaska Agric. Expt. Station, pers. comm.) would explain why squirrels were storing such low quality food as spruce buds (Smith 1967). What long-term effects this crop failure might have on the upper Susitna River Basin's red squirrel population is not known, but Smith (1967) reported a 67% drop in a red squirrel population following the second year of a two-year cone crop failure in white spruce forest and suggested that the squirrels had emigrated into surrounding black spruce stands.

Porcupines occupy a broad range of forest and shrub habitats (Woods 1973). In mountainous regions they prefer heavily wooded forests during the winter (Hock and Cottini 1966, Harder 1979), but may occasionally be found above treeline, even during the coldest months (Irving and Krog 1955). We recorded occasional porcupines only in forested areas of the upper Susitna River Basin.

In interior Alaska, Wolff (1977) found that snowshoe hare habitat preference depended on population density: during population lows hares were restricted to dense black spruce forest and willow-alder thickets; during highs they used a wider variety of vegetation types, including recently burned areas with minimal cover. He concluded that a patchy environment of recently burned sites with inclusions of unburned spruce was the preferred hare habitat. The chronic scarcity of snowshoe hares in the upper Susitna River Basin was probably related to a scarcity of suitable habitat. Noticeably absent from this area were recent burns and riparian shrub thickets--early successional habitats that could provide hares the opportunity to substantially increase and expand their numbers beyond the safe but unproductive stands of dense spruce and alder thickets in which we found them.

5 - ANTICIPATED IMPACTS

5.1 - Watana Dam and Impoundment

(a) Impoundment

The general types of impacts on raptors that can result from development activities are listed in Tables 17-19; inundation is an additional impact of hydroelectric projects. The Watana impoundment would flood 15.1 km of the better quality raptor cliffs (type "A"), leaving only 0.9 km above waterline (Table 20). Four active and four inactive Golden Eagle nest sites, two active and one inactive Bald Eagle sites, and two inactive raven sites would be destroyed (Table 21). Loss of this nesting habitat would force these birds to other sites, either along the remaining cliffs of the Susitna River and tributaries or in the nearby cliff-tor habitat of the uplands, or, in the case of Bald Eagles, to other nest trees. Unflooded cliff habitat in the surrounding area (e.g., along Fog and Tsusena creeks and those draining into the south side of the Devil Canyon impoundment) could increase in importance to these birds. If fish became available in the impoundment (which now appears unlikely), Bald Eagles might use large trees surrounding the impoundment for nesting.

The impoundment would destroy the breeding habitat of about 33,000 pairs of small- and medium-sized upland birds (Table 25). More than 1000 breeding territories of each of 13 bird species would be flooded (Table 25), with the following species each losing over 2000 breeding territories: Yellow-rumped Warbler (3900), Ruby-crowned Kinglet (3600), Dark-eyed Junco (3000), Swainson's Thrush (2900), Tree Sparrow (2800), Varied Thrush (2000), and Wilson's Warbler (2000). Approximately 65 km^2 of forest habitats would be inundated, habitats that generally support the highest bird densities of the region (Table 8). A number of bird species are restricted to forest habitats for breeding (see Table 9), as

TABLE 25

NUMBER OF BREEDING TERRITORIES OF SMALL- AND MEDIUM-SIZED UPLAND BIRDS THAT WOULD BE IMPACTED THROUGH HABITAT DESTRUCTION OR ALTERATION AS A RESULT OF THE SUSITNA HYDROELECTRIC PROJECT, ALASKA. (NUMBERS WERE DERIVED FROM THE DENSITIES OF SPECIES TERRITORIES ON THE RESPECTIVE BIRD CENSUS PLOTS IN 1981, MULTIPLIED BY THE AREA OF CORRESPONDING AVIAN HABITAT TO BE AFFECTED BY THE PROJECT [TAKEN FROM PLANT ECOLOGY REPORT, APA 1982].)

	WATANA			DEVIL CANYON			ACCESS	TOTAL
Species	Impoundment	Construction Zone	Total	Impoundment	Construction Zone	Total	Total	
Spruce Grouse	210	200	410	102	244	346	38	794
Willow Ptarmigan	11	73	84	1	7	8	3	95
Rock Ptarmigan							2	2
Am. Golden Plover		30	30		1	1	3	34
Greater Yellowlegs	4	11	15		5	5		20
Common Snipe	407	313	720	14	29	43	1	764
Least Sandpiper		10	10				1	11
Baird's Sandpiper		20	20		1	1	2	23
Hairy Woodpecker	105	100	205	51	122	173	21	399
Downy Woodpecker							1	1
N. 3-toed Woodpecker	395	210	605	78	162	240	13	858
Alder Flycatcher							3	3
Horned Lark		15	15				2	17
Gray Jay	524	292	816	114	325	439	35	1290
Black-capped Chickadee							5	5
Boreal Chickadee	670	527	1197	151	334	485	52	1734
Brown Creeper	105	100	205	51	122	173	5	383
American Robin	239	185	424	8	41	49	24	497
Varied Thrush	2014	1217	3231	649	1214	1863	174	5268
Hermit Thrush	991	576	1567	492	699	1191	98	2856
Swainson's Thrush	2928	2060	4988	1140	2166	3306	302	8596
Gray-cheeked Thrush	1122	1083	2205	41	190	231	16	2452
Wheatear		2	2					2
Arctic Warbler	476	1747	2223	19	294	313	62	2598
Ruby-crowned Kinglet	3555	2304	5859	538	1110	1648	117	7624
Water Pipit		41	41		2	2	5	48
Yellow-rumped Warbler	3921	2931	6852	1442	2527	3969	367	11,188
Blackpoll Warbler	1207	968	2175	331	493	824	62	3061
Northern Waterthrush	270	253	523	133	307	440	67	1030
Wilson's Warbler	2008	4736	6744	439	1442	1881	236	8861
Common Redpoll	1196	1182	2378	368	734	1102	115	3595
Savannah Sparrow	1486	4294	5780	50	569	619	157	6556
Dark-eyed Junco	2983	2112	5095	739	1595	2334	209	7638
Tree Sparrow	2803	6777	9580	102	1032	1134	234	10,948
White-crowned Sparrow	1610	2850	4460	62	492	554	74	5088
Fox Sparrow	1621	1363	2984	192	486	678	63	3725
Lapland Longspur	34	278	312	4	22	26	17	355
Snow Bunting		15	15				2	17
TOTAL BREEDING PAIRS	32,895	38,875	71,770	7311	16,767	24,078	2588	98,436

are red squirrels and porcupines. While this habitat loss would constitute a major impact on these species, most are common in the area (Table 7) and are represented by healthy populations in adjacent regions.

Flooding of the fluviatile shorelines and alluvia, both in the main Susitna River and up the mouths of tributary creeks, would destroy breeding habitat of a few bird species (Harlequin Duck, Common Merganser, Semipalmated Plover, Spotted Sandpiper, Wandering Tattler, Arctic Tern, Dipper) and thus reduce their numbers in the Basin. Some of these species are considered uncommon, but none rare, in the region. Impact on wintering habitat of the Dipper (open water along fast-running tributaries and in the Susitna River channel) might be the most serious impact in this category, because local alternative sites of open water might not be available. Flooding would also deprive early migrant waterfowl of one of the first sources of open water in the region--the rapidly flowing waters of the Susitna River. Both of these impacts might be alleviated if year-round open water was provided by the project between Devil Canyon dam and Talkeetna.

The large impoundment that would be formed could provide habitat for waterbirds, but the degree of utilization would depend upon the rate and kind of development of food resources in the new lake. Because of the late spring thaw, the lake would be available only for the late-migrating diving ducks, loons, and grebes; but in fall it might remain open long enough to be used by late-migrating swans. As with the other large lakes of the region, a low level of use by breeding waterfowl can be anticipated, provided food resources are available. The drawdown zone would impede use of the reservoir edge by nesting loons and grebes, which usually nest at the edge of sedge shorelines or on small low-lying islands; but, where narrow, it might not impede waterfowl nesting, because many species nest farther back from the water's edge if appropriate cover is available. Migrant shorebirds, whose main movement passes through central Alaska during the last three weeks of May, would probably use exposed areas of the drawdown zone for resting and feeding. This zone would be an ecological desert for small mammals.

(b) Camp/Village Sites/Construction Zone

Impacts caused by factors other than flooding (e.g., camp/village sites and borrow areas) would be of two main types: 1) habitat destruction and alteration and 2) disturbance to animals themselves, especially birds, by various types of human activities during and after construction. The "construction zone" (defined by the Plant Ecology report, APA 1982, as all facilities components except the impoundment) for the Watana facility would impact almost as much area as the impoundment (13,725 ha vs 14,691 ha; APA 1982), and would affect the breeding habitat of 39,000 pairs of birds (Table 25). The species subject to the highest losses would be Tree Sparrow (6800 breeding territories), Wilson's Warbler (4700), and Savannah Sparrow (4300), primarily because the construction zone would impact large areas of upland shrub habitats used by these common to abundant species. Additionally, the habitat of over 1000 breeding pairs each of another nine bird species would be impacted, including some using the more restricted forest habitats (Yellow-rumped Warbler, Ruby-crowned Kinglet, Dark-eyed Junco, Swainson's Thrush, and Varied Thrush). The overall effect on the populations of the common upland shrub-nesting species probably would not be too serious, because upland shrub habitats are widespread in the region and could probably absorb the displaced birds. It is unlikely, however, that the displaced forest-nesting birds could find alternative sites in the more restricted and more heavily impacted forest habitats.

About camp/village sites, ground squirrels could be expected to increase and become tame, especially if fed by workers, and would probably become pests. Some birds, too, such as ravens, magpies, and Mew Gulls, would be attracted to any open refuse dumps.

Perhaps more importantly, there could be significant effects on sensitive bird species and habitats near camp/village sites, primarily on raptors and on waterbirds and wetland habitats. Increased air traffic over the Fog Lakes wetlands as a result of activities about the dam site or about the south-side camp/village site, or over the Stephan-Murder lake area as a result of trips between Watana and Devil Canyon camps/villages/dam sites, could adversely impact waterfowl populations. While it is possible that some individuals of some species might show some habituation to these disturbances, the net result would be a reduction in the suitability of these areas for raptors and waterfowl.

A few waterbirds use the small ponds between Deadman and Tsusena creeks, but because their numbers are small, potential losses caused by human activities would be minor relative to their overall population levels in the region.

The camp site is adjacent to raptor/raven cliff habitat along Deadman Creek. An active raven nest and territorial Merlins were observed here in 1981. The habitat at this location would be flooded, eventually, by the impoundment, so the major impact would be from proximity to the reservoir rather than to the camp.

The village site is within 1.5 km of a Bald Eagle nest that was active in both 1980 and 1981. While this nest is a borderline distance from the village site relative to disturbance, activity by future village residents any closer than this distance would most likely cause the eagles to desert this nesting area.

5.2 - Devil Canyon Dam and Impoundment

(a) Impoundment

The Devil Canyon impoundment would have many of the same effects on bird and non-game mammal populations as the Watana impoundment. The impoundment would flood 27.4 km of the better quality raptor cliffs (type "A"), but would leave 24.9 km above waterline. One active and two inactive Golden Eagle nest sites and one active and one inactive raven site would be destroyed. (Table 21).

As mentioned above, in spite of the presence of cliffs with good structural characteristics, Devil Canyon is for some reason little used for raptor nesting. Possibly, the deep, narrow canyon with its often strong and buffeting winds makes this area undesirable for raptors. With the filling of the deeper, narrow portions of the canyon upstream of the Devil Canyon dam, the environmental conditions along the remaining type "A" cliffs conceivably could be altered enough to make the cliffs more attractive to raptors and ravens. That is, the remaining canyon would be wider and shallower and perhaps have less violent winds and thus might be more hospitable to cliff-nesting birds. If not, birds nesting in the impoundment area would be forced elsewhere, either to the remaining cliffs of the Susitna River and tributaries or to the nearby cliff-tor habitat of the uplands. Unflooded cliff habitat along Portage and Devil creeks and others draining into the south side of the proposed Devil Canyon impoundment (e.g., Cheechako Creek) might become important to the displaced birds.

In addition to cliff habitat, the Devil Canyon impoundment would destroy the breeding habitat of over 7000 pairs of small- and medium-sized upland birds (Table 25), including 21 km^2 of forest habitats, which are generally the most productive avian habitats of the region (Table 8). The Swainson's Thrush and Yellow-rumped Warbler, both forest-nesting species, would each lose over 1100 breeding territories. A number of other bird species are also restricted to these forest habitats for breeding (see Table 9), as are red squirrels and porcupines.

Flooding of the fluviatile shorelines and alluvia by the Devil Canyon impoundment would destroy the breeding habitats of the same bird species affected by the Watana inundation--Harlequin Duck, Common Merganser, Semipalmated Plover, Spotted Sandpiper, Wandering Tattler, Arctic Tern, Dipper--and would similarly impact the wintering habitat of the Dipper (open water along fast-running tributaries and in the Susitna River channel). Flooding would also deprive early migrant waterfowl of one of the first sources of open water in the region--the rapidly flowing waters of the Susitna River--unless waters farther downstream were available as a result of the project.

As with Watana, the Devil Canyon reservoir could provide habitat for waterbirds, but the degree of utilization would depend upon the rate and kind of development of food resources in the new lake. Because of the late spring thaw, the lake would be available only for the late-migrating diving ducks, loons, and grebes; but in fall it might remain open long enough to be used by late-migrating swans. As with the other large lakes of the region, a low level of use by breeding waterfowl could be anticipated, provided food resources are available.

Because of the steep banks and more limited extent of drawdown compared to the Watana impoundment, the changed shoreline at the Devil Canyon site probably would not exert the level of impact of Watana. There would be less waterbird nesting habitat around the impoundment's shoreline and less drawdown area to attract migrant shorebirds.

(b) Camp/Village Sites/Construction Zone

The impact of the Devil Canyon camp/village sites would generally be the same as those at the Watana sites, that is, habitat destruction and alteration compounded by disruption from human activities during and after construction. The construction zone for the Devil Canyon facility would impact almost three times the area of the impoundment (Plant Ecology report, APA 1982) and would affect the breeding habitat of 17,000 pairs of birds (Table 25). Since 45 km^2 of forest habitat would be affected, including 24 km^2 of mixed deciduous-coniferous forest, the impact would be greatest on forest-inhabiting species: Yellow-rumped Warbler (2500 breeding territories destroyed), Swainson's Thrush (2200), Dark-eyed Junco (1600), Varied Thrush (1214), and Ruby-crowned Kinglet (1100). In addition, over 1000 breeding territories each of two shrub birds would be affected, Tree Sparrow and Wilson's Warbler.

An active Golden Eagle nest site along the north side of the Susitna River, below the dam site, is 1.5 km from the camp site and 1.6 km from the village site. In 1974, a Gyrfalcon nested in Cheechako Creek Canyon, 2.2 km east of the village site (White 1974). This nest site was active in 1980 (species unknown) and was inactive in 1981. It is unlikely that either raptor site would be seriously disturbed by activities in the vicinity of the proposed Devil Canyon camp/village sites, either because of distances involved or, in the case of the eagle nest, because of the intervening Susitna River.

No wetlands significant to waterbirds occur in this area, but air traffic between Devil Canyon and Watana camp/village/dam sites could adversely impact the relatively important Stephan-Murder Lake wetlands, especially if overflights were at low elevations AGL. Landing aircraft on lakes when swans were present would drive them from the lakes (J. G. King and T. N. Bailey, USFWS, pers. comm.).

(c) Dam Site

Cheechako Creek, the tributary canyon 1.0 km southeast of Devil Canyon dam site and south-southeast of Borrow G contains raptor cliff habitat. A Gyrfalcon nested here in 1974 (White 1974), and a Goshawk nested in birch woods on the east bank in 1981. Raptors would probably be driven from these sites by construction activities, but if care were taken to avoid damage to the canyon itself, individuals could be expected to return to nest in the area after activities subside. Human activities associated with a proposed recreation facility in the Cheechako Creek area, however, would probably cause permanent desertion of the area by raptors.

5.3 - Borrow Areas

Mining of borrow areas would cause two main types of impacts: 1) habitat destruction and alteration and 2) direct disturbances due to human activities. The potential effects of borrow mining on the number of breeding territories of small- and medium-sized upland birds have been included above under the "Construction zone" discussion of the respective dam facilities and below under access road. Overall, the amounts and types of avian and small mammal habitat that would be impacted by any and all of the possible borrow areas appear small relative to the availability of these habitats in the region. Some borrow areas would eventually be flooded anyway, and some (Borrow E) would eventually be recontoured by subsequent seasonal river action.

The specific effects of borrow mining would vary somewhat at each site, depending on the types of habitats destroyed and the types that would remain after construction and reclamation activities. Birds and small mammals dependent on the destroyed or altered habitats would disappear, whereas new habitats formed would increase populations of species that favor the newly created habitats. Replacement shrub and forest habitats would be slow in forming, because of the harsh environment at the elevations of most of the proposed construction; most of the present woody habitats are over 100 years old. Overall impact on forest habitats would be greater than on shrub habitats, partly because of the relative proportions in which each occurs in the region and partly because a high proportion of the forest habitats, which are already less extensive, would be inundated by the proposed reservoirs and otherwise affected by construction zone activities. Thus, the additional loss of forest habitats to borrow areas would have more of an impact on the avifauna than would destruction of relatively prevalent shrub habitats.

The activity and noise surrounding the mining operations might disturb breeding raptors/ravens at nearby cliffs. Following is a list of the nest sites within about 1.6 km (1 mile) of the potential borrow areas and thus potentially subject to disturbance. Any nest sites not in use by 1 June in any year could be considered inactive in that year (Roseneau et al. 1981) and not subject to the impacts of construction noises and the movement of equipment.

(a) Borrow Areas B and D

(i) 40 m and 200 m, respectively, from an active raven nest along Deadman Creek that would eventually be inundated by Watana impoundment

(b) Borrow Area E

(i) 50 m from Golden Eagle nest site

(ii) 0.5 km from two raven nest sites

(c) Borrow Area G

(i) 1.3 km from 1974 Gyrfalcon nest and 1981 Goshawk nest

(d) Borrow Area H (adjacent to Fog Creek)

(i) 0.3 km from raven nest site

(ii) 0.4 km from two unknown species of raptor/raven nest sites

(iii) 0.8 km from three raven nest sites

(iv) 0.0 km from 1974 Goshawk nest (White 1974)

(e) Borrow Area I

(i) 0.6 km from Golden Eagle nest site

(ii) 1.7 km from a raven nest site and two unknown species of raptor/raven nest sites in Fog Creek

(f) Borrow Areas J and L

(i) 1.0 km and 2.0 km, respectively, from an active raven nest along Deadman Creek that would eventually be inundated by Watana impoundment

(ii) 50-100 m from two Golden Eagle nests that would eventually be inundated by Watana impoundment

(g) Borrow Area K

(i) 1.6 km from 1981 Goshawk nest and 1974 Gyrfalcon nest

5.4 - Access Route

Construction, maintenance, and use of the access route would have three main types of impacts: 1) destruction of habitat for the roadbed itself and alteration of habitat adjacent to the road and in borrow areas, 2) disturbances, such as noise and moving equipment, along the road, and 3) increased access to the region and therefore increased use by humans. The effect of this last impact on birds and small mammals is undetermined at this time, but would be greatest on the larger birds, including waterfowl and raptors.

Birds and small mammals dependent on the habitats destroyed or altered by construction would disappear from the immediate area of the road and borrow areas, whereas new habitats formed would increase populations of species that favor the newly created habitats. Permanently retarded plant successional development, such as that found adjacent to roads and railroads, would provide habitat for several species of shrubland sparrows and of small mammal species generally restricted to open herbaceous-dominant plant communities--arctic ground squirrel, tundra vole, and meadow vole. Although borrow areas would be revegetated after construction, recovery of shrub and forest habitats would be slow, because of the harsh environment at the elevations of most of the access route. Most of the shrub and forest habitats in the upper Susitna River Basin are over 100 years old, although recovery rates might be faster along Indian River, which is at lower elevations.

Known raptor/raven nest sites within 1.6 km (1 mile) of the access route or access route borrow pits and thus subject to potential disturbance are as follows:

(a) Bald Eagle nest in cottonwood near the junction of Indian and Susitna rivers is only 500 m from the access road and 100 m from Borrow Area 1. Proposed development would certainly cause desertion of this nest site.

(b) Gyrfalcon nest (1974) and Goshawk nest (1981) in Cheechako Creek canyon, just east of Devil Canyon dam site, are about 1.6 km from access road.

(c) Two raven nest sites are within 0.5 km of access road along Tsusena Creek.

Wetlands likely to be adversely impacted by the access route are primarily those along Indian River and in the Chulitna Pass area. We have viewed these only cursorily from the air, so cannot predict specific impacts or levels thereof in this area. Otherwise, only WB 150 (Swimming Bear Lake), a productive alpine lake east of upper Devil Creek, appears close enough to be seriously impacted by the northern leg of the access route. The route, however, could be "fine-tuned" to avoid serious impact to this waterbody.

6 - LITERATURE CITED

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