FINAL REPORT

WATERBIRDS AND WETLANDS

CHISANA-UPPER TANANA RIVERS, ALASKA, 1979

(WITH EMPHASIS ON THE SCOTTIE-DESPER CREEK WETLANDS)

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ABSTRACT

Field studies in the upper Tanana River Valley were conducted from April to October 1979 to further evaluate the wetland habitats and waterbird populations in the vicinity of the Northwest Alaskan Gas Pipeline corridor as they might be impacted by construction activities. Thirteen of the more heavily used waterbodies censused in 1977 were recensused in 1979; the entire length of Gardiner Creek was surveyed for waterbirds; but the main emphasis in 1979 was on the Scottie-Desper Creek wetlands, adjacent to the U.S.-Canada border. Here, waterbird populations were monitored throughout the season, and habitat evaluations included the sampling of some ponds for limnologic and invertebrate faunal characteristics.

Except for loons and grebes, waterbird populations in the upper Tanana River Valley were lower in 1979 than 1977. The greatest decline between the two years was in the waterfowl, especially in the prairie breeding ducks that were in Alaska in record numbers in 1977, apparently as a result of drought-displacement from the prairies.

Gardiner Creek was of low value to waterbirds, primarily because of lack of suitable habitat. Gardiner Creek Flats, up Chisana River from the mouth of Gardiner Creek, provides locally important habitat for Canada Geese, both during migration and during breeding and post-breeding activities.

The three areas in the vicinity of the pipeline corridor in the upper Tanana River Valley that were used intensively by waterbirds during spring breakup in 1979 all thawed early and seemed to have available food: Clearwater Lake and the nearby farm fields along Remington Road, Dry Lake, and Gardiner Creek Flats. The Scottie-Desper Creek wetlands were little used for staging by spring migrants, because of late spring breakup compared to areas farther west. They received more use during fall migration, especially by ducks between mid-August and mid-September 1979. Ground utilization of the area by geese, swans, and cranes was low to almost nil at all seasons.

The Scottie-Desper Creek wetlands supported a greater density of waterbirds than the Tanana-Chisana River area along the pipeline corridor between Tetlin Junction and Scottie Creek; however, these wetlands produced 30-40% fewer young per unit area than Minto Lakes or the Yukon Flats. Waterbodies that were hydrologically connected to the creek system generally supported higher densities of adult and young waterbirds, especially ducks, than did those that were hydrologically isolated, apparently because of their higher nutrient levels. Some species, such as Arctic Loon, however, seemed to favor

the isolated type of waterbodies. Nutrient levels in some of the connected waterbodies suggested that they were highly productive relative to other interior Alaska waterbodies that have been studied.

The density and species richness of waterbodies within 1.6 km of the Alaska Highway were lower than those in areas more than 3.2 km from the highway. This difference appeared largely attributable to the preponderance of hydrologically isolated waterbodies near the road, compared to the larger, hydrologically connected waterbodies farther down the creek system.

If the hydrologic system downstream from the pipeline crossing is not damaged by siltation, chemical pollution, or by permanent changes in water levels, and if the habitat in the vicinity of Little Scottie Creek is not damaged, pipeline construction across the Scottie-Desper Creek drainage upstream of the Alaska Highway is unlikely to result in significant, permanent damage to the waterbirds of the area.

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INTRODUCTION

Studies of the use by waterbirds* of the wetlands of the upper Tanana River Valley and vicinity were undertaken to provide a basis for evaluating potential effects of the construction of the Northwest Alaskan Natural Gas Pipeline through the region and for determining means of mitigating possible project-related adverse impacts.

A census of 45 wetland sites between Tetlin Junction (63°19'N, 142°36'W) and the U. S.-Canada border (62°37'N, 141°00'W) (Spindler and Kessel 1977) and a cursory survey of wetlands along the pipeline corridor from Fairbanks (65°51'N, 147°43'W) to the North Slope (Kessel *in litt.*) in July 1977 indicated that, with the possible exception of the coastal wetlands of the North Slope, the wetland resources in the Desper Creek and Scottie Creek drainages were the most likely to be impacted significantly by pipeline construction. With the exception of the Scottie-Desper Creek drainage, most of the productive wetlands in the upper Tanana River Valley are fairly well insulated from the pipeline route and most construction activities by the noise and movement disturbances that occur along the Alaska Highway

* In this report, "waterbirds" refers to water-affiliated non-passerine birds: loons, grebes, waterfowl, cranes, shorebirds, and raptors which use the wetlands.

and by the main channels of the Chisana and Tanana rivers, which function as a major transport medium for spring snow melt, glacial silts, and other fluvia. The Northwest Alaskan Gas Pipeline, however, was planned to cross the Scottie-Desper Creek drainage, and, in 1977, the Scottie-Desper Creek wetlands appeared to support a relatively high population of waterbirds (Spindler and Kessel 1977). Hence, an intensive study of waterbird use of these wetlands was undertaken in 1979. The overall objective of this intensive study was to determine the type and intensity of waterbird use of these wetlands relative to various environmental factors, such as habitat characteristics, season, and human disturbance.

Two additional projects conducted in 1979 were designed to supplement and complement waterbird data from 1977 (Spindler and Kessel 1977). Censuses of 13 of the more heavily used waterbodies in 1977 were repeated in 1979 to obtain information on annual variations in waterbird use; and a survey was conducted along Gardiner Creek (which crosses the Alaska Highway at Mile 1246.6 and was not surveyed in 1977) to determine its use by waterbirds.

Schedule of 1979 Field Activities

Field work began on 16 April 1979, with the monitoring of spring migration and spring breakup; it was terminated on 12 October, after the main passage of most fall migrants. Dates of various field activities are given in Table 1.

Weather

Temperatures, as recorded at the Northway Airport, 50 km (30 mi) northwest of Scottie Creek, averaged a few degrees warmer during most of the 1979 field season (except June) than the 10-year average (National Oceanic and Atmospheric Administration [NOAA] 1979). Mean daily temperatures in April were 2.2°C (3.9°F) warmer than average, so spring breakup was probably relatively early. Despite the warmer average, however, 29 of the 30 days of April had minimum temperatures below freezing. The greatest deviation from average temperatures occurred in October, when mean daily temperatures were 3.5°C (6.3°F) above normal, undoubtedly resulting in a later-than-normal freezeup (Harding Lake [64°25'N, 146°50'W] froze over 3 weeks later in 1979 than in either 1977 or 1978 [Kessel, pers. obs.]).

Total precipitation between April and October 1979 was 19.3 cm (7.6 inches), which was 3.02 cm (1.19 inches) less than normal (NOAA 1979). All months, except July, were drier than normal (Fig. 1). July, which is usually the wettest month, had 2.84 cm (1.12 inches) more precipitation than normal, causing flooding in the Scottie-Desper Creek wetlands in July (Fig. 2).

Table 1. Field Schedule for 1979 studies of waterbirds and wetlands, upper Tanana River Valley, Alaska.

Date	Activity
16 April - 17 May	Monitored spring migration and breakup between Delta Junction and U. S.-Canada border. Conducted aerial surveys on 20, 24, 28 April and 2, 6, 14 May.
18 May - 23 May	Censused waterbirds in Stratum 1
24 May - 31 May	Censused waterbirds in Stratum 3
7 June - 13 June	Censused waterbirds in Stratum 1
14 June - 18 June	Censused waterbirds in Stratum 3
19 June - 4 July	Pond mapping, bathymetry, limnology, and invertebrate sampling
12 July - 15 July	Censused waterbirds between Willow Lake and Gardiner Creek
19 July - 23 July	Censused waterbirds in Stratum 1
24 July - 28 July	Censused waterbirds in Stratum 3
29 July - 31 July	Sampled invertebrates (incomplete)
2 August - 4 August	Censused waterbirds in Stratum 2
10 August - 12 August	Surveyed Chisana River and Gardiner Creek
20 August - 25 August	Censused waterbirds in Stratum 1
26 August - 28 August	Censused waterbirds in Stratum 3
29 August - 11 September	Sampled invertebrates and limnology
17 September - 19 September	Censused waterbirds in Stratum 1
20 September - 25 September	Censused waterbirds in Stratum 3
26 September - 12 October	Monitored fall migration and freezeup in the Scottie-Desper Creek wetlands. Conducted an aerial survey on 8 October.

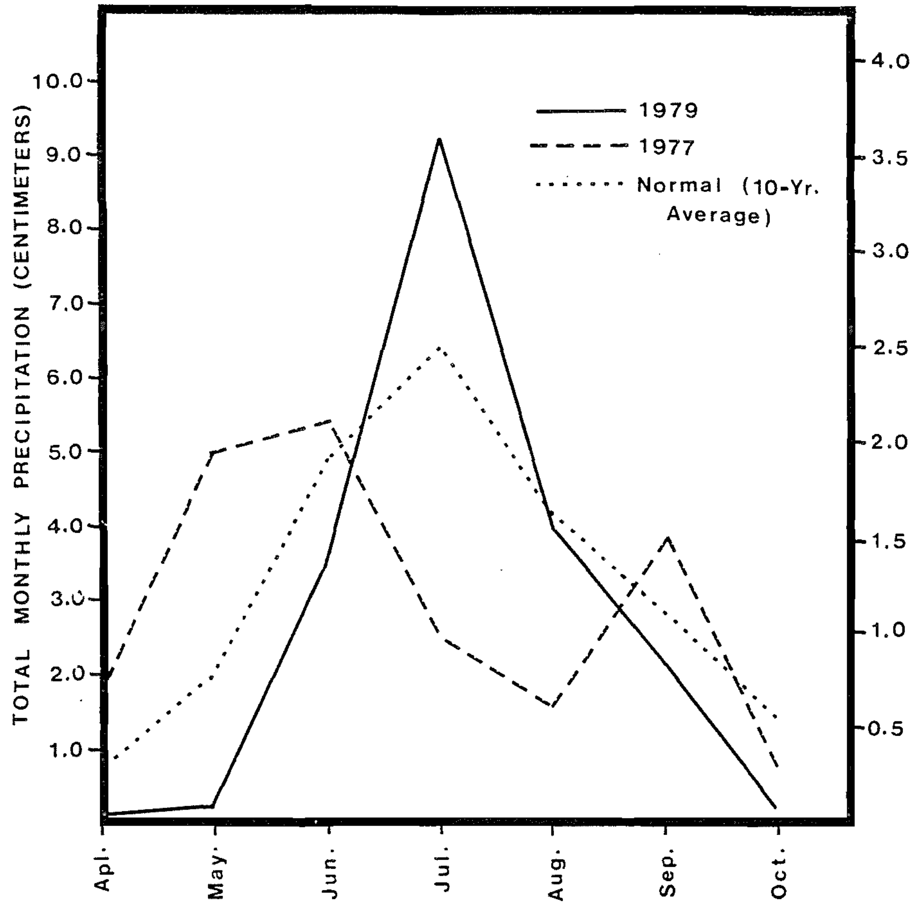

Figure 1. Total monthly precipitation for April-October 1979 compared with 1977 and with the 10-year average, Northway Airport, Alaska (NOAA 1977, 1979).

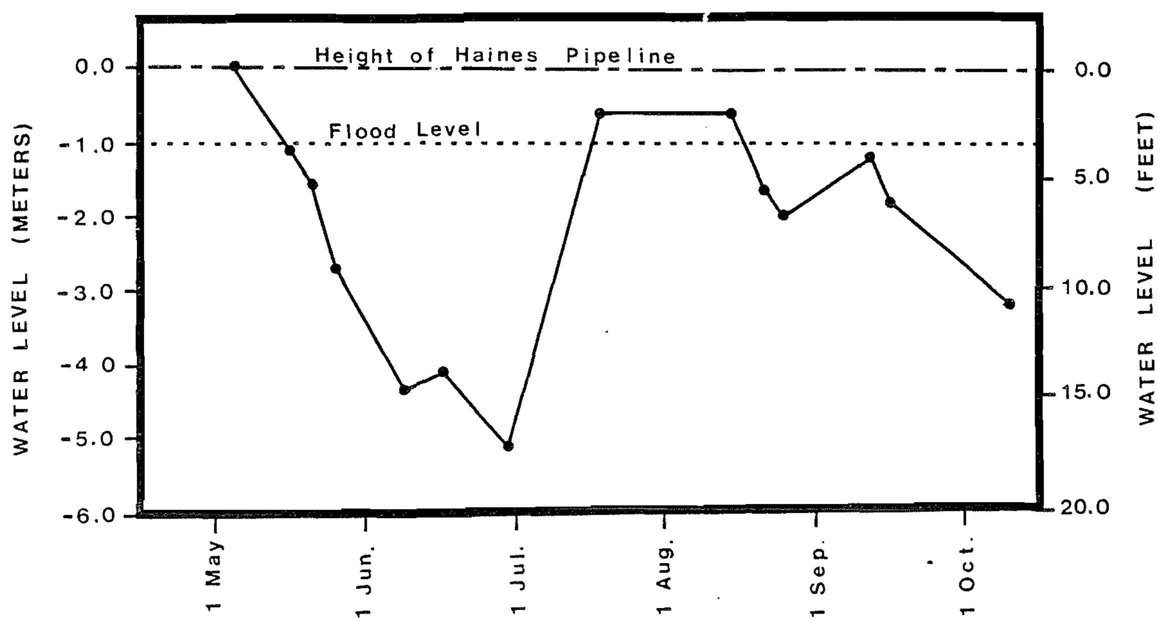

Figure 2. Water level fluctuations of Scottie Creek at the crossing of the Haines Pipeline, Mile 1224 Alaska Highway. Measurements were relative to the Haines Pipeline. Water was considered at flood level when wet meadows downstream became inundated.

STUDY AREA

Upper Tanana River Valley

Waterbird studies in 1979 were conducted in the wetlands along the Tanana River from the vicinity of Clearwater Lake near Delta Junction to its origin at the confluence of the Chisana and Nebesna rivers, along the Chisana River to Scottie Creek, and in the Scottie-Desper Creek drainage (Fig. 3). These wetlands are part of a larger drainage system that carries water from the Alaska Range and Wrangell Mountains and from the Tanana-Yukon Highlands into the Tanana River and, eventually, to the Yukon River. The entire valley lowland, collectively referred to in this report as the upper Tanana River Valley, varies in width from less than 3 km (1.8 mi) near Johnson Slough to nearly 50 km (19 mi) at several locations. The highly productive Tetlin Lakes wetlands occur in one of the wider portions of the valley.

The upper Tanana River Valley is underlain by discontinuous permafrost, except near Tetlin Lake and in the Scottie-Desper Creek drainage which are in areas of continuous permafrost (Selkregg 1976). Associated with permafrost is poor drainage, and in the upper Tanana River Valley the result is thousands of small ponds, lakes, bogs, and wet meadows. Spindler and Kessel (1977) estimated that roughly a third of the valley floor between Tetlin Junction and the Alaska-Canada border was covered by open water.

Most of the lakes and ponds in the valley do not exceed 2.5 m in depth (McKnight 1962). Shallow basins produce favorable conditions for aquatic plants, so many of the lacustrine waterbodies have dense beds of submergent and floating vegetation. Less productive waterbodies are also present; these are usually isolated waterbodies and are often associated with bogs.

The major rivers of the region are of glacial origin and have heavy sediment loads and swift currents that make them inhospitable to aquatic vegetation. Some of the meandering creeks that are not of glacial origin are more productive, in terms of plant biomass, and typically have a more substantial vertebrate community associated with them.

The lowland vegetation is a typical northern taiga mosiac of meadows, shrub thickets, woodlands, and forests, some in various stages of succession and others in a semipermanent, subclimax state. The complex patterns of vegetation types in the taiga arise from such interrelated factors as fire, permafrost, alluviation, soil type, slope, aspect, and water relations (Neiland and Viereck 1976; Viereck 1970, 1973, 1975). Much of the lowland of the valley bottoms, whether forested or treeless, is bog.

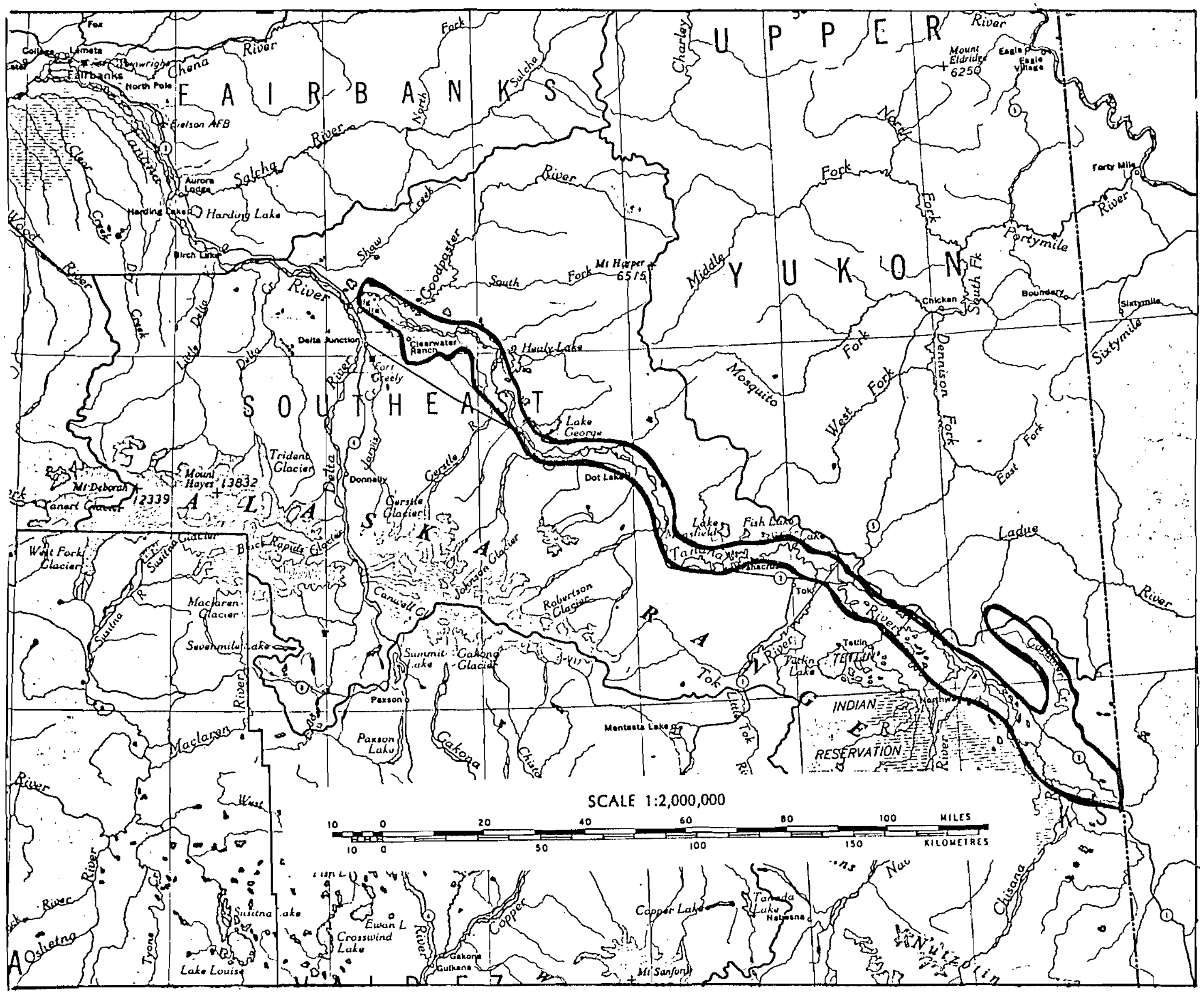

Figure 3. Map of the upper Tanana River Valley study area, Alaska, 1979.

Scottie-Desper Creek Drainage

Major emhasis of the 1979 field studies was on a 55 km^2 (21 mi^2) lowland study area formed by the drainages of Scottie, Little Scottie, and Desper creeks (Fig. 4). This Scottie-Desper Creek study area was bounded by the Alaska-Canada border on the east, Airs Hills on the south, unnamed hills on the north, and the edge of the wetland complex above the confluence of Scottie Creek and Chisana River to the west; it straddled the Alaska Highway between Mile 1221.3 and Mile 1226.0.

The drainage basins for Scottie Creek and Desper Creek are relatively small. Desper Creek drains approximately 47 km^2 (18 mi^2) directly north of the study area, whereas Scottie Creek drains a 130 km^2 (50 mi^2) area north and northeast of the study area, including part of Yukon Territory, Canada.

Over 100 small ponds and lakes were scattered throughout the study area, covering approximately 20% (11 km^2) of the land surface (Spindler and Kessel 1977). About half of these waterbodies were hydrologically connected to the creek system. Many appeared to be cryogenic, "cave-in" lakes, formed by local thawing processes in perennially frozen ground (Wallace 1948).

Permafrost also affects the hydrology of an area by reducing the absorption capacity of the substrate and hence increasing surface runoff during periods of spring thaw or heavy rains. Heavy rains on the study area caused substantial and rapid rises in water levels of all creeks. Generally, Desper Creek, with its smaller drainage system, responded more rapidly to increased precipitation than did Scottie Creek. Desper Creek began to rise fairly rapidly 1.5 to 2 days following a storm, whereas Scottie Creek would begin to rise slowly about 1.5 days after a storm and then rise much more rapidly after about 3 days.

The vegetation of the study area ranged from forests on the raised, better drained sites, to open and scattered woodlands and treeless shrublands where growth conditions were more rigorous (such as on a cold, moist substrate), to meadows where soil moisture was relatively high (Fig.5).

A brief description of the various habitats of the Scottie-Desper Creek study area, delineated according to Kessel (1979), follows. The entire study area would fall into Markon's (1979) "Wetlands Formation," but, contrary to Markon, we have not recognized "bogs" or "marshes" as habitats *per se*, since these, in themselves, are usually mixtures of several different habitats used by birds. Also, based on bird use, we have recognized different breakdowns from Markon's within lacustrine, fluviatile (stream-river), and shrub habitats.

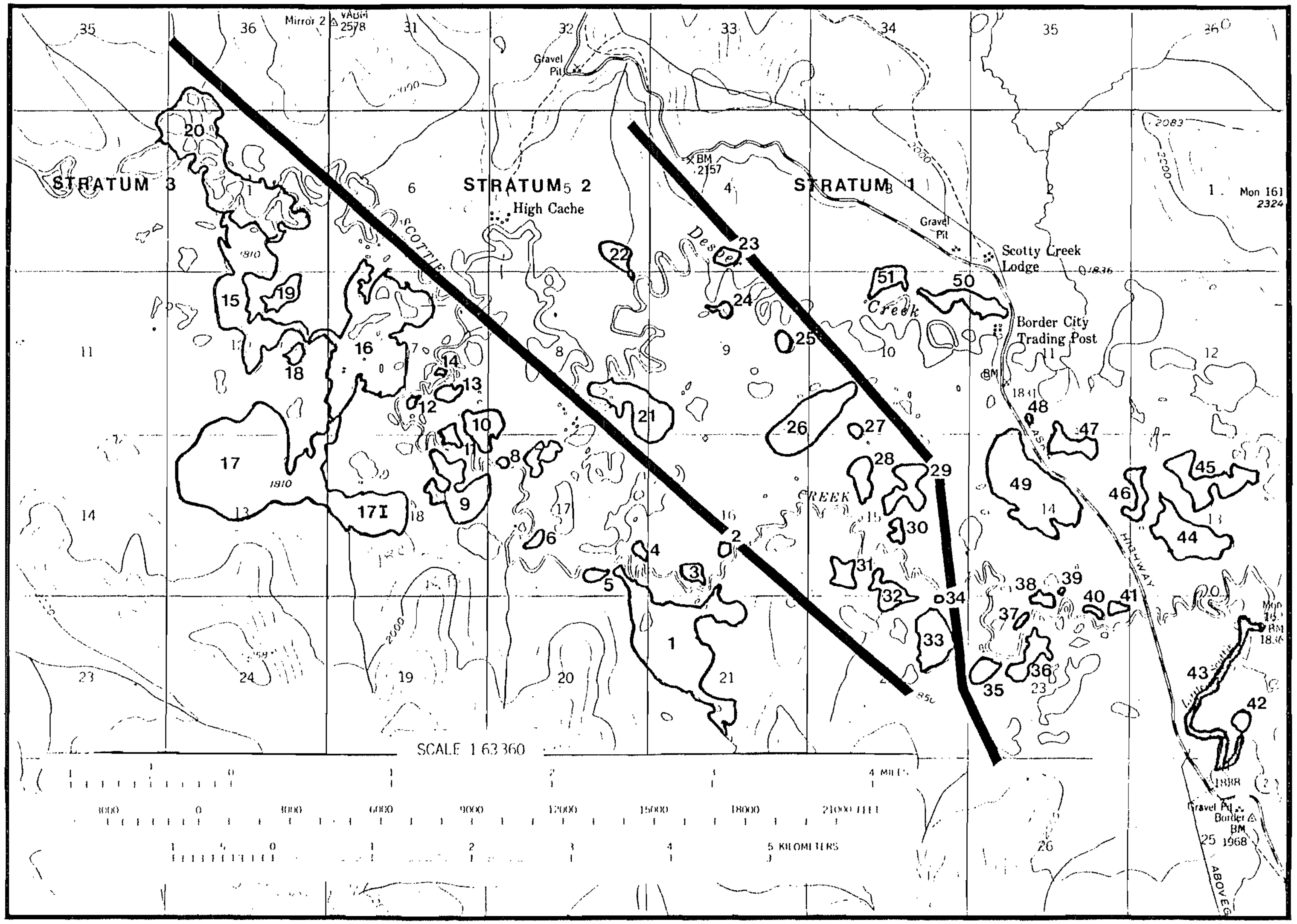

Figure 4. Map of Scottie-Desper Creek study area, 1979, showing waterbody identification numbers and geographic strata boundaries.

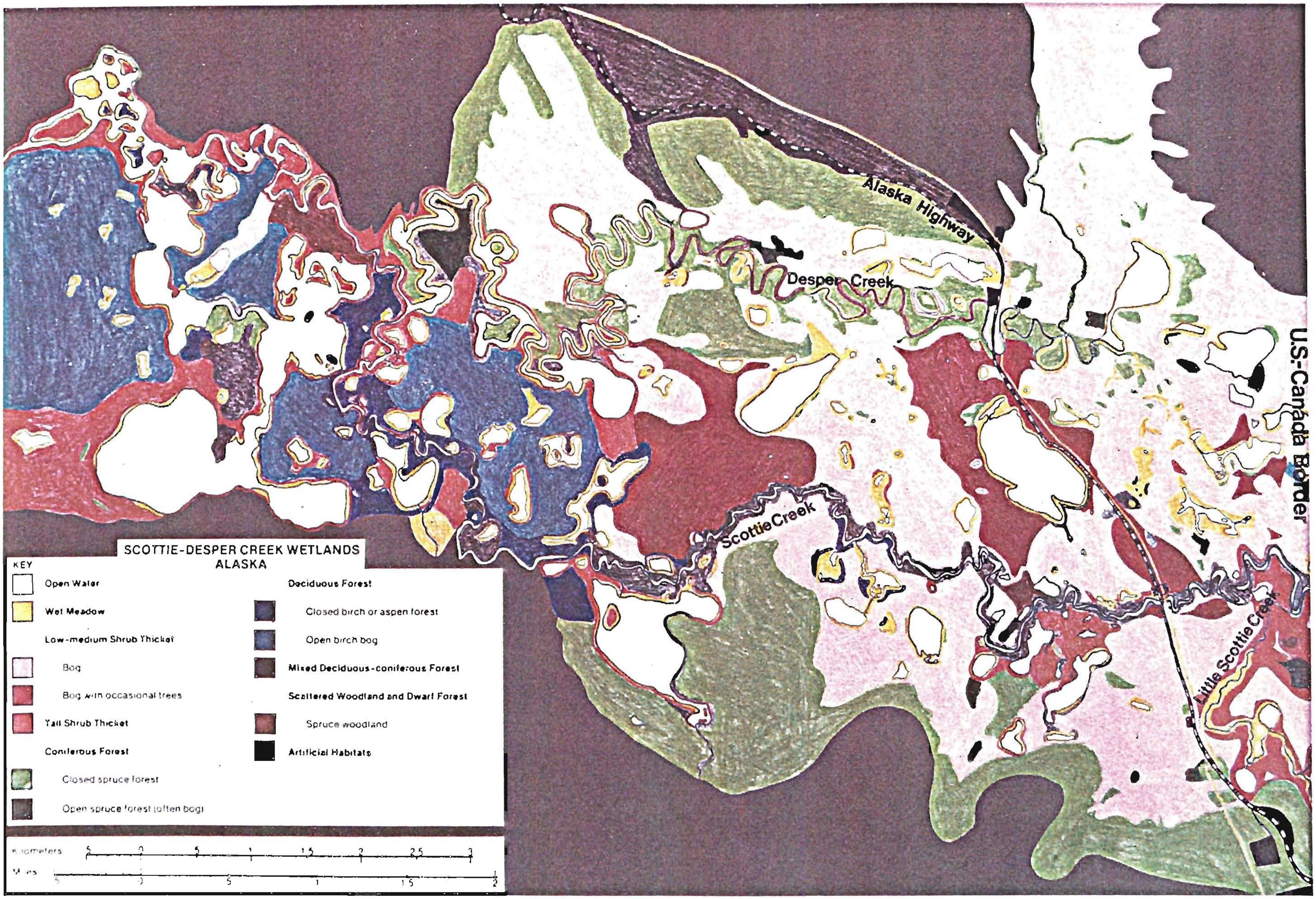

Figure 5. Map of the distribution of avian habitats of the Scottie-Desper Creek study area, eastern Alaska.

We restrict our use of the term "wetlands" to those habitats utilized by waterbirds, i.e., the first three habitats described below--Lacustrine Waters, Fluviatile Waters (and shorelines), and Wet Meadows. Bogs are not included as wetlands unless they are wet meadow bogs.

Lacustrine Waters

The ponds and lakes of the study area composed this habitat. Hydrologically, they were divisible into two types--those isolated from the creek system (or with only unidirectional flow from pond to creek) and those connected to the creek system. There was no evidence of subsurface connections between the isolated ponds and the creek system; the substrate in the area was tightly packed and fine-grained, and water levels in isolated ponds did not change commensurately with the rapid rise and fall of creek waters after storms.

The waterbodies varied considerably in surface area and to a lesser extent in depth. With the exception of SDC 17, which was 10.4 m deep and 143.5 ha, all ponds had a maximum depth of less than 5 m, were roughly ellipsoid in shape, and ranged in surface area from 0.5 ha to 76 ha. The isolated ponds typically had poorly developed littoral zones, few submergent vascular plants, and clear water. The dominant aquatic plants were pond lilies, Nuphar polysepalum and, to a lesser extent, Nymphea tetragona. The connected ponds typically had well-developed littoral zones and adjacent wet meadows, dense beds of submergent aquatic plants, and darkly stained water. The most abundant aquatic plants in these waterbodies were water milfoil (Myriophyllum spicatum), several species of pondweeds (Potamogeton vaginatus, P. gramineus, P. pectinatus, P. perfoliatus, and Zanichellia palustris), bladderwort (Utricularia spp.), and water smartweed (Polygonum amphibium).

The larger connected waterbodies, for the most part, had less submergent vascular vegetation than the smaller ones, and algae were the principal autotrophs.

Fluviatile (Riverine) Waters

The creeks on the study area were divisible into two types. Little Scottie Creek and Desper Creek were shallow, low-volume creeks that supported submergent vegetation in their channels and wet meadow vegetation along their gently-sloping banks; Desper Creek freezes almost solid in winter (Chihuly et al. 1979), and Little Scottie Creek probably does, too. Scottie Creek was a relatively deep-channeled, high-volume creek with steep banks and few aquatic plants. The banks were leveed and forested, and the creek apparently carries running water throughout the winter (Chihuly et al. 1979).

Wet Meadow

Wet meadows constituted less than 5% of the study area. This habitat occurred primarily around the perimeters of lacustrine waterbodies and, in localized areas, along the banks of creeks. Meadows dominated by Carex rostrata or C. aquatilis were the most common. Often, to the landward, these sedge meadows graded into a narrow band of bluejoint grass meadow (Calamagrostis canadensis). Common forbs found in localized areas, especially in thin bands along poorly developed shorelines, were buckbean (Menyanthes trifoliata), marsh marigold (Caltha palustris), wild calla (Calla palustris), and marsh fleabane (Senecio congestus). A small percentage of the wet meadow habitat was bog. Several isolated ponds were forming quaking bogs that supported sedges, spike rushes (Eleocharis spp.), and forbs.

Tall Shrub Thicket

All the tall shrubs (2.5-4.9 m high) on the study area were willows (Salix spp.), although mountain alder (Alnus crispa) occurred in the surrounding foothills. Most of the tall shrub habitat occurred around the perimeters of the lacustrine waterbodies, landward of the wet meadow zone. Tall shrubs were more prevalent in the western portions of the study area than elsewhere.

Low-Medium Shrub Thicket

Low-medium shrubs (0.4-2.4 m high) covered much of the study area. The dominant shrubs were leather leaf (Chamaedaphne caliculata), blueberry (Vaccinium uliginosum), and Labrador tea (Ledum palustre). Other common shrubs included dwarf birch (Betula nana) and sweet gale (Myrica gale). Large areas of low-medium shrub habitat occurred in association with tussock sedges, and almost equally common were associations with Sphagnum moss. Both situations were bogs, with moisture-saturated organic soils. In an east-west transition, the low-medium shrub bogs began to include occasional trees of spindly paper birch (Betula papyrifera) and black spruce (Picea mariana) in the center of the study area, and farther westward these trees became dense enough to form an open deciduous forest bog--a classical example of a continuum of intergrading plant communities along a moisture gradient.

Coniferous Forest

Both white spruce (Picea glauca) and black spruce forests occurred on the study area. White spruce was restricted to the well-drained areas of topographic relief on the valley floor and in the surrounding foothills. Black spruce, which can tolerate a damper substrate, occurred sporadically throughout the area. The major concentration of pure stands of black spruce was along Desper Creek. Black spruce bogs were frequent.

Deciduous Forests

Deciduous forests occurred primarily on the western portions of the study area, where drainage appeared to be better than farther east. Paper birch was the dominant deciduous tree on the valley floor, whereas aspen (Populus tremuloides) occurred in pure stands only on the steep slopes of the foothills. Several individual trees of balsam poplar (P. balsamifera) were also present on the study area.

Mixed Deciduous-Coniferous Forest

Mixed forests, in which neither deciduous nor coniferous tree species comprised 90% or more of the canopy, occurred along Scottie Creek and throughout the surrounding foothills. White spruce and paper birch formed the mixed forest on the levees of Scottie Creek, whereas white spruce and aspen formed the mixed forest in the foothills.

Scattered Woodland and Dwarf Forest

One area across Desper Creek from High Cache appeared, from a distance, to be scattered black spruce woodland.

Artificial Habitats

The artificial habitats in this area consisted of the buildings along the Alaska Highway and the extensive gravel pit workings near the Alaska-Canada border.

METHODS

Aerial Surveys

Seven aerial surveys, totaling 25 hr of flight time, were flown during spring and fall migration (see Table 2 for dates). Surveys were conducted from a single-engined, fixed-winged aircraft flown between 75 and 150 m (250-500 ft) above ground level. Only one pass per survey was made over an area. Data obtained on these surveys included 1) location and availability (snow-ice conditions) of waterbird use areas, 2) numbers of waterbirds per use area, and 3) species composition of each use area. Supplemental observations for habitat mapping of

Table 2. Dates and coverage of aerial surveys, upper Tanana River Valley, Alaska, 1979.

Date	Area
20 April	Tanacross to Delta Junction
24 April	Delta Junction to Alaska-Canada border
28 April	Delta Junction to Alaska-Canada border
2 May	Dry Creek to Alaska-Canada border
6 May	Tetlin Junction to Alaska-Canada border
14 May	Northway to Alaska-Canada border
8 October	Northway to Alaska-Canada border

the Scottie-Desper Creek study area were made on the fall survey flight.

Ground Censuses

Systematic censuses of waterbirds were conducted monthly, from May through September, on the Scottie-Desper Creek study area. Additionally, one census was conducted from 12 to 27 July 1979 of 13 of the more heavily used waterbodies along the proposed Northwest Alaskan Gas Pipeline route between Tetlin Junction and the Alaska-Canada border for data comparison with the 1977 census (Spindler and Kessel 1977).

On the Scottie-Desper Creek study area, 37 waterbodies, totaling 5.5 km^2 (2.1 mi^2), were selected for the monthly censuses. They were selected on several bases: to include 1) waterbodies censused in 1977 (Spindler and Kessel 1977), 2) a broad representation of the waterbody types of the area, 3) ponds at different distances from the Alaska Highway, and 4) ponds of reasonable accessibility. These 37 waterbodies, which were located in Stratum 1 and Stratum 3 (see below), comprised the maximum that could be censused every month. During the July census period, however, 14 additional, less accessible waterbodies in Stratum 2, totaling 0.9 km^2, were censused, providing 58% coverage (6.4 km^2) of the wetlands of the study area for that mid-summer period.

Each waterbody that was censused was assigned an SDC (Scottie-Desper Creek) number; numbers assigned in 1977 by Spindler and Kessel (1977) were retained. "Grace Lake" of Spindler and Kessel (op. cit.) is SDC 49 in this report; Little Scottie Creek is SDC 43.

Our choice of reasonably accessible waterbodies contributed some bias to our results. Accessibility, in large part, was a function of the nearness of a waterbody to the creek system, our major avenue of transportation; and our studies later showed that waterbodies hydrologically connected to the creek system received heavier use by waterbirds, especially ducks. Thus, waterbird densities derived from the monthly censuses are probably higher than densities of waterbirds over the entire wetlands of the study area. We estimate that while our five monthly censuses covered only 50% of the wetland habitat, we counted between 75% and 90% of all the waterbirds on the study area.

Census techniques, using waterbodies as the primary sampling units, were the same as those used by Spindler and Kessel (1977): Small ponds and marshes were censused by two people walking in opposite directions around the perimeter. All birds seen when the crew first arrived were recorded to prevent double-counting later, and all birds seen or flushed from the water or surrounding wetlands during the walk around the shoreline were counted. Birds flying over the wetlands were not counted unless they were foraging over (e.g., terns) or landed on the site. Large lakes and fluviatile waters were censused by two observers in a canoe (without motor). Midway Lake was so large (6 km^2), we subdivided it into sections, which were censused sequentially.

Total numbers of waterbirds and species composition were determined on each census; sex, age, and activity of individuals were recorded whenever possible. Density figures used in this report are based on square kilometers of wetland habitat (see definition, p. 10), unless otherwise indicated.

Seasonal Chronologies and Waterbird Production Data

Data on seasonal chronologies were obtained through continual observation during the field season. For chronologies of various events of the breeding cycle, it was often possible to approximate dates of egg-laying and hatching by back-dating from aged eggs or young through the use of information derived from the literature (average clutch size, incubation period, fledgling period.)

During the nesting season, as part of the censusing effort, waterbodies and adjacent wet meadows were searched for signs of breeding birds. When nests were found, they were inconspicuously marked for subsequent monitoring. Eggs were counted and then floated to determine the stage of incubation (Westerkov 1950).

Records were kept of all brood sightings throughout the season, until late August when it became difficult to distinguish juvenals from adult females. Duck broods were aged according to classes based on plumage characteristics (Gollop and Marshall 1954, Giles 1969). No attempt was made to age non-duck species that were more than a day or two old.

Brood data were gathered from Scottie and Desper creeks as well as from the 37 waterbodies censused monthly, so densities of young were calculated on a total area of 8.0 km^2 of wetland habitat.

Habitat Mapping

Mapping of the avian habitats of the Scottie-Desper Creek study area was based on ground and aerial observations made in the field and on supplemental aerial photo interpretation from 1:36,000 color plates. An enlarged projection of the U. S. Geological Survey Nebesna C-1 Quadrangle map of 1955, revised 1963 (scale=1:63,300) was used as a base, but many of the water boundaries were adjusted from field observations. Habitats were classified according to Kessel (1979).

Limnology

Fifteen of the 37 waterbodies used for waterbird censuses were selected for limnologic studies. Selections were made subjectively, to ensure geographic (near and far from Alaska Highway), size, and hydrologic (isolated and connected) variation among the waterbodies.

The collection of limnologic data was synchronized with the schedule for waterfowl censuses. Data were obtained from an early summer sampling period, 19 June-4 July, and again in the fall, between 29 August and 11 September.

Physical Variables

Temperature.--Replicate surface temperatures were obtained with a standard hand thermometer; readings were taken immediately upon withdrawal of a water sample.

Water transparency.--Measurements were made by submerging a 20-cm secchi disc from the shaded side of the canoe and recording the depth at which it was visible without sunglasses. Because of variable environmental conditions (time of day, roughness of water, cloud cover, too shallow ponds, etc.), the readings grouped into three classes: low = secchi transparency reading of <1.0 m; medium = secchi transparency between 1.0 and 2.0 m; and high = secchi transparency of >2 m. Class 3 included some shallow, clear ponds that were less than 2 m deep.

Area.--Areas were obtained with a planimeter from the base map used for habitat mapping, which was an enlarged, corrected map, based on the U. S. Geological Survey C-1 Nebesna Quadrangle.

Bathymetry.--A lead sounding line was used to obtain depth readings. Measurements were taken at regular intervals along a lengthwise transect of the waterbody. Most waterbodies had a uniform bottom contour, but where irregular depths occurred, we took a second depth transect, perpendicular to the first, across the irregular area. Maximum depths were recorded for each pond.

Chemical Variables

All water samples for determination of chemical variables were collected from the surface. Samples were either obtained from a canoe with a brass Kemmerer water sampler, or by wading to a depth of 0.5 m to 1.0 m and submerging a container to obtain a sample.

Total alkalinity, hardness, and dissolved oxygen.--A digital titrator (Hach Chemical Co.) with prepackaged titrants in the form of replaceable cartridges was used to determine total alkalinity, hardness, and dissolved oxygen. Titrations were performed in accordance with specifications provided by the Hach Chemical Company.

Total alkalinity was determined using 1.589 N and 0.1589 N sulfuric acid titration cartridges. Phenolphthalein and brom cresol green-methyl red were used as the colorimetric endpoint indicators at a pH of 8.3 and 4.5, respectively.

A 0.794 M EDTA titration cartridge was used for all hardness titrations. Water samples were prepared for titration by adding 1 ml of buffer solution, followed by a prepackaged amount of ManVer II (Hach Chemical Co.) hardness indicator.

The Azide Modified Winkler method was employed for determinations of dissolved oxygen, using prepackaged reagents and a 0.1988 N phenylarsine oxide titration cartridge.

Nitrate, nitrite, ammonia, phosphate, and silicon.--All collecting equipment was double-washed with 10% HCl, followed by six rinses with double-deionized water. Each sample was obtained as follows: 1) A 150-200 ml water sample was filtered through a Gelman glass fiber filter (0.47μ nominal retention) into a 120 ml polyethylene bottle, leaving it only three-fourths full to allow for expansion during freezing; 2) three to five drops of 10% mercuric chloride were added as a preservative, and the samples were stored in the shade until they could be frozen (within 2 to 5 days); and 3) samples in the polyethylene bottles remained frozen until the time of analysis, a period of about 6 months. Laboratory analyses of the dissolved fractions of each limnologic variable were performed with a continuous flow autoanalyzer (Technicon AutoAnalyzer II), following procedures outlined in Patton and Whitledge (1977).

Nitrite concentrations were determined by the Greiss reaction in which sulfanilamide and N-(1-Naphthyl) ethylenediamine dihydrolchloride (NNED) reacted with nitrite in aqueous acidic solution to form an intensely pink diazo dye with an aborption maximum of 540 nm. Nitrate was reduced to nitrite by its passage through a column containing copperized cadmium filings, and was then measured in the same manner as nitrite.

Ammonia concentrations were determined by a modification of the Berthelot reaction. Hypochlorous acid and phenol react with ammonia in aqueous alkaline solution to form indophenol blue, which has an absorption maximum of 637 nm.

Phosphate (reactive phosphorus, as an approximation of orthophosphate) was measured via an automated version of the Murphy and Riley procedure.

It was determined as reduced phosphomolybdic acid, which has an absorption maximum of about 889 nm in the presence of antimony.

Silicon (orthcsilicic acid) concentrations were measured by the Armstrong, Sterns, and Strickland procedure. In this method, orthosilicic acid is combined with molybdate in aqueous acidic solution to form silicomolybdic acid, which is then reduced via stannous chloride to a heteropoly acid, which has with an absorption maximum at 820 nm.

Acidity.--Spring pH readings were obtained with a Sargent Welch model RB pH meter. Due to technical difficulties, a Van Waters and Rogers model 55 meter was used during fall sampling. Both meters were standardized before each use with buffers of known pH.

Invertebrates

Following a cursory survey of the 15 waterbodies used for limnologic studies, two were chosen for studies of their invertebrate fauna. SDC 10 was selected because preliminary visual assessment indicated that it possessed a high abundance and diversity of invertebrates. SDC 17I was selected because, in contrast, it lacked a readily observable fauna. Three periods of invertebrate sampling were planned, but mid-summer sampling was aborted because of flooding caused by heavy precipitation. Hence, samples of macrobenthic invertebrates and zooplankton were obtained for only two periods: 19 June-4 July, and 29 August-11 September. Sampling was done according to a stratified random sampling design; Stratum 1 included depths ≤1.0 m. Stratum 2 was >1.0 m.

Each pond was mapped, using a plane table and crude alidade (Lind 1974). Bathymetric contours were obtained by taking depth readings along at least ten canoe transects for each pond and taking readings at regular intervals with a calibrated lead line. Maps, gridded on a scale of 5 m x 5 m, were constructed in the field; invertebrate sampling locations were identified, using a random number table and the gridded bathymetric map.

Three types of invertebrate sampling equipment were required. A simple, 25-cm (10-inch) diameter cylinder was used in the littoral region (Stratum 1), since it contained vegetation and/or detritus that prohibited the use of an Ekman sampler. Macrovegetation was removed from the cylinder by hand and preserved. Then a hand net (200 μ mesh) was swirled through the cylinder to agitate the substrate and associated fauna and then drawn up through its center, straining out the samples; 15 hand net samples were taken from each cylinder.

An Ekman sampler (15 cm square) was used to sample the benthos in the deep (>1.0 m) strata of both ponds. Occasionally, in waterbody SDC10, large amounts of vegetation prohibited proper closure of the sampler jaws. In such cases, the sample was discarded and another taken in an adjacent, undisturbed area.

The cylinder sample included both benthic invertebrates and zooplankton, whereas the Ekman sampled only the benthos. Therefore, zooplankton in the deep strata was sampled with a Wisconsin net. At each site where a benthic sample was taken with the Ekman, a corresponding vertical Wisconsin haul was made, using an 80 μ mesh net.

Since different gear was used to sample the two strata, we obtained comparative samples using both devices at each of five sampling locations to determine if the differing invertebrate dominance patterns obtained could have been the result of gear selectivity. The similarity of dominant invertebrate groups in paired samples indicated that the gear types did not influence the dominance results obtained.

Five samples were obtained in each stratum of each pond during both seasonal sampling periods, yielding a total of 40 invertebrate samples. The cylinder and Ekman samples were given a preliminary processing in the field, by gently sieving the contents through a 220 μ mesh screen in the bottom of a large sieve bucket. After 15 to 20 minutes of swirling the sample through the sieve, the sieve contents were preserved in 7-10% formalin. Samples were later transferred to 80% alcohol and stored until sorted.

All samples were hand sorted to separate the macroinvertebrates from the substrate. Invertebrates were identified to varying taxonomic levels (Appendix C-1). With the exception of the order Lepidoptera, insects were identified to the family level using Merrit and Cummins (1978). Other groups were identified using keys in Pennak (1978).

Data Analysis

Geographic stratification.--For some analyses, the Scottie-Desper Creek study area was divided into three strata, based on waterbody distances from the Alaska Highway (Fig. 4). Stratum 1 included 17 waterbodies, totaling 1.3 km^2 (0.5 mi^2), that occurred within 1.6 km (1 mi) of the Alaska Highway; Stratum 2 included 14 waterbodies, totaling 0.9 km^2 (0.4 mi^2), within about 1.6 and 3.2 km (1 to 2 mi) of the highway; and Stratum 3 included 20 waterbodies, totaling 4.2 km^2 (1.6 mi^2), that were beyond 3.2 km (2 mi) from the highway.

Importance values.--An "Importance Value" was calculated for each of the 37 waterbodies censused throughout the 1979 field season as an indication of the relative value of each waterbody to waterbirds. The importance value of each waterbody was the sum of relative mean abundance (number of birds) from the five censuses, the relative mean density (birds/km^2), and the relative mean species richness (number of species) (Curtis and McIntosh 1951):

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

Limnologic data set.--While 14 limnologic parameters were measured on 15 waterbodies, not all were used in subsequent statistical analyses. Summer and fall limnologic data sets proved to be roughly similar, and seasonal variation was impossible to interpret on the basis of only two sampling periods; hence, the data from the two seasons were averaged into a single data set (Appendix B). Conductivity data proved to be faulty and was discarded. Measurement of dissolved oxygen was discontinued after the first sampling period, because the shallow ponds were too subject to wind-mixing for the readings to be meaningful. Water transparency, which had to be ranked into three classes, was not used, either.

Invertebrates.--The relative dominance of the various invertebrate groups found in Pond 17I and SDC 10 was determined by volumetric ranking. The assumption was made that all invertebrate groups had essentially the same specific gravity and therefore could be compared volumetrically. Volumetric samples of invertebrate groups were compared in two ways: between samples (considering all invertebrate groups) and within samples (comparing individual invertebrate groups).

Statistical procedures.--A principal component analysis (Biomedical Computer Program BMDP4M, OrthoB rotation [Dixon and Brown 1979]) was used to ordinate 15 waterbodies along gradients of limnologic characteristics. Principal component analysis is a statistical method with the capability of reducing multivariate data into a few dimensions which "...are the linear combination of the original variables that successively account for the major independent patterns of variation in the sample" (Bryant and Atchley 1975:3). Each dimension or "principal component," accounts for a unique and successively smaller portion of the total variance within the data set. If the original variables are highly interrelated, the first few principal components will account for a high percentage of the total variation.

Waterbody similarities were also compared by a cluster analysis (Biomedical Computer Program BMDP2M [Dixon and Brown 1979]). This technique reduces or classifies multivariate data into groups based on a measure of association or similarity between variables. Thus, waterbodies most similar in limnologic characteristics were clustered first and those less similar were clustered progressively later.

Stepwise multiple regression (Biomedical Computer Program BMDP2R [Dixon and Brown 1979]) was used to order limnologic variables according to their effectiveness in predicting waterbird density and species richness, and stepwise discriminant function analysis (Biomedical Computer Program BMDP7M [Dixon and Brown 1979]) was used to identify the variables that best separated the waterbody types. Regression procedures were terminated when an added variable failed to account for a significant portion of the variablility of the dependent variable, i.e., when the increase in R^2 was less than 0.05.

The nonparametric Wilcoxen Signed Ranks Test (Conover 1971) was used to test for differences between the median population statistics of 1977 and 1979 for the 13 waterbodies censused along the Northwest Alaska Pipeline route between Tetlin Junction and the Alaska-Canada border. This test is based on ranks, and large differences between just a few of the paired replicates does not inordinately influence the results. We considered differences significant if tests showed $p \leq 0.05$. Calculations of mean densities (birds/km^2) for the two years and their standard deviations was based on the ratio estimation method (Cochran 1963).

SEASONAL CHRONOLOGIES, 1979

Spring

Spring breakup in the upper Tanana River Valley proceeded at different rates with different types of waterbodies. Table 3 summarizes some of the characteristics of breakup and bird use of the major waterbodies of the upper Tanana River Valley during spring 1979.

Waterbodies influenced by warm springs were the first to open, and some, especially Clearwater Lake, were heavily used by the earliest

Table 3. Chronology of spring breakup and waterbird use of selected waterbodies in the upper Tanana River Valley, Alaska, 1979.

Waterbody	Date open water first observed	Estimated date of first open water	Comments on breakup	Use by migrant waterbirds
Clearwater Creek	16 April	Open all year	Ice-free all year due to warm springs.	Light to moderate use. Overwintering Mallards and Common Mergansers. Primarily ducks during spring migration.
Clearwater Lake	16 April	Partially open all year except during coldest weather.	First lake to open up in the upper Tanana River Valley. Always open for earliest migrants. 50% ice-free on 16 April 79.	Heavy use; very heavy by early migrant geese, swans, ducks and gulls.
Tanana River at Tanacross	17 April	Open year round.	Ice-free all year, apparently due to warm springs. Open stretch extended from Tanacross to Robertson River on 24 April 79.	Light use, primarily by ducks.
Chisana River	24 April	16 April	Open from just upstream of Gardiner Creek to the Eliza Lake area on 24 April 79. Opened earlier than most glacial rivers; started to breakup on 16 April 79, according to Northway residents.	Heavy use in April, light in May. High importance to early migrant Canada Geese and several duck species. Once ponds melted, use of the river decreased.
Moose Creek, Northway Jct.	24 April	20 April	Almost completely open by 24 April 79.	Moderate use, primarily by Mallards.
Tanana River at Billy Creek	24 April	22 April	Tanana River broke up at different rates, with only intermittent short stretches opening at first. Stretch at Billy Creek was one of the first to open.	Light to moderate use, primarily by ducks. Fifteen Pintails present on 24 April 79.

Table 3 (continued)

Waterbody	Date open water first observed	Estimated date of first open water	Comments on breakup	Use by migrant waterbirds
Dry Lake	24 April	22 April	The second lacustrine waterbody to melt in the upper Tanana River Valley.	Heavy use by ducks (primarily Mallards), Canada Geese, and swans.
Sand Lake	24 April	24 April	Ice persisted well into May, but the edges of the lake and the contiguous wet meadows along Sand Creek opened up on 24 April 79.	Heavy use; very heavy by several species of ducks, both divers and dabblers as well as gulls, Arctic Terns, and swans.
Gerstle River	24 April	22 April	--	Light use.
Johnson River	24 April	24 April	The main channel began to open on 24 April 79.	Light use.
Tanana River	28 April	Open all winter at Tanacross	Intermittent stretches open throughout upper Tanana River by 28 April 79.	Light use.
Sears Creek	28 April	28 April	Started to break up on 28 April 79.	Light use.
Healy Lake	28 April	28 April	Started melting around edges on 28 April 79.	Unknown.
Desper Creek	28 April	27 April	Short sections open on 28 April; completely open by 2 May 79.	Moderate to heavy use. Several sections of creek, where channel widened or fed into large ponds, were the most important staging habitats in Scottie-Desper Creek wetlands. Extensive use, primarily ducks but also geese.

Table 3 (continued)

Waterbody	Date open water first observed	Estimated date of first open water	Comments on breakup	Use by migrant waterbirds
Scottie Creek	28 April	26 April	Short sections open by 28 April 79; completely broken up by 2 May, but with numerous ice jams.	Mostly light use, except heavy by ducks and Canada Geese at "Maze."
Little Scottie Creek	28 April	27 April	--	Moderate use by ducks.
Unnamed small ponds	2 May	28 April to 2 May	Nearly all the small ponds in the upper Tanana River Valley open by 2 May 79.	Moderate to heavy use ;used extensively by all species.
Fish Lake	2 May	2 May	Just beginning to melt around the edges on 2 May 79. Ice probably persisted well into second week of May.	Unknown.
Wolf Lake	2 May	2 May	Just beginning to melt at edges on 2 May 79. Ice probably persisted well into second week of May.	Unknown.
Long Lake	2 May	1 May	One of the first lakes to melt completely. Located adjacent to Midway Lake which was still 100% frozen on 2 May 79.	Moderate use.
Eliza Lake	6 May	6 May	Just beginning to melt at edges on 6 May 79. Completely open when next seen on 14 May.	Moderate use by numerous species, including large multi-species rafts of ducks.
Yarger Lake	6 May	6 May	Just beginning to melt at edges on 6 May 79. Completely open when next seen on 14 May.	Moderate to heavy use by numerous species, including large multi-species rafts of ducks.

migrant waterfowl. Next to open were the rivers, probably because moving waters speeded breakup. Rivers began opening by mid-April 1979, well ahead of most ponds and lakes; and some river areas were of major importance to waterbirds until more suitable habitat became available.

Once the small, shallow ponds started to open, about 1 May, most waterbirds left the rivers for the more biologically productive ponds. The last of the waterbodies to open were the deeper and larger ponds and lakes. Although many of these waterbodies started to melt around the edges in early May, ice often persisted until mid-May. Use of ponds and lakes by migrants was heavy as soon as even the edges of this habitat became available.

In addition to these aquatic sites, the fields of the OHM farm along Remington Road, Delta Junction, were essentially snow-free by mid-April and were used by the early-arriving geese and dabbling ducks. Other agricultural areas and several wet meadows in the upper Tanana River Valley were also used by migrants as they became snow-free.

Spring migration and patterns of habitat use are reported below according to four geographic subdivisions of the upper Tanana River Valley.

Delta Junction-Clearwater Area

This subdivison was composed primarily of Clearwater Lake and the farm fields in the vicinity of Delta Junction. The area was important to early spring migrants, since it provided the earliest available waterfowl habitat in the upper Tanana River Valley. The area continued to be moderately important to waterbirds throughout migration (Table 4). Ground counts were primarily of birds using the fields along Remington Road and using the half of Clearwater Lake visible from the army dock; aerial counts were more comprehensive and hence resulted in higher numbers of birds.

Clearwater Creek, which feeds into Clearwater Lake, has open water all year because of warm springs, and Mallard, Common Merganser, and Bald Eagle apparently overwinter here (Univ. of Alaska unpubl. records). Migrant Canada Geese were at this location as early as 8 April 1979 (R. J. Ritchie, Alaska Biological Research, pers. comm.). Clearwater Lake thawed early and the snow melted rapidly from the southeast-facing slopes of the OHM barley fields, making the Delta Junction-Clearwater Area a veritable oasis for the earliest waterbirds.

Up to 6000 Canada Geese used the area at the peak of migration on 23 April (Table 4). These birds usually spent the night on the farm fields and the daylight hours on Clearwater Lake. Several small ponds on the OHM Farm melted early and attracted large concentrations

Table 4. Numbers of waterbirds observed during spring migration 1979, Delta Junction-Clearwater area. After 28 April only birds on the OHM Farm were counted.

Species	April 16	17	20*	21	22	23	24*	25	26	28*	29	30	May 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Horned Grebe										1				1	1	1			4				4	24	16	7	6	3	6	12	3
Whistling Swan														40			30									3					
Trumpeter Swan				8	4	2		7	2																						
Swan sp.			50				14	6	10	12																					
Canada Goose	1200	1500	2000	3000	2000	6000	5500	5000	4000	1500	875	823	380	240	73	40		5					8		8						
White-fronted Goose							7	200	200	40	10	8										2	4	2	2	2					
Snow (Blue) Goose								2																							
Mallard			6	18	9	10	100	30	200	200	40	40	35	30	30	18		2	10		4		4	10	2	2	1	3	1	3	4
Pintail						8	50	150	250	100	40	50	30	50	30	14		4	12	4	2		4	10	8	4	1	5	5	7	
Green-winged Teal								2					18	20	18									2					9	18	6
Northern Shoveler								10	1						2	2		2				3	2	1			2			5	2
American Wigeon							40			24	2	4	30	30	30	8							2	2	2	2	1				2
Canvasback											4													2	1	1					
Ring-necked Duck										2								1				2									
Greater Scaup												16																			
Lesser Scaup																								4		2		5		2	10
Goldeneye Sp. **						2	10	4																							
Bufflehead									2	20	2	2		2		2	2		2					2			1		1		
Common Merganser	7		12	4					4																						
Red-br. Merganser																										1					
Unidentified ducks			25							100																					
Bald Eagle								3																1							
Sandhill Crane											10		12	85	184	35	540	23	28		72	1016	797	1353	654	70	32		60	49	65
Killdeer											1																				
Am. Golden Plover																								12			15	16	27	55	
Whimbrel																				4	4	2	7		12	10		5	6	3	
Upland Sandpiper																													1	2	
Lesser Yellowlegs											1				1								2							2	6
Wilson's Phalarope																							1								
Northern Phalarope									1						1									1							
Common Snipe												1																			
Baird's Sandpiper																						1						2			
Herring Gull			4	45		6		10	10	19																					
Mew Gull										3				3	6	8	14	10	11	20	14	25	18	18	16	30	50	25	18	23	60

*Dates of aerial surveys
**All positively identified were Barrow's Goldeneye

of ducks, primarily Mallard and Pintail, beginning about 24 April. Migrant Horned Grebe used these ponds heavily in mid-May. Swans were conspicuous users of Clearwater Lake early in the season. All swans positively identified prior to 28 April were Trumpeter Swan, whereas May migrants were Whistling Swan. Migrant Sandhill Crane made some use of the farmlands during the first two weeks of May, with peak numbers 9-12 May. Shorebirds, especially Whimbrel and American Golden Plover, used the fields during the second two weeks of May.

Tanana River Valley Area, Clearwater Creek to Northway

This subdivision included the Tanana River from Clearwater Creek to its origin at the confluence of the Chisana and Nebesna rivers near Northway, a distance of about 240 km (149 miles). Four of the aerial surveys were flown over this area during migration, but not always over the same route (Table 5).

On 18 April, ground observations at Dry Lake, which was still frozen but had only 50% snow cover on the surrounding meadow, revealed five Mallard. No waterbirds were seen in the entire area during the aerial flight on 20 April, and the only open water was a short section of the Tanana River between Tanacross and the Robertson River, much of which apparently remains open all winter (Arthur Warbelow, 40-Mile Air, pers. comm.).* There were also some snow-free flats near Sam Creek, Dot Lake, and Black Lake.

More sections of the Tanana River had opened by 24 April, but bird use was light. The only other locations with open water on this date were Dry Lake and the marshy edges of the outlet of Sand Lake. Nearly all birds recorded on the aerial flight (Table 5) were at these latter two sites.

Breakup had not progressed appreciably by the 28 April survey, but waterbird populations had increased significantly. Dry Lake was nearly ice-free and contained 55 swans, 30 Canada Geese, and 30 Mallard. Sand Lake was still 90% frozen, but 400 ducks, primarily Mallard and Pintail, were crowded into the thawed edges.

Rivers, creeks, and small ponds were largely thawed by 2 May, and most snow cover had melted. Dabbling ducks, especially Mallard, were using the low-lying marshy areas throughout the valley. Most large lakes of the area were still frozen, except at the shoreline. Sand Lake, however, was about 30% open, and most of the birds seen on this aerial count were there.

* On 12 April 1980, breakup in the Tanana River Valley Area appeared to be a week to 10 days earlier than in 1979 (S.M. Murphy, pers. obs.).

Table 5. Numbers of waterbirds observed on aerial flights during spring migration 1979, Tanana River Valley area.

Species	20 April Tanacross to Delta Junction	24 April Northway to Delta Junction	28 April Northway to Delta Junction	2 May Northway to Dry Creek
Swan sp.			55	21
Canada Goose			36	42
White-fronted Goose		50*		
Mallard		52	217	80
Pintail		15	150	75
American Wigeon			50	54
Scaup sp.				10
Goldeneye sp.			2	
Bufflehead			2	12
Oldsquaw			2	
Unidentified ducks		25	53	
Bald Eagle				2
Lesser Yellowlegs				2
Herring Gull		10		
Bonaparte's Gull				200
Arctic Tern				2
TOTAL	0	152	567	500

* Flying flock

Chisana River Valley Area, Northway to Scottie Creek

This subdivision included the Chisana River from its confluence with the Nebesna River to its confluence with Scottie Creek, a distance of about 64 km (40 miles). Five surveys were flown over the Chisana River and surrounding wetlands, with special emphasis on the waterbodies between the Chisana River and the Alaska Highway (Table 6); the same route was followed on all surveys.

Breakup on the Chisana River was several days ahead of that on the Tanana and Nebesna rivers and was nearly complete by 24 April. The Chisana River contained the only open water in this subdivision on 24 April, and all birds seen on the aerial survey (Table 6) were concentrated in one of two stretches of the river: in the general area of its confluence with Gardiner Creek and between Eliza Lake and Tenmile Lake. Canada Goose was the most abundant species on this survey, corresponding to its peak abundance at this time in the Delta Junction-Clearwater Area (cf Table 4).

Snow and ice conditions had not changed significantly by 28 April, but duck numbers had increased, as had the number of species present. Canada Goose numbers were declining, but it was the peak period for Mallard and Pintail migration (Table 6).

Many of the small and shallow ponds of the area had thawed by the 2 May aerial survey, and the pattern of habitat use by waterbirds shifted from exclusive use of the Chisana River to near exclusive use of the more biologically productive ponds.

Habitat use patterns were little changed by 6 May, since the ice on the large lakes was just beginning to melt around the edges. A second migration wave began about 6 May, however, resulting in greater total numbers and more species, including numbers of Arctic Loon, Horned Grebe, and several shorebird species.

By 14 May nearly all waterbodies were ice-free. The largest lakes still had some patches of ice, but were occupied by large, mixed flocks of loons, grebes, and ducks. Twenty-seven species of waterbirds were recorded on 14 May, including peak numbers of diving ducks, Arctic Loon, Horned Grebe, and shorebirds, which accounted for almost twice the total numbers observed 6 May.

Scottie Creek Area

This subdivision included the Scottie-Desper Creek drainage to the confluence of Scottie Creek and the Chisana River. Five aerial surveys over this area were supplemented by daily ground observations between Miles 1221.8 and 1226.0 Alaska Highway from 29 April through

Table 6. Numbers of waterbirds observed on aerial flights during spring migration 1979, Chisana River Valley area.

Species	24 April	28 April	2 May	6 May	14 May
Arctic Loon				6	33
Red-necked Grebe					5
Horned Grebe				4	40
Swan sp.	5		31	2	4
Canada Goose	665	151	50	21	18
Snow Goose					1
Mallard	54	78	7	21	20
Pintail	15	124	1	1	4
Green-winged Teal					2
Northern Shoveler				4	16
American Wigeon		36	38	47	65
Canvasback		1	21	20	28
Redhead				2	1
Ring-necked Duck			1	2	
Scaup sp.		56	11	75	89
Goldeneye sp.	10	20	2	9	10
Bufflehead		14	23	15	24
Oldsquaw			6		6
Common Merganser		4			
Red-breasted Merganser			2		2
Unidentified ducks	20		20	66	83
Bald Eagle	1	3		1	5
Sandhill Crane		2			1
American Coot				8	
Lesser Yellowlegs				1	17
Northern Phalarope				10	12
Common Snipe				1	2
Unidentified shorebirds				4	66
Herring Gull	1				
Mew Gull			14	34	2
Bonaparte's Gull			2	22	149
Arctic Tern			2	11	10
TOTAL	771	489	231*	387	715

* Lower number is a sampling artifact caused by a changed distribution pattern after ponds thawed.

16 May (Table 7). The Scottie Creek drainage was unimportant to early spring migration because of the late thaw. The phenology of this area was almost a week behind that of other parts of the upper Tanana River Valley, but when the thaw started it proceeded rapidly. The first sign of open water was on the creeks on 28 April, and the first waterbirds were seen on 29 April on Little Scottie Creek. Shallow ponds thawed during the first week of May, but the larger and deeper waterbodies retained some ice until as late as 15 May (Table 3).

On 2 May the aerial survey showed that ponds were still frozen, and almost all the birds were concentrated along the creeks at two locations about 2.4 km (1.5 mi) south of the Alaska Highway: 1) Desper Creek near its confluence with Scottie Creek and 2) waterbody SDC 20, the portion of Scottie Creek just north of SDC 15 (Fig. 4).

By 6 May nearly all the snow had melted, all of the small ponds were open, and waterbird numbers were 2.5 times those of the 2 May survey. Bird use of the available lacustrine habitat was extensive, but the riverine habitat had not been abandoned as on the Chisana River, because the riverine habitat types used by birds in the Scottie Creek area (Desper Creek, SDC 20, and Little Scottie Creek) had many lacustrine features--wide channel, slow current, and submergent and emergent vegetation--making them attractive to waterbirds.

The last spring aerial survey was flown on 14 May and revealed the greatest waterbird abundance recorded. The combination of an influx of late migrants, including Arctic Loon, Horned Grebe, diving ducks, and gulls, and resident dabbling ducks that had begun to nest, accounted for the peak numbers.

The deeper lakes (SDC 1, 17, and 49) were still more than 50% ice-covered, but birds were using the thawed edges. SDC 17 had the greatest number of birds on it (56 birds of seven species), even though it was still 70% ice-covered.

Use of the waterbodies within sight of the Alaska Highway was light throughout the migratory period. Most birds used waterbodies SDC 43 (Little Scottie Creek), 49, or 50. Little Scottie Creek (SDC 43) was the only waterbody along the road that consistently attracted birds prior to 6 May. Thereafter, most of the ponds in the area opened up, and small numbers of birds regularly used SDC 41, 47, 48, 50 (Fig. 4). SDC 50 supported the highest number of species. During the second and third week of May it was used by Arctic Loon, diving ducks, and gulls. Later in May the floating mat vegetation around the perimeter attracted several shorebird species, including Pectoral Sandpiper, Long-billed Dowitcher, Northern Phalarope, and Least Sandpiper. The ice in SDC 49, the largest waterbody along the highway in this area, did not start to melt until 11 May; Arctic Loon, diving ducks, and gulls used the lake as soon as water was available. Since this lake

Table 7. Numbers of waterbirds observed during spring migration 1979, Scottie Creek area.

	April					May															
	17	24*	28*	29	30	1	2*	3	4	5	6*	7	8	9	10	11	12	13	14*	15	16
Arctic Loon											6	3	1		1	3	3		11		9
Horned Grebe						14						1							6		2
Whistling Swan										25											
Canada Goose							25												12		
Mallard				8	11	4	2	4	4	2	14	7	2	3	2	2	4	3	16		1
Pintail					12	4		2	2			2	2		1				6	2	2
Green-winged Teal								2	3			7	2	3		2		10		6	2
Northern Shoveler											6	2									3
American Wigeon				4	6	10	11				8			5	2	2	3	3	25		
Canvasback					5	12	4				35								24		
Ring-necked Duck				1		4															
Scaup sp.											20								34		2
Goldeneye sp.				2			2												2		
Bufflehead					4	4	2		1		7		1						6	1	
Oldsquaw													2						2		
Merganser sp.																			2		
Unidentified ducks											50								20		
Bald Eagle							1				1	1		1			1	1			
Lesser Yellowlegs									5			1			2	1	3	2		1	3
Solitary Sandpiper																		1			
Northern Phalarope							2								6						
Common Snipe				1	1	1		1	1		2	2	2	4	1	2		3		2	5
Unidentified shorebirds															1		15	13	9		
Mew Gull					3		10	3	10			6	5	5	2	5	6	7	6	2	5
Bonaparte's Gull														2	3	50	35	39	32	1	1
Arctic Tern																	3		9		1
TOTAL	0	0	0	16	42	53	59	12	26	27	149	32	17	23	21	67	73	82	222	15	36

*Dates of aerial surveys. Aerial surveys covered approximately 83 km^2 (32 mi^2), whereas ground counts covered only about 16 km^2 (6 mi^2).

was one of the last waterbodies in the upper Tanana River Valley to thaw, however, it was of minor importance to spring migrants.

Summer

Chronologies of summer activities in the region were obtained primarily from the Scottie-Desper Creek study area, which was monitored closely throughout the 1979 field season. Chronologies of events for the more numerous species are shown in Figure 6. Information on molting chronologies was not obtained, because few molting birds were seen on the study area.

The first egg-laying initiated on the Scottie-Desper Creek study area was by Mallard, with the earliest date about 29 April. Egg-laying in most other dabblers was underway by mid-May, and all dabblers had finished laying by 20 June. Diving ducks began nesting 2 to 3 weeks later. The Bufflehead was the only diver to initiate nests before June. Lesser Scaup had the latest breeding schedule, with egg-laying not beginning until 8 June. Arctic Loon and Horned Grebe began nesting in mid-May, and Spotted Sandpiper began nesting about 1 June. Extended laying periods, indicative of renesting by birds that failed initial nesting attempts, occurred in the Mallard, American Wigeon, Green-winged Teal, and Lesser Scaup.

The hatching sequence among species was essentially the same as that of laying, with minor differences due to differing incubation times. The first eggs to hatch were those of Pintail on about 2 June. The peak of hatching for dabbling ducks, loons, grebes, and the Spotted Sandpiper was in June, and for diving ducks was in July. Hatching continued as late as 17 August, when we estimated that the eggs in the last scaup nest hatched.

Young dabbling ducks had all fledged by September, and by mid-September the only remaining flightless young were Lesser Scaup. Late-nesting scaup had flightless broods as late as 4 October, and it is questionable if these young developed enough to migrate before freezeup (although the late freezeup in 1979 may have enabled these birds to survive).

Fall

Southward migration for many waterbirds starts as early as mid-summer. Gulls, terns, and many shorebird species are among the earliest to migrate. On the Scottie-Desper Creek study area in 1979, total numbers of the three summer resident larids (Mew Gull, Bonaparte's Gull, and Arctic Tern) had decreased sharply from their June highs by the end of July, and the last sightings were in mid-August (except for one immature Arctic Tern still on SDC 1 on 8 September).

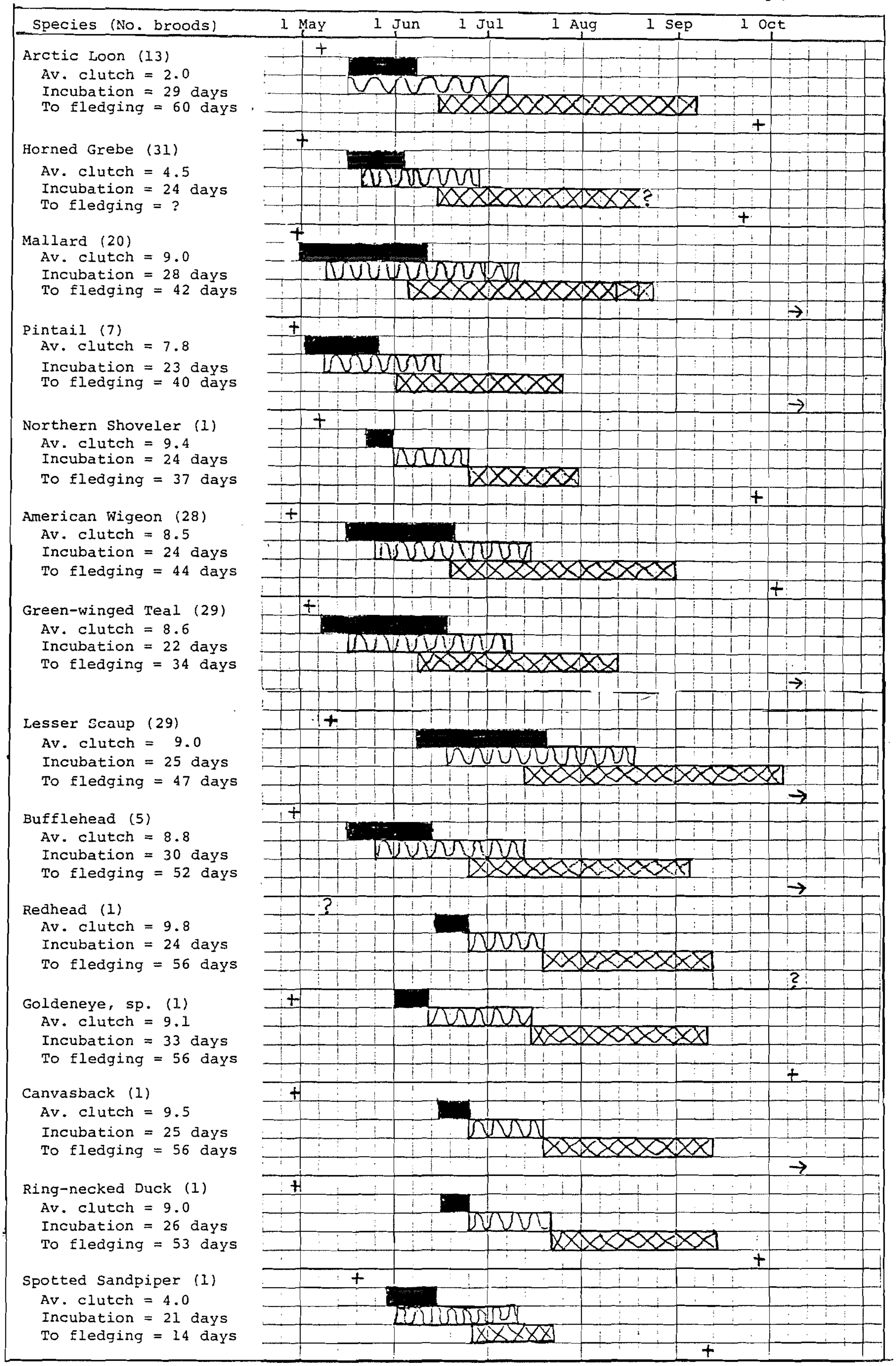

Figure 6. Seasonal chronologies of waterbirds on the Scottie-Desper Creek study area, Alaska, April-October 1979. Clutch sizes, incubation periods, and number of days to fledging were obtained from the literature. Key: + = arrival, ▬ = egg laying, [ΛΛ] = incubation, [XX] = brood rearing, → = departure.

All shorebirds species, except Common Snipe and Northern Phalarope, declined in abundance during July and August because of high water levels which innundated mud or sand flats. In September water levels dropped and late migrating shorebirds, such as Pectoral Sandpiper, used the exposed shorelines. In years with lower water levels in late summer, more migrant shorebirds probably use the Scottie Creek area.

An influx of ducks onto the study area was evident in mid-August, and by late August total waterbird numbers had nearly doubled over those of late July. Numbers of Arctic Loon and Horned Grebe, however, were declining by August.

The peak of fall duck migration occurred during the first two weeks of September, and waterbird numbers, especially dabbling ducks, had dropped by late September. Mallard, Bufflehead, and scaup were the most abundant ducks in September, and their numbers in late September were similar to those in late August.

Whistling Swan, Trumpeter Swan, Canada Goose, White-fronted Goose, and Sandhill Crane all migrate through the upper Tanana River Valley, but they seldom landed on the Scottie-Desper Creek study area. A total of 600 cranes occurred sporadically between 22 August and 18 September, with 550 of these on 6 September. Only twice were cranes seen on the ground.

White-fronted Goose migration occurred between 22 August and 7 September. A total of 2870 birds was counted, with peaks of 1000 birds each passing over on 30 August and 3 September. These geese apparently staged along the Chisana River, and use of the Scottie Creek area was minimal; 10 white-fronts were seen on SDC 16 on 27 August.

Canada Goose migration was first noted on 6 September, and 300 birds were counted between then and 11 October. Small groups landed on the Scottie Creek area, both near the Alaska Highway and farther southwest on the study area.

Swan migration had probably not yet reached its peak when field work terminated on 12 October. A total of 232 Whistling Swan was seen on 4 days between 29 September and 9 October, almost all passing over the area. A flock of 47 Whistling Swan apparently flushed off SDC 17 on 8 October. Twenty-five Trumpeter Swan flew over the Scottie Creek area on 10 October.

The only fall aerial survey was flown on 8 October, between Northway and the Alaska-Canada border. On this date most waterbodies were partially covered by ice, although most small, shallow ponds were completely frozen, and the deeper ponds and lakes and the fast-moving rivers were completely open. Waterbird observations and freezeup conditions noted on the 8 October flight are summarized in Table 8.

Table 8. Numbers of waterbirds and freezeup conditions on aerial flight of 8 October 1979 between Northway and the U.S. - Canada border.

Waterbodies	Ice cover (%)	Total no. of waterbirds	Red-necked Grebe	Whistling Swan	Canada Goose	Mallard	Pintail	Green-winged Teal	Canvasback	Scaup sp.	Bufflehead	White-winged Scoter	Surf Scoter	Scoter sp.	Common Merganser	Unidentified ducks
			Number of birds per species													
SDC 4	100	0														
SDC 8	40	4	4													
SDC 15	30	46				5					30	10			1	
SDC 16	40	70				25	5	20			20					
SDC 17	0	187		47		60			30		50					
SCD 20	20	10				5					5					
SDC 29	80	6														6
SDC 33	40	2									2					
SDC 36	75	4	2								2					
SDC 47	75	10									10					
SDC 49	17								2	2		13				
Moose Creek	0	0														
Chisana River	0	29													20	9
Eliza Lake	75	0														
Yarger Lake	25	33				5				3	15			10		
2 lakes east of Yarger Lake	40	25				5				10	10					
Tenmile Lake	80	45				40				3	2					
Deadman Lake	0	16			2					4	10					
Gardiner Creek	0	0														
Desper Creek	50	53				38					15					
Scottie Creek	0	20													20	
TOTAL		579	6	47	2	183	5	20	30	22	173	10	13	10	41	15

Total numbers of waterbirds were relatively high on this aerial survey, especially in Scottie Creek area, indicating that this latter area may be of much greater importance to migrant waterbirds in fall than in spring. The Scottie Creek area had a count of 415 birds on the 8 October survey, whereas the highest count in spring surveys was 225 birds on 14 May.

WATERBIRD POPULATIONS AND HABITAT PRODUCTIVITY OF THE SCOTTIE-DESPER CREEK WETLANDS

Waterbird Populations

Population data for the Scottie-Desper Creek wetlands study area were derived primarily from the five monthly censuses of 37 waterbodies in Strata 1 and 3 taken during the 1979 field season: 18-31 May, 7-18 June, 19 July-4 August, 20-28 August, and 17-25 September (Appendix A).

Fifty-five species of waterbirds were observed on the Scottie-Desper Creek area in 1979. Forty-four of these were enumerated on the monthly censuses (Table 9); other species seen on the study area but not during censuses were Whistling and Trumpeter swans, Oldsquaw, Red-breasted Merganser, Sandhill Crane, American Golden Plover, Hudsonian Godwit, Whimbrel, Greater Yellowlegs, Upland Sandpiper, and Double-crested Cormorant*. All of these latter species, with the possible exception of the Red-breasted Merganser, were only migrants through the study area. The greatest number of species occurred on the May census (35 species), when spring migrants were still moving through the area, and on the July census (31 species), when fall shorebirds movements were already under way. Twenty-three species of waterbirds were either breeders or suspected breeders on the study area (see below).

Waterbird Abundance

Variation in the seasonal densities (birds/km^2 of wetlands) and total numbers of waterbirds recorded on the five monthly censuses are illustrated in Figure 7. Peak abundances of waterbirds were observed on the first census (May), when spring migration was still in progress for many species, notably shorebirds and diving ducks. Migration was completed by the time of the June census, and numbers of waterbirds had decreased considerably. The density of birds on the June census best approximated the resident population. Minimum numbers were recorded in July; at this time many resident birds, both breeders and nonbreeders, had already departed, and only a few fall migrants, mostly shorebirds,

* A single Double-crested Cormorant seen on SDC 16 on 30 May 1979 was the first record of this species in interior Alaska.

Table 9. Density (birds/km^2 of wetland) and relative abundance of waterbirds observed on the monthly censuses of 37 waterbodies (5.5 km^2) on the Scottie-Desper Creek wetlands, Alaska, 1979

	May		June		July		August		September		Mean*	
	Density (#/km^2)	Relative Abundance (%)	Density (#/km^2)	Relative Abundance (%)	Density (#/km^2)	Relative Abundance (%)	Density (#/km^2)	Relative Abundance (%)	Density (#/km^2)	Relative Abundance (%)	Density (#/km^2)	Relative Abundance (%)
LOONS AND GREBES												
Arctic Loon	4.5	1.6	4.2	2.0	6.0	5.3	5.5	2.5	0.2	0.1	4.1	2.1
Red-necked Grebe	0	0	0	0	0	0	0	0	0.2	0.1	0.2	t
Horned Grebe	4.9	1.8	6.4	3.1	8.9	7.9	4.7	2.1	3.1	2.3	5.6	2.9
Subtotal	9.4	3.4	10.8	5.1	14.9	13.2	10.2	4.6	3.5	2.5	9.7	5.1
GEESE												
Canada Goose	0	0	0	0	0.2	0.2	0	0	0	0	0.2	t
White-fronted Goose	0	0	0	0	0	0	1.8	0.8	0	0	1.8	0.2
Subtotal	0	0	0	0	0.2	0.2	1.8	0.8	0	0	2.0	0.2
DABBLING DUCKS												
Mallard	18.2	6.5	12.5	6.1	3.1	2.7	23.1	10.5	30.0	21.9	17.4	9.1
Pintail	14.0	5.0	5.5	2.7	1.6	1.5	7.1	3.2	4.0	2.9	6.4	3.4
Green-winged Teal	18.2	6.5	18.9	9.2	9.1	8.1	48.0	21.8	21.5	15.7	23.1	12.1
Blue-winged Teal	0.2	0.1	0.5	0.3	0	0	0	0	0	0	0.4	0.1
Northern Shoveler	7.3	2.6	7.1	3.4	1.8	1.6	13.5	6.1	3.8	2.8	6.7	3.5
American Wigeon	18.5	6.7	18.7	9.1	4.4	3.9	40.4	18.3	6.0	4.4	17.6	9.2
Subtotal	76.4	27.4	63.2	30.7	20.0	17.8	132.1	59.9	65.3	47.8	71.4	37.4
DIVING DUCKS												
Canvasback	4.9	1.8	0.5	0.3	2.5	2.3	1.8	0.8	1.5	1.1	2.3	1.2
Redhead	0	0	0	0	0.2	0.2	0	0	0	0	0.2	t
Ring-necked Duck	4.4	1.6	6.7	3.3	0.4	0.3	4.5	2.1	0	0	4.0	1.7
Greater Scaup	0	0	0	0	0.5	0.5	0	0	0	0	0.5	0.1
Lesser Scaup	57.6	20.7	42.7	20.8	22.2	19.7	27.3	12.4	20.7	15.2	34.1	17.9
Barrow's Goldeneye	2.0	0.1	1.5	0.7	0.2	0.2	0.7	0.3	0.7	0.5	1.0	0.5
Bufflehead	17.3	6.2	18.7	9.1	12.5	11.1	36.5	16.6	37.8	27.7	24.5	12.9
Harlequin Duck	0.4	0.1	0	0	0	0	0	0	0	0	0.4	t
White-winged Scoter	9.1	3.3	0	0	2.0	1.8	0	0	0.7	0.5	3.0	1.2
Surf Scoter	0.2	0.1	0	0	0.9	0.8	0.5	0.2	1.1	0.8	0.6	0.3
Black Scoter	0	0	0	0	0	0	0	0	0.7	0.5	0.7	0.1
Common Merganser	0	0	0	0	0	0	0	0	0.9	0.7	0.9	t
Subtotal	95.9	34.4	70.1	34.1	41.4	36.8	71.3	32.3	64.1	46.9	72.2	37.8
SHOREBIRDS												
Semipalmated Plover	1.8	0.7	1.6	0.8	0.2	0.2	0	0	0	0	0.9	0.4
Killdeer	0.2	0.1	0.2	0.1	0	0	0	0	0	0	0.2	t
Black-bellied Plover	0.4	0.1	0	0	0	0	0	0	0	0	0.4	t
Lesser Yellowlegs	18.4	6.6	12.0	5.8	3.8	3.4	0	0	0	0	11.4	3.6
Solitary Sandpiper	0.2	0.1	0.4	0.2	0.2	0.2	0.2	0.1	0	0	0.2	0.1
Spotted Sandpiper	5.5	2.0	2.0	1.0	1.8	1.6	0	0	0	0	3.1	1.0
Northern Phalarope	8.7	3.1	4.7	2.3	16.2	14.4	0.5	0.2	0	0	7.5	3.2
Common Snipe	1.8	0.7	0.5	0.3	0.9	0.8	3.3	1.5	1.6	1.2	1.6	0.9
Long-billed Dowitcher	3.5	1.2	0	0	0.2	0.2	0	0	0	0	1.8	0.4
Semipalmated Sandpiper	6.5	2.3	0.5	0.3	0	0	0	0	0	0	3.4	0.7
Least Sandpiper	0.4	0.1	2.0	1.0	0.7	0.6	0.2	0.1	0	0	0.7	0.3
Baird's Sandpiper	0.4	0.1	0	0	0	0	0	0	0	0	0.2	t
Pectoral Sandpiper	26.4	9.5	0	0	0	0	0	0	1.5	1.1	13.9	2.9
Dunlin	0.2	0.1	0	0	0	0	0	0	0	0	0.2	t
Subtotal	74.4	26.7	23.9	11.6	24.0	21.3	4.2	1.9	3.1	2.3	25.9	13.6
GULLS AND TERNS												
Herring Gull	0	0	0.2	0.1	0	0	0	0	0	0	0.2	t
Mew Gull	7.1	2.5	7.3	3.5	0.7	0.6	0	0	0	0	5.0	1.6
Bonaparte's Gull	6.9	2.5	18.7	9.1	1.1	1.0	0	0	0	0	8.9	2.8
Arctic Tern	7.8	2.8	11.5	5.6	9.1	8.1	0	0	0	0	9.4	3.0
Subtotal	21.8	7.8	37.5	18.2	10.9	9.7	0	0	0	0	23.3	7.4
OTHER												
Bald Eagle	0.5	0.2	0.4	0.2	0.5	0.5	0.5	0.2	0.5	0.4	0.5	0.3
American Coot	0	0	0	0	0	0	0.2	0.1	0	0	0.2	t
Belted Kingfisher	0.2	0.1	0	0	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1
TOTAL	278.5	100.0	205.8	100.0	112.5	100.0	220.5	100.0	136.7	100.0	190.8	100.0

* Mean Density calculated only for months the species was present.
Percent sightings on all censuses.
t Trace = <0.05

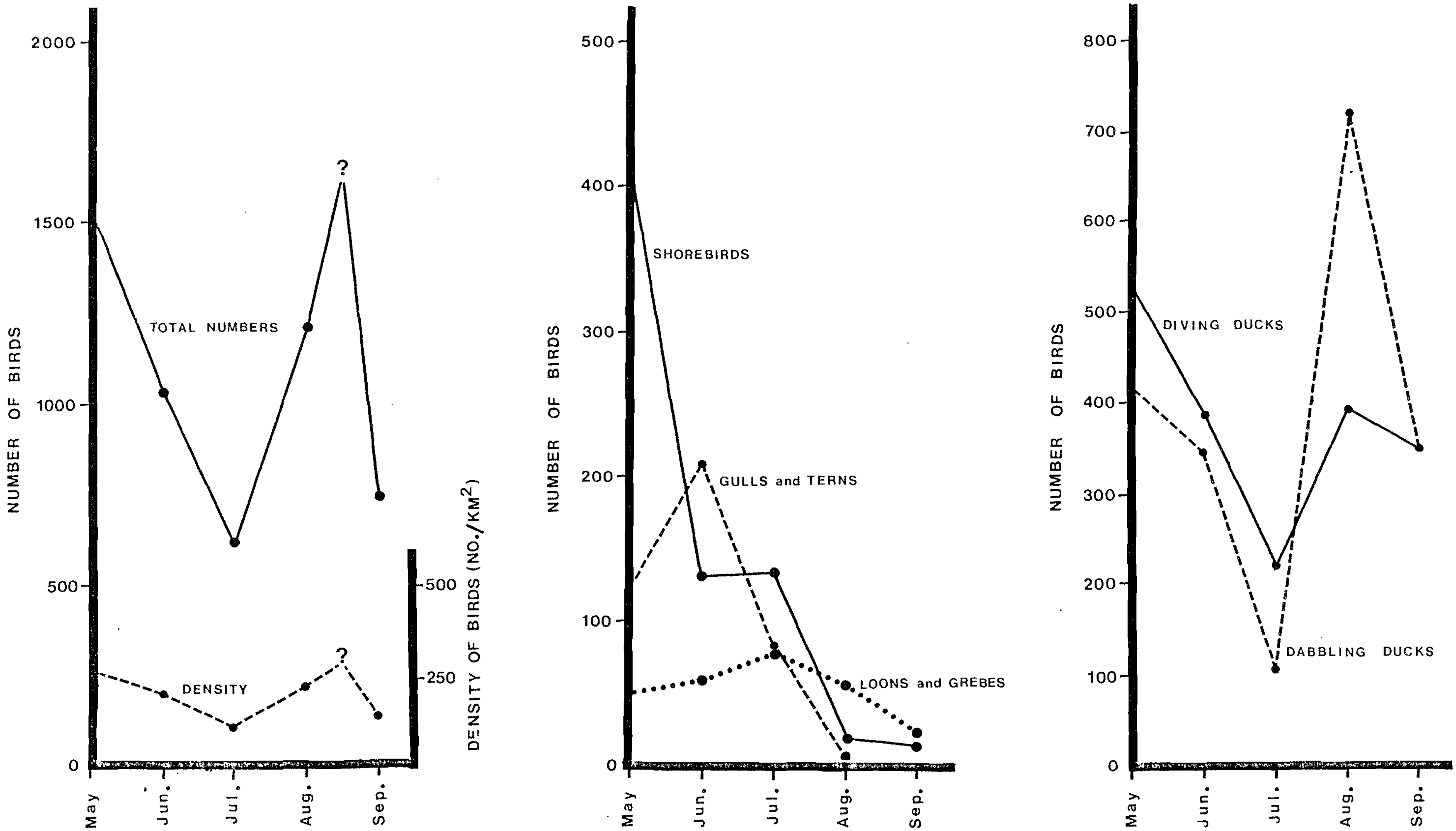

Figure 7. Seasonal variations in density and abundance of waterbirds on the Scottie-Desper Creek wetlands. Data are from the 1979 monthly censuses of 37 waterbodies on the study area.

had reappeared. The main influx of fall migrants, especially ducks, did not begin until late August, and numbers peaked during the first two weeks of September (between the August and September census periods), when densities probably exceeded 300 birds/km^2. Thereafter, numbers decreased until freezeup.

The densities and relative abundances of each species recorded on each monthly census are given in Table 9. Seasonal population levels varied considerably among individual species, but the variability was muted when species were grouped phylogenetically: Loons and Grebes, Dabbling Ducks, Diving Ducks, Shorebirds, and Gulls and Terns. Seasonal trends for the several phylogenetic groups are illustrated in Figure 7. A discussion of species and species groups follows.

Arctic Loon, the only loon species on the study area in 1979, had completed its migration and had already begun nesting when censusing began in mid-May. Densities varied only slightly between May and August, ranging from 4.2 to 6.0 birds/km^2. Only one loon remained by the time of the September census.

Horned Grebe was the only resident grebe in 1979, although the Red-necked Grebe was an uncommon fall migrant. Horned Grebe was slightly more abundant and variable than Arctic Loon. Peak densities of 8.9 birds/km^2 occurred in July, when adult birds were congregating prior to fall migration.

No resident geese were present during 1979. Even migrant Canada and White-fronted geese were uncommon on the study area, although the wetlands were along their migratory corridor (see Seasonal Chronologies).

Ducks comprised over 75% of all waterbirds recorded on the censuses. Densities ranged from 61 ducks/km^2 in July to 203 ducks/km^2 in August, with a mean density of 144 ducks/km^2 of wetland. The mean abundances of dabbling and diving ducks were about equal (Table 9).

Six species of dabbling ducks were recorded on the censuses, and the individual species showed nearly the same trend in seasonal abundance as did the phylogenetic group in Figure 7--except that the Mallard increased in abundance between the August and September censuses, while the others decreased. Dabbler migration was completed by mid-May when the first census was conducted. Numbers on this census probably best reflected the breeding density on the study area, because males were congregating and leaving the study area as early as the first week of June. The decline in abundance in June and July reflected the steady departure from the area of post-breeding males, nonbreeders, and females with unsuccessful nests. Apparently, at least in 1979, while dabblers found the Scottie-Desper Creek wetlands suitable for staging and nesting, most went elsewhere for molting. Numbers increased dramatically in late August as fall migrants, particularly Green-winged Teal and American

Wigeon, started moving through. The peak of fall migrants for dabbling ducks occurred during the first two weeks of September.

Twelve species of ducks have been loosely grouped as "diving ducks" for the purposes of this report, including mergansers and sea ducks (Table 9). This group followed much the same pattern of seasonal variation as the dabbling ducks, but with less amplitude. The high numbers on the May census reflected the late migration of several diving duck species, especially scaup. None of the censuses give a good indication of the size of the breeding population, because large numbers of nonbreeders were present during the breeding season. Lesser Scaup and Bufflehead comprised 89% of all divers in 1979; and, although both species bred in the area, sizable aggregations of nonbreeders were present on the large lakes throughout May and June. Like the dabblers, the divers departed the study area in mid-summer, and numbers did not increase again until the influx of fall migrants in late August. Bufflehead was the most abundant fall migrant, and numbers were still high at the end of September.

Of the sea ducks and mergansers, only White-winged Scoter and Surf Scoter were present on more than one census, and both species were transient.

Peak shorebird densities (74 birds/km^2) were recorded on the May census, which took place during the peak of migration for most species; 14 species were recorded on this census. Densities in June had dropped to 24 birds/km^2, representing mostly breeders. Overall densities remained the same into July, although individual species fluctuated widely, apparently because of fluctuating water levels. Most resident shorebirds decreased in abundance concurrently with the unusually high water levels in July (Fig. 2), but there was a substantial increase at this time in the number of Northern Phalarope--a species that makes little use of exposed shorelines. Except for the Common Snipe, most resident shorebirds had left the study area by the late August census, and migrants were absent. Common Snipe and Pectoral Sandpiper were the only shorebirds present in September.

The three residents of the gulls and terns grouping (Mew Gull, Bonaparte's Gull, and Arctic Tern) had largely completed spring migration and had probably begun to breed by the time censusing began in mid-May. At this time, total density was 21.8 birds/km^2, divided almost equally among the species. Daily observations indicated an increase of these birds, especially Bonaparte's Gull and Arctic Tern, during mid-June, the result of flocking of apparently failed or nonbreeders (see below). Total densities of gulls and terns had increased to 38 birds/km^2 by the June census. By the late July census, most gulls and terns had left the area, and all were gone by the late August census.

Other waterbirds recorded on censuses were Bald Eagle and Belted Kingfishers, which were residents in low densities (Table 9), and American Coot, which was a rare migrant.

Waterbird Production

Nineteen species of waterbirds were known to have nested on the Scottie-Desper Creek wetlands in 1979 (Table 10), and another six species were suspected of breeding (Semipalmated Plover, Lesser Yellowlegs, Solitary Sandpiper, Common Snipe, Least Sandpiper, and Belted Kingfisher), although we did not find nests or young.

Since the detectability of nests and broods varied with species, comparisons of production among the species groups in Table 10 should be avoided; comparison within species groups, however, is appropriate. Also, these data are not comparable to those used below to compare 1977 and 1979, since they were gathered from a larger series of waterbodies and over an extended period of time.

Arctic Loon was a common, evenly distributed breeder across the study area, typically nesting on the hydrologically isolated waterbodies. Usually only one pair nested on a given waterbody, but three broods were successfully hatched on SDC 49--a relatively large waterbody subject to disturbance from floatplane and Alaska Highway traffic.

Horned Grebe was a common breeder on small, nutrient-rich ponds. Most nested one pair per pond, but there were seven nests on the 0.083 km^2 of SDC 10--a concentration that appeared to be the cause of some aggressive behavior.

Eleven species of ducks bred on the study area in 1979 (Table 10), and collectively they produced over 86% of the young (661 young) observed. The five species of breeding dabbling ducks accounted for 62% of the total duck production, with Green-winged Teal, American Wigeon, and Mallard comprising most of this production. The six species of breeding diving ducks accounted for 38% of the duck production in 1979; the Lesser Scaup was the most abundant waterbird and produced more young than any other species.

Although Red-tailed Hawk (Buteo jamaicensis harlani), Great Horned Owl (Bubo virginianus), and probably Marsh Hawk (Circus cyaneus) bred on the study area, Bald Eagle was the only raptor considered a waterbird. We found four Bald Eagle nest sites (Fig. 9), three of which had adults present, and two of which produced young.

Shorebird nests and young proved difficult to locate, so our density figures are doubtlessly low. We found nests and broods of Spotted Sandpiper and Northern Phalarope, and observed courtship activity in Lesser Yellowlegs and Common Snipe.

Table 10. Waterbird production statistics, Scottie-Desper Creek wetlands, Alaska, summer 1979. Data were collected throughout the breeding season on the 37 waterbodies in Strata 1 and 3, plus Scottie Creek and Desper Creek; total wetland area covered was 8.0 km^2 (3.0 mi^2).

	No. of young	Density of young ($\#/km^2$)	No. of broods	Density of broods ($\#/km^2$)	Mean brood size Class Ia young**	No. of nests found*
LOONS AND GREBES						
Arctic Loon	20	2.5	13	1.6	1.5	1
Horned Grebe	57	7.1	31	3.9	1.8	8
DABBLING DUCKS						
Mallard	103	12.9	20	2.5	6.2	1
Pintail	37	4.6	7	0.9	5.2	
Green-winged Teal	150	18.8	29	3.6	6.4	
Northern Shoveler	2	0.3	1	0.1	2.0	
American Wigeon	122	15.3	28	3.5	5.6	1
Subtotal	414	51.8	85	10.6	4.9	2
DIVING DUCKS						
Canvasback	8	1.0	2	0.3	8.0	1
Redhead	1	0.1	1	0.1	1.0	
Ring-necked Duck	5	0.6	1	0.1	5.0	
Lesser Scaup	194	24.3	29	3.6	6.8	1
Barrow's Goldeneye	4	0.5	1	0.1	4.0	
Bufflehead	35	4.4	5	0.6	7.6	
Subtotal	247	30.9	38	4.8	6.5	2
SHOREBIRDS						
Spotted Sandpiper	3	0.4	1	0.1	3.0	2
Northern Phalarope	4	0.5	1	0.1	4.0	2
Subtotal	7	0.9	2	0.3	3.5	4
GULLS AND TERNS						
Mew Gull	2	0.3	1	0.1	2.0	3
Bonaparte's Gull	3	0.4	2	0.3	1.5	
Arctic Tern	1	0.1	1	0.1	1.0	
Subtotal	6	0.8	4	0.5	1.5	3
OTHER						
Bald Eagle	3	0.4	2	0.3	1.5	2
Unidentified ducks	10	1.3	3	0.4	3.3	
TOTAL	764	95.5	179	22.4	4.3	20

* Fate of most nests unknown.
** Class Ia = up to about 1 week old.

The low density of young gulls and terns (0.8 young/km^2) compared to the density of adults (23.3 birds/km^2), coupled with increased flocking of adults during mid-June, lead us to believe that there was nearly total breeding failure in all species of the group in 1979. We have no explanation, however, for this apparent breeding failure.

Waterbird Densities and Species Richness by Geographic Strata

To determine if waterbird use differed on wetlands close to the Alaska Highway from those distant from the highway, we compared waterbird densities and species richness (number of species) of the three geographic strata, which were at different distances from the Alaska Highway.

Stratum 2 was censused only during the late July census period, when population levels on the Scottie-Desper Creek study area were at their lowest. During this period Stratum 1 (nearest the Alaska Highway) had 133.8 birds/km^2, Stratum 2 had 95.6 birds/km^2, and Stratum 3 had 109.3 birds/km^2. This was the only census period in which waterbird densities were greater on Stratum 1 than Stratum 3, and this aberration was apparently caused by an exodus of the flocks of gulls and male ducks from Stratum 3 in July.

Mean seasonal densities, based on all five monthly censuses in Strata 3 and 1, showed a density of 202.3 birds/km^2 in Stratum 3 and only 134.2 birds/km^2 in Stratum 1. Total species richness was also consistently greater throughout the season in Stratum 3 than in Stratum 1; and there was a consistent difference in the abundance of ducks compared to non-duck species in the two strata, with ducks being denser in Stratum 3 throughout the season and non-duck species (primarily loons, grebes, shorebirds, and gulls and terns) being denser in Stratum 1 (Fig. 8).

The areal distribution of the most extensively used portions of the study area, as determined by the systematic ground censuses, daily observations, and the 8 October 1979 aerial survey, is illustrated in Figure 9.

Population Comparisons with other Interior Alaska Wetlands

It is difficult to compare the intensity of use by waterbirds of the Scottie-Desper Creek wetlands with other interior Alaska sites, because our data base was different than that used by Lensink (1965) on the Yukon Flats and Shepherd et al. (1967, 1968) at Minto Lakes--the only other wetlands where ground census data are available. Whereas

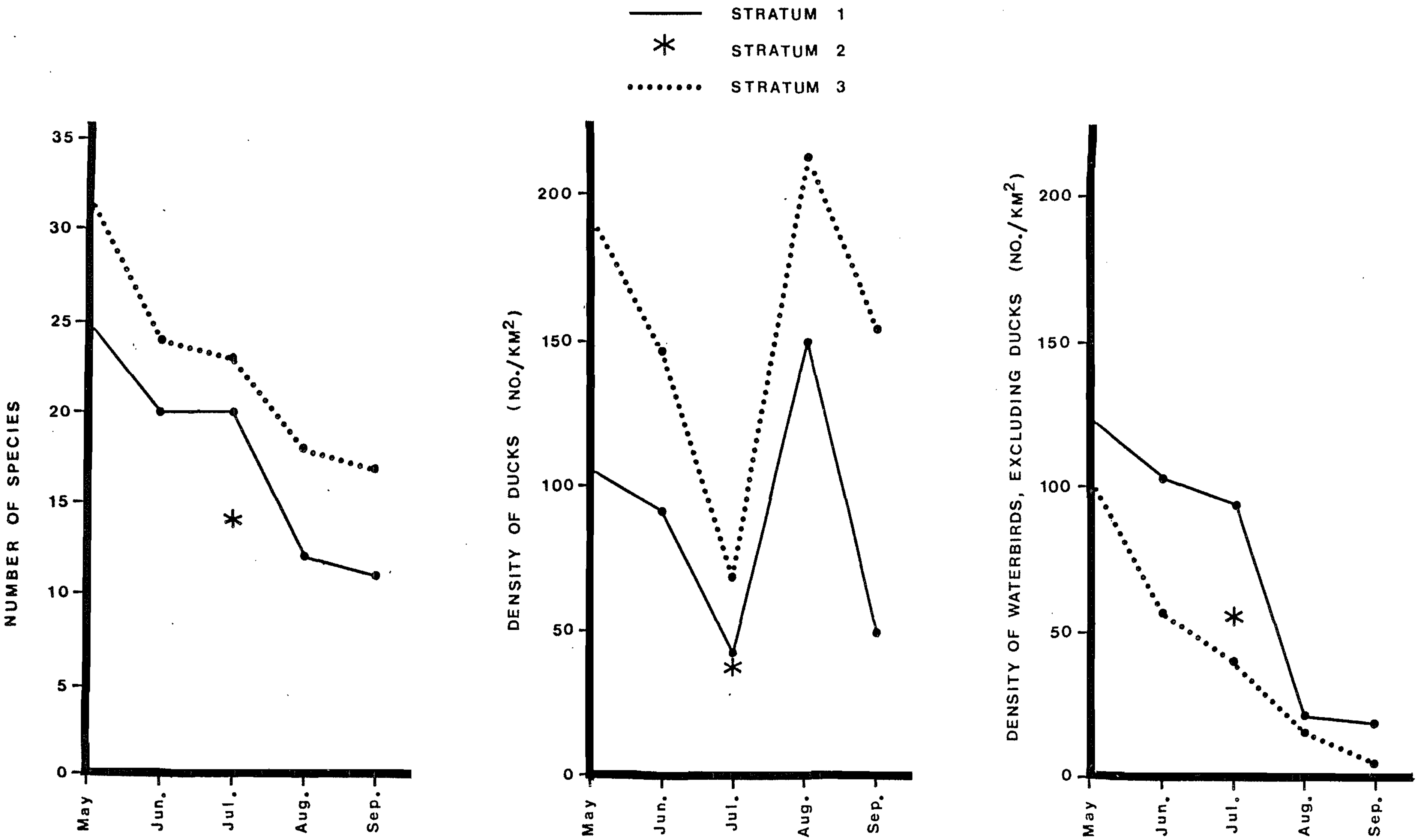

Figure 8. Comparison of species richness (number of species) and density of waterbirds on the various strata of the Scottie-Desper Creek wetlands as recorded on monthly censuses in 1979.

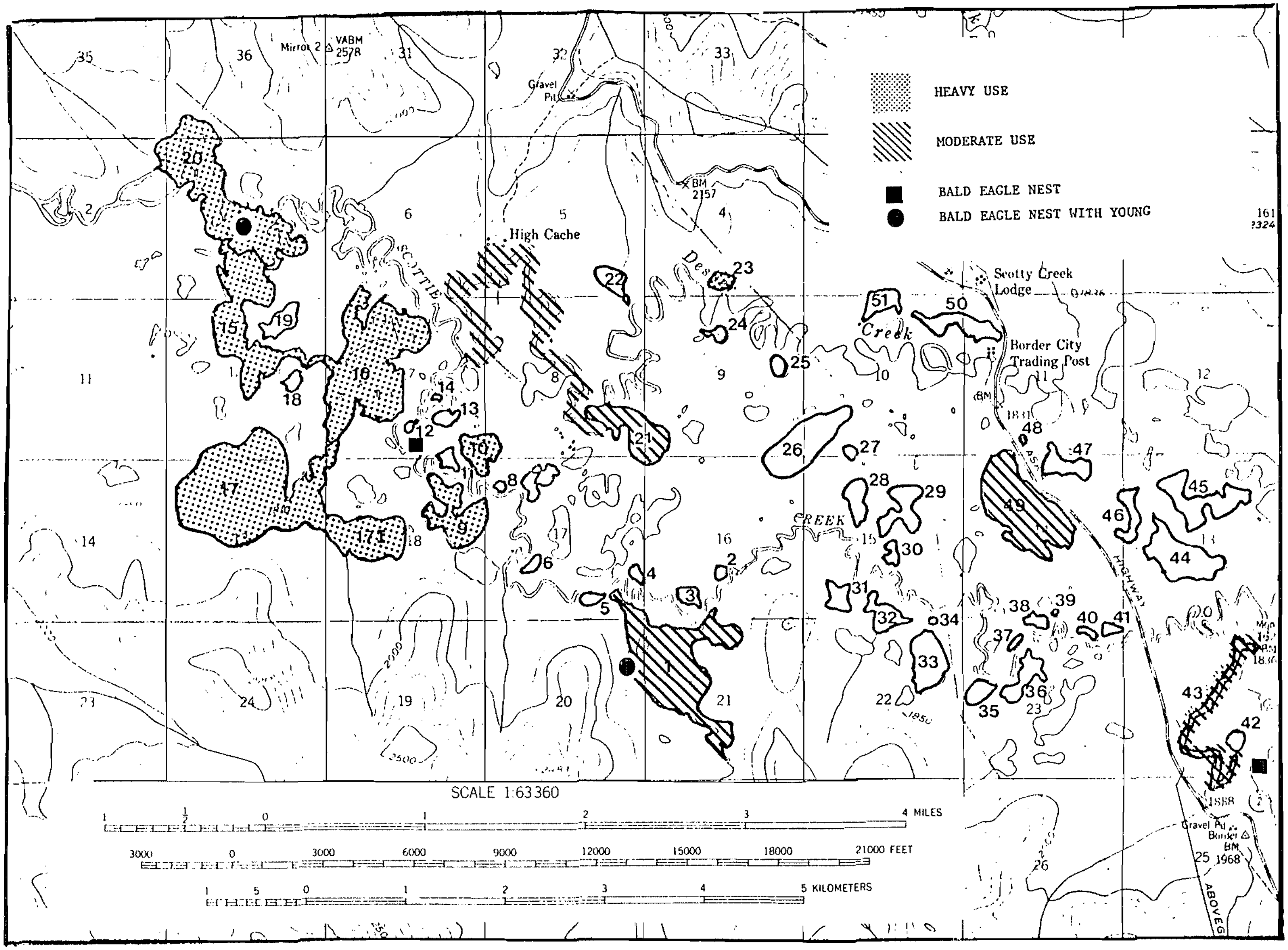

Figure 9. Areas of the Scottie-Desper Creek wetlands used most extensively by waterbirds in 1979. Localities of active Bald Eagle nests are also shown.

we used the total number of all waterbirds per square kilometer of wetland habitat, the other studies used the number of breeding pairs of ducks per square mile of surface or land block area. Since both Lensink (op. cit) and Shepherd et al. (op. cit.) also gave data on brood densities, however, we have attempted a rough comparison of wetland use through a comparison of duck brood densities.

To convert our duck brood density data, which was obtained from 8 km^2 of wetland habitat, to the entire Scottie-Desper Creek study area (11 km^2 of wetlands) and then to a land block basis (55 km^2 study area), we made the assumption that, while we searched only 73% of the wetlands, we covered the most productive areas and therefore found 90% of the duck broods on the study area (see Methods). Thus, we estimate that there were 12.5 duck broods/km^2 of wetland habitat on the Scottie-Desper Creek study area in 1979, or 2.5 duck broods/km^2 of land block area.

As can be seen from Table 11, this density of duck broods exceeds that found in either 1977 or 1979 on the comparative censuses of 13 of the more heavily used waterbodies in the vicinity of the pipeline corridor between Tetlin Junction and the U.S.-Canada border in the upper Tanana River Valley, but it is considerably lower than the mean brood densities that have been recorded at Minto Lakes and on the Yukon Flats--two of the best waterfowl areas of interior Alaska (fide J. G. King, Waterfowl Supervisor, U. S. Fish and Wildlife Service).

Limnology

Lakes and ponds are functional, dynamic units of a watershed, and the general productivity of such waterbodies is determined by a large number of interacting factors (Hutchinson 1957). In an attempt to determine the major proximate factors influencing the composition, distribution, and abundance of waterbirds on the Scottie-Desper Creek wetlands, we measured a number of limnologic variables on 15 selected waterbodies (see Methods).

Hydrology plays a fundamental role in controlling the dynamics of a wetland system, affecting both physical and chemical characteristics and ultimately the biological characteristics (Gosselink and Turner 1978). This pivotal role of hydrology is highlighted in the Scottie-Desper Creek area where each of our analyses of the limnologic data illustrated a basic division of waterbodies based on whether they were connected to or isolated from the creek system.

A principal component analysis (Morrison 1976) separated the 15 waterbodies into these two hydrologic groups (Fig. 10). The analysis reduced 11 measured limnologic variables to three principal components that accounted for 80% of the total variation in the data. Component I, which accounted for 33% of the variation, was most heavily influenced

Table 11. Comparison of duck brood densities for several interior Alaska wetlands.

	No. broods/km^2 wetlands	No. broods/km^2 land block
Upper Tanana River Valley		
1977	7.3*	1.2**
1979	5.2*	0.9
Scottie-Desper Creek study area		
1979	12.5	2.5**
Minto Lakes		
1962-1966	-	3.6+
Yukon Flats		
1961-1964	-	4.1++

* Calculated from Table 19.
** Calculated equivalent land block densities based on 17% coverage by wetland habitat in the upper Tanana River Valley census area (Spindler and Kessel 1977) and 20% coverage in the Scottie-Desper Creek study area.
\+ Shepherd et al. 1967, 1968.
++ Lensink 1965.

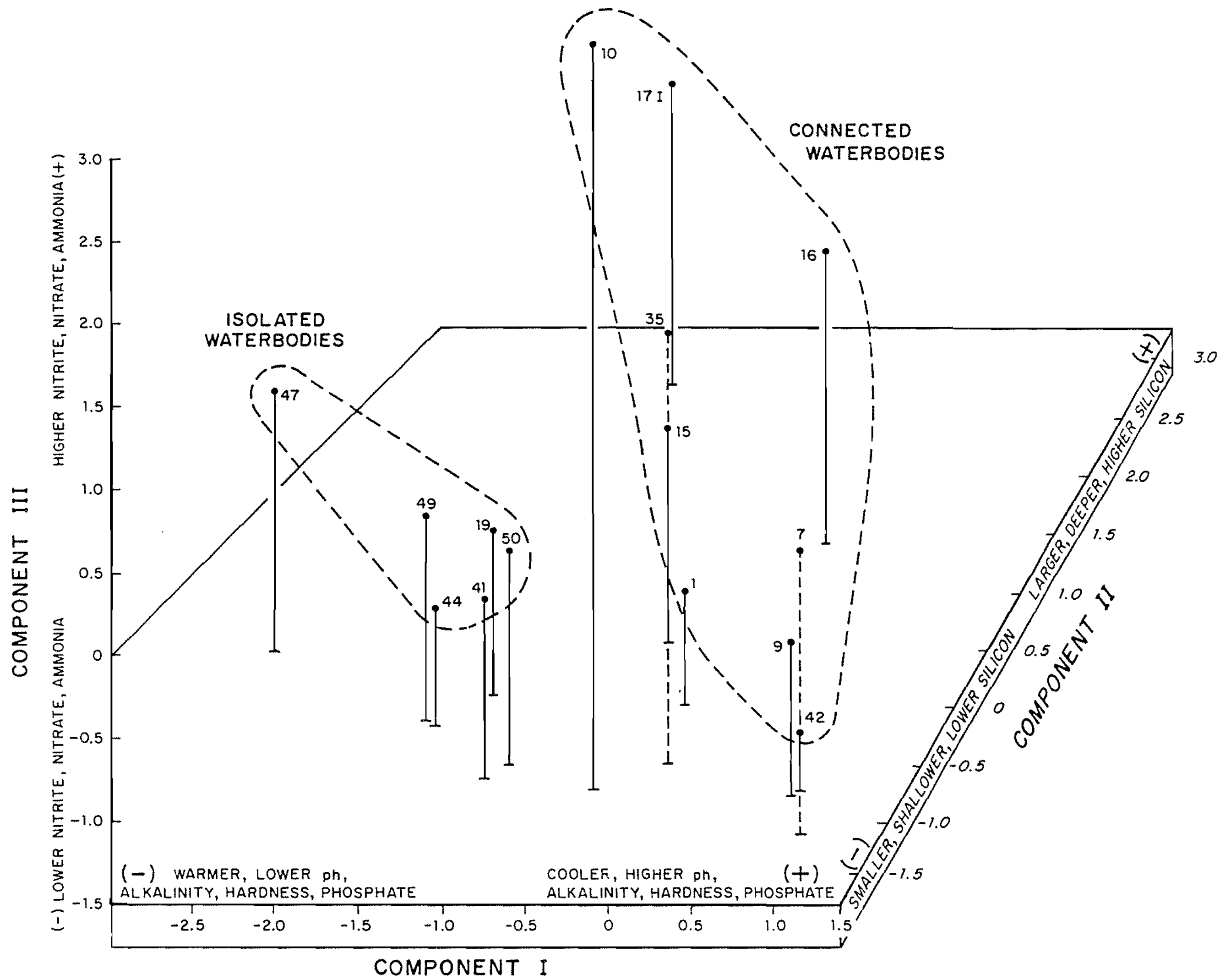

Figure 10. Ordination of six isolated and nine connected waterbodies, based on a three-dimensional plot of the centroids of factor scores along the first three principal component axes. Component I accounted for 33% of total variation; Component II, 24% of the variation; and Component III, 23% of the variation. Factor loadings for each variable are given in Appendix D-1.

("loaded") by phosphate, pH, alkalinity, hardness, and temperature. Depth, area, and silicon loaded most heavily on Component II, which accounted for 24% of the variation. Nitrogen (nitrite, nitrate, and ammonia) contributed most heavily to Component III, which accounted for 23% of the variation.

Limnologic data for each waterbody was projected onto ("scored against") the three principal components to ascertain where each waterbody was located in the three-dimensional space. The ponds were separated into two basic groups, solely on the basis of Component I (Fig. 10). Generally, the isolated ponds were warmer, had lower pH, alkalinity, hardness, and phosphate than the waterbodies connected to the creek system.

Neither Component II or III contributed to the primary division of waterbody types, but they did illustrate some of the variability that occurred within the two main groupings. For instance, in the three-dimensional ordination, waterbody SDC 47 was separated at some distance from the other isolated ponds. A comparison of the limnologic measurements from this pond (Appendix B) with the means of all the isolated ponds (Table 12) shows that SDC 47 was different in several respects: it was the deepest of the isolated ponds, yet was relatively warm, and it was the most acidic of all ponds measured. Similarly, among the connected waterbodies, SDC 10, 16, and Pond 17I stood out on the ordination as different from the others, SDC 10 being separated by Component III and SDC 16 and 17I by Component II. An examination of the limnologic variables (Appendix B) shows that SDC 10 had by far the highest amount of nitrite and nitrate of any waterbody sampled; Pond 17I, at 10.4 m, was more than twice the depth of the next deepest pond, and it contained the highest silicon levels of any waterbody; SDC 16 also had unusually high silicon levels.

Also apparent from the three-dimensional ordination in Figure 10 is that the range of variation (heterogeneity) of limnologic characteristics is considerably greater among the connected ponds than among the isolated ponds, especially along Component II (depth, area, and silicon) and Component III (nitrogen).

Limnologic similarities (and differences) among the 15 ponds were also examined with a cluster analysis technique, and the resulting association pattern was similar to that of the principal component analysis (Fig. 11): The isolated and connected ponds were respectively clustered, the isolated ponds showed a greater homogeneity (total clustering was reached at a higher level of similarity), and SDC 10, 16 and Pond 17I were the last (most different) to cluster, with SDC 16 and Pond 17I being more similar to each other than to SDC 10.

Using the two waterbody groupings elucidated through the cluster and principal component analyses, a stepwise discriminate function

Table 12. Means (±SD) of limnologic variables obtained from six isolated and nine connected types of waterbodies, Scottie-Desper Creek wetlands, during an early summer and a fall sampling period, 1979.

Variable	Isolated waterbodies	Connected waterbodies	All waterbodies
Temperature (°C)	15.41 ± 2.03	13.53 ± 1.01	14.29 ± 1.49
pH	7.01 ± 0.28	7.50 ± 0.27	7.31 ± 0.27
Total Alkalinity (mg$CaCO_3$/liter)	35.50 ± 12.90	89.11 ± 34.37	67.67 ± 28.12
Hardness (mg$CaCO_3$/liter)	29.50 ± 15.18	90.33 ± 33.25	66.00 ± 27.73
Maximum Depth (m)	2.47 ± 1.25	3.11 ± 2.88	2.85 ± 2.39
Nitrite (μg-at/liter)	0.16 ± 0.03	0.45 ± 0.36	0.34 ± 0.28
Nitrate (μg-at/liter)	1.39 ± 0.85	2.16 ± 1.65	1.85 ± 1.40
Phosphate (μg-at/liter)	0.20 ± 0.05	0.66 ± 0.15	0.47 ± 0.12
Ammonia (μg-at/liter)	2.91 ± 0.36	4.37 ± 1.07	3.78 ± 0.87
Silicon (μg-at/liter)	19.17 ± 7.92	33.18 ± 22.27	27.58 ± 18.15
Area (ha)	13.72 ± 19.43	30.16 ± 29.73	23.58 ± 26.25

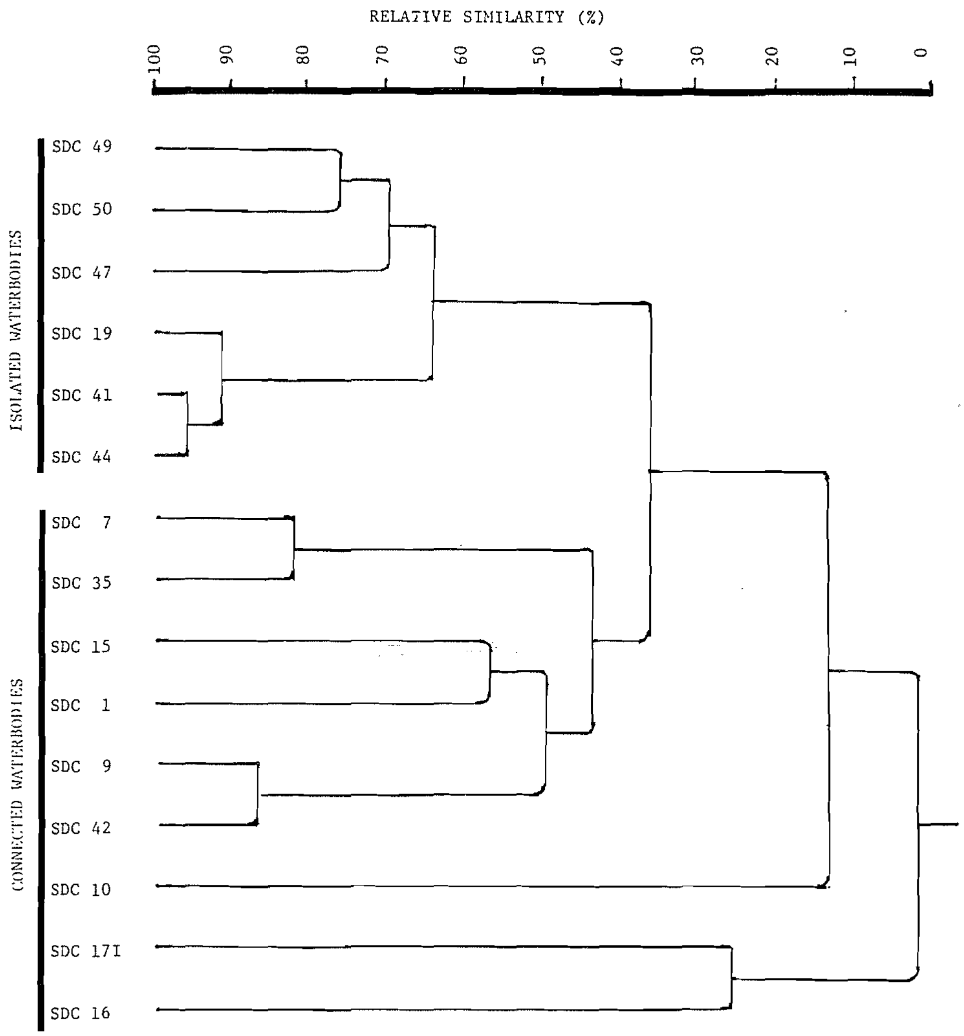

Figure 11. Cluster analysis of 15 waterbodies in the Scottie-Desper Creek wetlands, Alaska, based on their chemical and physical characteristics. All the isolated waterbodies clustered early, indicating their relative homogeneity and their relative dissimilarity to the connected waterbodies.

analysis (Morrison 1976) was performed to more specifically identify the limnologic variables that could best separate the two waterbody types. This multivariate technique showed that 93% of the waterbodies (14 out of 15) could be separated into isolated or connected types solely by the level of phosphate they contained. Only SDC 15, which had an intermediate level of phosphate, was incorrectly classified; and this pond was correctly identified as a connected waterbody when pH was added in the second step of the analysis.

While phosphates proved to be the best predictor in distinguishing between the two hydrologic types, a number of other limnological variables also differed. Generally, as already shown in the principal component analysis, in the isolated waterbodies, nutrients, alkalinity, hardness, and pH were lower, and the temperature warmer than in the connected waterbodies (Table 12).

The distribution of isolated and connected waterbody types on the Scottie-Desper Creek wetlands was not uniform. Their distribution reflected the evolutionary development of cryogenic or cave-in lakes as described by Wallace (1948). Stratum 1 waterbodies, upstream near the Alaska Highway, were mostly of the isolated type, which comprise the "youthful stage" of cave-in lake formation. The downstream Stratum 3 waterbodies were almost exclusively of the connected type, described in Wallace (ibid.:175) as the "late mature stage...in which aggregates of lakes have coalesced...and the whole system has been intergrated, commonly by intersection of a drainage channel, so that there is drainage between and through the lakes...." Stratum 2 had a fairly even distribution of isolated and connected waterbodies.

Nutrients and Primary Productivity

The above analyses have suggested that several of the limnologic variables measured on the 15 waterbodies played important roles in characterizing the waterbodies: phosphate, pH, alkalinity and hardness, nitrogen, and silicon. Some of these same variables have been shown to be correlated with the level of primary production found in freshwater systems.

Both phosphorus and nitrogen are essential to all life, and one or both have often been found to be the factor(s) limiting primary production in waterbodies (Hutchinson 1957). Sources of phosphorus and nitrogen include both the physical and biological portions of the environment. Phosphorus can come from the weathering of rocks, the leaching of soils and the biota, or it can come from the decomposition of organic materials. Nitrogen can enter the system directly from the atmosphere or as dissolved nitrogen in surface or ground water or in precipitation (Wetzel 1975), and it is available through organic nitrification (Cole 1979). Forms of both nitrogen and phosphorus are transported via a stream system.

Alkalinity (bicarbonates, carbonates, and hydroxides) factors have proved significant to the primary productivity of some freshwater systems. In addition to buffering properties, the constitutent ions provide an inorganic pool of carbon, which is essential to the photosynthetic metabolism of algae and submerged macrophytes. Usually carbon is not limiting in the photosynthetic process of aquatic systems, but in some instances it has been found to directly influence productivity. Naumann (1932) concluded that total alkalinity, up to a level of 53 mg HCO_3/liter, was directly related to productivity in some Swedish oligotrophic lakes. Similarly, alkalinity up to 48 mg HCO_3/liter was used by Moyle (1949) as an index to primary productivity for some lakes in Minnesota. In the Scottie-Desper Creek system, the alkalinity values of the isolated waterbodies averaged only 35.5 mg HCO_3/liter, making us suspect that carbon could be a limiting factor in the primary productivity of these ponds.

We are unsure of the biological significance of silicon, although it is apparently used during diatom blooms, probably in the construction of the diatom frustules (Hutchinson 1957). Silicon occurs naturally as orthosilicate in freshwater, and it comes from the soil, weathered rock, and from the decomposition of organic matter (e.g., diatoms). There was a wide range of silicon levels among the ponds and a generally higher level in connected than in the isolated waterbodies.

While the availability of inorganic nutrients is critical to primary productivity levels (Good et al. 1978), their availability is influenced by many factors, including the hydrodynamics of the wetland system (Gosselink and Turner 1978:63):

> The source, velocity, renewal rate, and timing of the water in a wetland ecosystem directly controls the spatial heterogeneity of wetlands and the nutrient, O_2, and toxin load of the sediments. These secondary factors in turn control or modify such ecosystem characteristics as species composition and richness, primary productivity, organic deposition and flux, and nutrient cycles.

In view of the complexity of the energy-production cycles of wetland systems, we have only scratched the surface of the productivity relationships of the Scottie-Desper Creek wetlands. But since the connected waterbodies were hydrologically dynamic (affected directly or indirectly by periodic inundations) compared to the isolated waterbodies, it is not surprising that we found higher levels of inorganic nutrients in the connected waterbodies. On the basis of the higher nutrient levels and of our casual observation of a greater plant standing crop biomass (algae and/or submergent macrophytes) in connected waterbodies, we feel confident in assuming a higher level of primary productivity in these waterbodies compared to the isolated waterbodies.

Nutrient regimes have been implicated in the relatively high primary productivity of some lakes in interior Alaska (Alexander and Barsdate 1971, 1974; Barsdate and Alexander 1971). The Tangle Lakes system in the Alaska Range is considered a relatively productive system for Alaska (Alexander and Barsdate 1974), and the nutrient levels (phosphates and nitrates) of the connected waterbodies at Scottie-Desper Creek approximate those of Tangle Lakes (Table 13). In fact, connected SDC 10, with levels of 4.9 μg-at/l of nitrate, exceeded those previously recorded from other interior Alaska waterbodies.

Invertebrates

To gain further insights into factors influencing the level of use by waterfowl of different waterbodies, the invertebrate fauna of two types of waterbodies was examined. SDC 10 and Pond 17I were within a mile of each other in Stratum 3 (see Methods). Both ponds turned out to be of the connected type and thus were relatively rich in nutrients. The main source of primary productivity differed, however, with the source in SDC 10 being submerged macrophytes and that in Pond 17I being algae.

In general, there are two main routes within an ecosystem by which energy is transferred from primary autotrophs (bacteria and plants) to higher heterotrophic levels. The first is by direct consumption of living autotrophs, and the other involves the degradation of dead organic material (detritus) by microorganisms, which in turn may be consumed by higher heterotrophs. The major energy source of the benthic invertebrate fauna of most shallow water ponds (e.g., SDC 10) is derived from detritus (Smith 1974). The energy source for zooplankton may be either from suspended detritus and associated microorganisms or from direct grazing of autotrophs.

Description of Invertebrate Ponds

SDC 10 was a small (0.083 km^2) beaver-dammed pond adjacent to Scottie Creek. The dam usually maintained a stable water level above that of the creek, but during the high waters of July, water from Scottie Creek flooded the pond for approximately a 2-week period, and flooding probably also occurred during spring breakup.

Most of the shoreline was dominated by bluejoint grass (*Calamagrostis canadensis*), although the southern 25% of the shoreline was lined by tall willow shrubs. There were several clumps of dead or dying willows in the water of the pond, apparently permanently flooded by the beaver dam. The pond was shallow, with a maximum depth of 1.6 m. The water was stained dark brown, causing a rapid attenuation of light in the water column; the average secchi disc transparency was 1.1 m.

Table 13. Nutrient levels in the Scottie-Desper Creek wetlands compared to other interior Alaska waterbodies. Units of measure are µg-at/liter.

	Ace* Lake	Deuce* Lake	Tanana** Valley	Lake** Louise	Tangle** Lakes	Scottie-Desper Creek Wetlands: Connected	Isolated	Combined
Nitrate	1.4	3.8	0.3	0.3	2.7	2.2	1.4	1.8
Phosphate	1.4	1.0	0.2	0.02	0.4	0.7	0.2	0.5

* Derived from summer-fall surface measurements, Alexander and Barsdate 1974.
** Barsdate and Alexander 1971.

Of the 15 waterbodies measured, SDC 10 ranked in the upper third for phosphates, ammonia, silicon, alkalinity, and hardness; and it had the highest nitrite and nitrate levels of any pond (Appendix B-1).

The pond supported a variety of plant life. About a third of the bottom supported a variety of submerged macrophytes, especially pondweeds (Potamogeton spp.); the other two-thirds was open water with occasional clumps of macrophytes. The density of submergents varied greatly, with the deeper areas containing less plant biomass, probably because of low light levels caused by the dark water. A low quantity of floating algae persisted throughout the summer without an obvious bloom. At the tall shrub edge of the pond, duckweeks (Lemna minor and L. trisulca) were abundant, and there were some emergent sedges (Carex aquatilis and C. rostrata).

Pond 17I was not a true pond, but was a constricted, 0.269 km^2 lobe of a much larger waterbody, SDC 17. It was the deepest waterbody measured, having a maximum depth of 10.4 m, and it possessed a hypolimnion that was anoxic at both spring and fall sampling periods. There was a distinct thermocline at approximately 3.5 m at the time of the first sampling period; in fall the thermocline was more diffuse and at approximately 9.0 m. The water was stained and had a secchi disc transparency of 2.7 m. Pond 17I was geographically removed from Scottie Creek, but was hydrologically influenced by it through connections with SDC 15, 16, and 17. Water levels in Pond 17I were much more affected by the creek than were those in SDC 10; levels rose and fell with those of Scottie Creek.

Much of the shoreline of Pond 17I was abruptly delineated by a moderately inclined bank choked with willows. The aquatic plant life consisted almost exclusively of algae (not identified). A bloom began in mid-June and persisted at varying levels until late September.

Relative to the other ponds, the nutrient levels of Pond 17I were relatively high (Appendix B-1). The pond ranked in the upper third for phosphates, ammonia, nitrate, and nitrite, and it ranked first in alkalinity, hardness, and silicon levels. The combination of an anoxic hypoliminion, allowing release of nutrients from the sediments (Wetzel 1975), and open exposure to strong winds probably caused periodic replenishment of nutrients to the surface, thus allowing a relatively high level of algal production to be sustained.

Invertebrate Fauna of Ponds 17I and SDC 10

Thirty-five invertebrate groups*, zooplankton and benthic invertebrates, were identified from the samples taken from Pond 17I

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* See Appendix C-1 for systematic list of names, including English names.

and SDC 10. Of these groups, Chironomidae (midges) larvae were the most important, ranking first by volume in both ponds (Fig. 12A). Other important groups found in both ponds were the Gammaridae (scuds or amphipods) and Chaoboridae (phantom midges). Collectively, these three groups ranked first in 75% of the samples from SDC 10 and 95% of the samples from Pond 17I.

SDC 10 had a dominance pattern that was more diverse than Pond 17I. After removing the dominant chironomids from consideration, dominance was shared among 10 groups in SDC 10, with no group dominating more than 25% of the samples (Fig. 12B). Pond 17I, in contrast, had only five groups (after excluding chironomids), with Oligochaeta (aquatic earthworms) ranking first in 70% of the samples.

By comparing the dominant invertebrate groups between pond strata ($\leq$1.0 m vs >1.0 m depths), additional information on the structure of the invertebrate communities was obtained. Chironomids dominated both strata in both ponds, with their importance being greatest (ranked first in 90% of samples) in the deep stratum of Pond 17I (Fig. 13). In the shallow stratum of SDC 10, Gammaridae (20%), Planorbidae (orb snails) (10%), and Limnephilidae (caddisflies) (10%) comprised the remaining major groups. The dominance shifted in the deep stratum, however, to emphasize Valvatidae (round-mouthed snails) (20%), Hyalella amphipods (10%), and Chaoboridae (10%). In the shallow stratum of Pond 17I, Oligochaeta and Gammaridae shared equal dominance (each ranked first in 10% of the samples), but in the deep stratum, the oligochaetes failed to dominate any samples.

With the exception of Lepidoptera and Leptoceridae, SDC 10 contained all invertebrate groups found in Pond 17I, and contained an additional 11 groups that were not found in 17I--Baetidae, Coenagroinidae, Lestidae, Aeshnidae, Limnephilidae, Polycentropodidae, Dytiscidae, Gyrinidae, Haliplidae, Conchostraca, and Harpacticoida. Since both SDC 10 and Pond 17I contained calanoid and cyclopoid copepods and cladocera (Appendix C-1), both would fall at the upper extreme of Hobbie's (1973) trophic scale for arctic lakes, i.e., both would be considered highly eutrophic for arctic waters.

The presence of substantial quantities of macrophytes in SDC 10 apparently contributed to the abundance and diversity of the invertebrate fauna in that pond. Different macrophytes attract different communities of invertebrates (Krull 1970), and different successional stages of macrophyte development in a pond support different levels of invertebrate populations (Voigts 1976). It follows that the more diverse the macrophyte community and the greater its spatial heterogeneity, the greater the invertebrate species richness and probably the total biomass. In a study in Iowa, for example, Voigts (1976:319) found that

> ...most abundance peaks [of invertebrate species] did not occur until the open emergent and open submergent phases, when narrow-leafed submerged

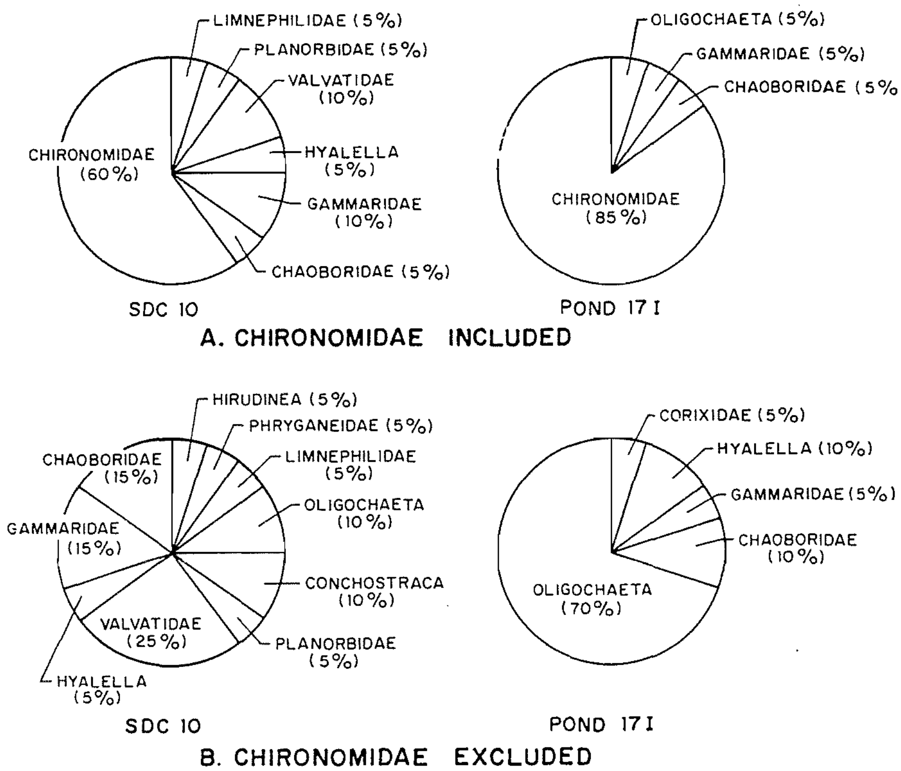

Figure 12. Diagrams showing invertebrate groups and dominance patterns found in waterbodies SDC 10 and Pond 17I, Scottie-Desper Creek study area, Alaska, 1979. Data from both strata and from both the early summer and fall sampling periods are combined. Each diagram section represents the percent of samples in which each invertebrate group ranked first by volume in a total of 20 samples.

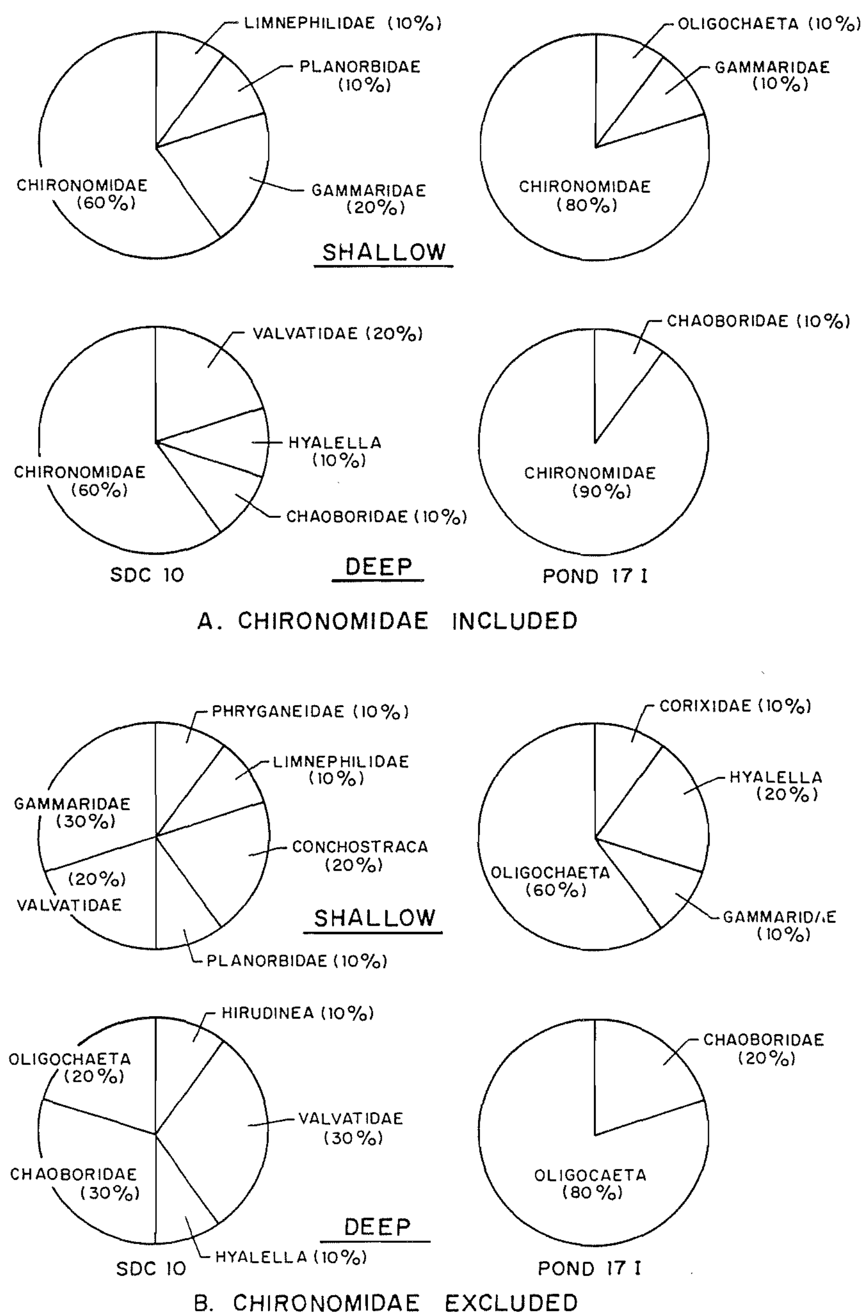

Figure 13. Diagrams showing invertebrate groups and dominance patterns found in the deep and shallow strata of waterbodies SDC 10 and Pond 17I, Scottie-Desper Creek study area, Alaska, 1979. Data from both the early summer and fall sampling periods are combined. Each diagram section represents the percent of samples in which each invertebrate group ranked first by volume in a total of 10 samples.

> vegetation was providing substantial cover. Amphipods were the most abundant invertebrate taxa, and their peak abundance was reached when the submerged vegetation... was at peak abundance.

Habitat Selection by Waterbirds

Limnology and Waterbirds

To see if there was any relationship between the limnologic variables measured on the 15 waterbodies on the Scottie-Desper Creek wetlands and the use of these waterbodies by waterbirds, we used stepwise multiple regression (Draper and Smith 1966) to order limnologic variables (independent variables) according to their effectiveness in predicting species richness or density (dependent variable). The resultant regression equations are presented in Table 14.

Size of the waterbody was the factor most influencing species richness, with the larger waterbodies generally supporting the greater number of species--illustrating a biological principle described by MacArthur and Wilson (1967) and Krebs (1978). Considering all species of waterbirds, 57% of the variation in species richness of the 15 waterbodies was accounted for by area. A total of 69% of the variability was accounted for when nitrite was added in the second step of the regression. When only the number of duck species was considered, the size of the waterbody accounted for 47% of the variation. Nitrite was again the second factor entered into the regression, but, with ducks, ammonia and phosphate also contributed significantly to the variability in species richness. Collectively, these four variables together explained 94% of the variability in the number of duck species per waterbody.

Nitrite was the limnologic variable most highly correlated with the density of waterbirds, accounting for 53% of the variability among waterbodies. When depth and area were added to the regression, 85% of the total variability of density was explained; both entered the equation negatively, indicating that the smaller and shallower waterbodies tended to have greater densities than the larger, deeper ones.

Nitrite also accounted for the greatest amount of the variation in the density of ducks (32%), but nitrate (negative correlation) and phosphate (positive correlation) entered second and third, respectively, into the equation, indicating that they exerted more influence than depth and area. These latter physical factors also contributed significantly to the equation, however, with the five factors together explaining 79% of the variation of duck densities among waterbodies.

Table 14. Stepwise multiple regression equations showing the relative importance of limnologic variables in predicting waterbird species richness or density on Scottie-Desper Creek wetlands.

Waterbird species richness	=	3.372 + 0.008 area + 2.809 nitrite	$R^2 = 0.69$	n = 15
Duck species richness	=	2.846 + 0.006 area + 4.51 nitrite - 1.232 ammonia + 4.165 phosphate	$R^2 = 0.94$	n = 15
Waterbird species density	=	706.636 + 1116.331 nitrite - 0.755 area - 724.803 depth	$R^2 = 0.85$	n = 15
Duck species density	=	110.143 + 406.212 nitrite - 62.837 nitrate + 261.497 phosphate - 169.991 depth - 0.154 area	$R^2 = 0.79$	n = 15

The fact that nutrients, especially nitrite and phosphate, were selected by the stepwise multiple regression procedure as the most important predictors of waterbird duck density corroborates the thesis that waterbodies with high nutrient levels support high levels of primary productivity (algae or macrophytes), which in turn support a high biomass of secondary and tertiary consumers, such as invertebrates and waterbirds.

Hydrologic Waterbody Types and Waterbirds

Since the nutrient regimes on the Scottie-Desper Creek wetlands appeared largely controlled by hydrologic factors (see Limnology), we compared the waterbird usage of the six isolated and nine connected types of waterbodies for which limnologic data were available (Tables 15 and 16). All indicators of waterbird usage showed sizable differences between the two waterbody types, with the isolated waterbodies receiving less use than the connected waterbodies. The differences were even more pronounced when only ducks were considered (Table 16), with ducks clearly making little use of the isolated waterbodies. Again, this pattern of use paralleled that of the nutrient levels of the waterbody types.

While some waterbird species , especially ducks, clearly favored the nutrient-rich connected waterbodies, other species, such as Arctic Loon and the gulls and terns, appeared to favor the isolated waterbodies. In Scandinavia, Nilsson and Nilsson (1978) also found the Arctic Loon using nutrient-poor lakes. We do not know the important factors in habitat selection for Arctic Loon or the other birds favoring the isolated waterbodies, but they have obviously evolved feeding strategies that allow them to use low-nutrient ponds.

We found a similar situation when we compared waterbird use of the 37 waterbodies censused throughout the 1979 field season. For this comparison, we calculated a composite "Importance Value" (see Methods) for each waterbody based on abundance, species richness, and density of birds. This derived value serves only to rank the use of the 37 waterbodies relative to each other; the values are meaningless in any other context. Figure 14 shows that SDC 17 was by far the most important waterbody for waterbirds in 1979; it was the largest waterbody on the study area and consistently attracted the greatest number of birds and the greatest number of species. The nine most important waterbodies were all in Stratum 3 and all were of the connected type.

Table 15. Mean population statistics for all waterbirds on the two types of waterbodies in the Scottie-Desper Creek wetlands, 1979.

	Isolated Waterbodies	Connected Waterbodies
Abundance (No. of birds)	18.4	59.5
Species richness (No. of species)	5.0	7.3
Density (No. of birds/km^2)	207.3	308.4

Table 16. Mean population statistics for ducks on the two types of waterbodies in the Scottie-Desper Creek wetlands, 1979.

	Isolated Waterbodies	Connected Waterbodies
Abundance (No. of birds)	5.9	45.4
Species richness (No. of species)	1.6	4.2
Adult Density (No. of birds/km^2)	319.4	874.8
Brood density (No. of broods/km^2)	7.3	19.2

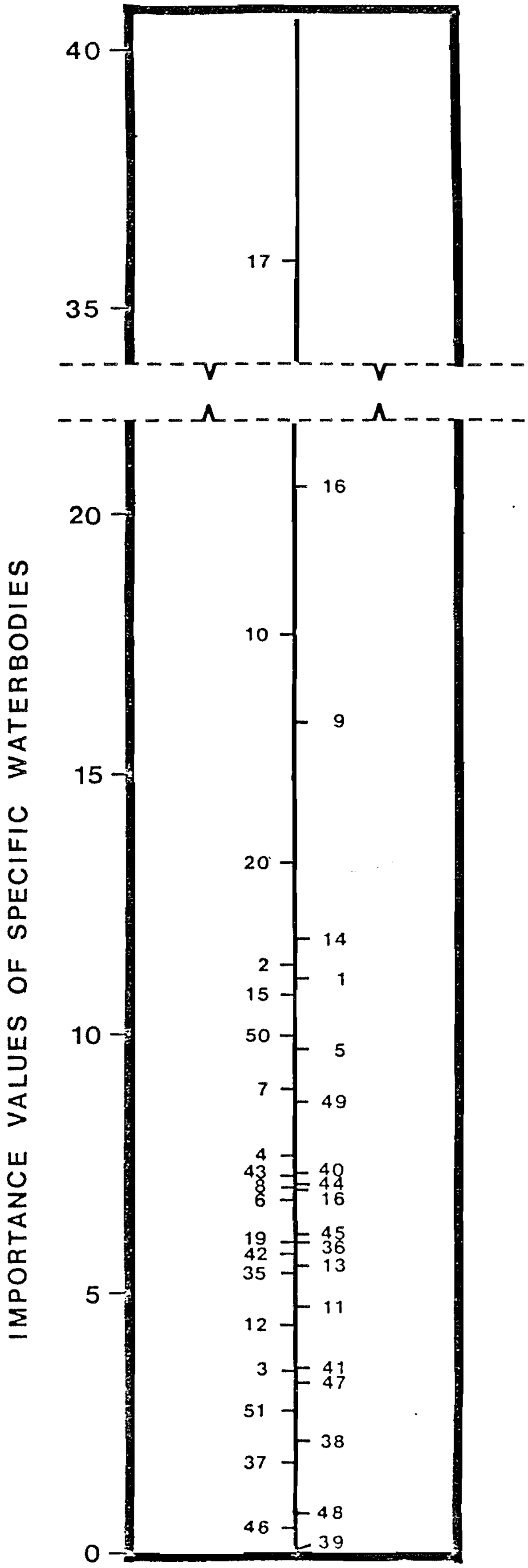

Figure 14. Thirty-seven waterbodies of the Scottie-Desper Creek wetlands ranked according to their importance to waterbirds. Importance values were calculated according to Curtis and MacIntosh (1951).

Invertebrates and Waterfowl

A number of recent studies have highlighted the importance of aquatic invertebrates in the diet of ducks, especially during the breeding season when egg production and chick growth cause high demands for protein (Bartonek and Hickey 1969, Swanson and Meyer 1973, Swanson et al. 1974, Krapu 1974, Krapu and Swanson 1975, Street 1978). Invertebrates contain a greater proportion of protein than do most plant foods (Krapu and Swanson 1975). Furthermore, the amino acids found in some of the commonest invertebrate groups have proved closely similar to those in egg proteins (Krapu and Swanson 1975) and nearly approximate the amino acid requirements of duck chicks (Sugden 1973). Thus, it is not surprising that several studies have found that wetland areas with large invertebrate food supplies are heavily used by breeding waterfowl (e.g., Arner et al. 1970, McKnight and Low 1969).

While SDC 10 and Pond 17I both ranked relatively high among the 37 waterbodies censused in overall importance to waterbirds (third and tenth, respectively), and both ranked similarly in total volumes of invertebrates per unit area, SDC 10 ranked first in the number of young ducks observed, third in waterbird density, fourth in total number of adults, and sixth in number of species. In comparison, Pond 17I ranked in the bottom third of the waterbodies in the number of young observed, 25th in waterbird density, eighth in total numbers of adults, and seventh in number of species. Although it is not possible to separate all the factors that attract waterbirds to a particular waterbody (animal or plant food, nesting sites, protective cover, etc.), a significant portion of the differences of waterfowl use of SDC 10 and Pond 17I appears attributable to the greater number and diversity of macrophytes and their associated invertebrates in SDC 10 compared to Pond 17I.

We obtained no data on specific preferences of waterbirds for different invertebrate foods. To do this would have required a major food habits study of the individual waterbird species compared to food availability, a project not warranted by the scope of the present study. Without knowledge of specific food preferences, it is not possible to know if a particular bird species is present because of the availability of preferred food items, or whether the species, being present, is feeding on what is most readily available. Nonetheless, it is of interest to note that studies at Great Slave Lake, Northwest Territories (Bartonek and Murdy 1970), showed that the diets of both flightless adults and young Lesser Scaup (the most abundant breeding duck on the Scottie-Desper Creek wetlands in 1979) were virtually 100% animal matter; and the invertebrates found in greatest volumes in their esophagi included many of the abundant invertebrates found especially in SDC 10 (i.e., Amphipoda, Diptera, Chonchostraca, and Gastropoda)--a pond that supported the greatest number of young scaup (45 young on 0.083 km^2 pond) of any waterbody on the study area.

COMPARISON OF 1977 and 1979 WATERBIRD POPULATIONS, TETLIN JUNCTION-SCOTTIE CREEK, ALASKA

Ground Censuses

Forty-five waterbodies were censused between Tetlin Junction and Scottie Creek in July 1977 (Spindler and Kessel 1977). In July 1979, using the same methods as in 1977, thirteen of the most densely populated of these waterbodies (excluding Eliza Lake, which was inaccessible due to Native allotments) were recensused to determine differences in waterbird distributions, species composition, densities, and production. The various waterbodies were compared for differences in species richness and differences in the densities of adults and young. Individual species were compared for differences in over-all abundance and frequency of occurrence. Comparisons were made both on a region-wide basis and by subdividing the region into two areas: Tanana-Chisana Valley (seven waterbodies totaling 9.8 km^2 [3.8 mi^2])* and Scottie Creek Drainage (six waterbodies totaling 5.3 km^2 [2.0 mi^2]).

Total waterbird numbers declined 38%, from 3049 adults in 1977 to 1882 adults in 1979 (Table 17). Total adult density for the 13 waterbodies was estimated (with 95% confidence limit) at 202.3±58.4 birds/km^2 in 1977 and 124.9±42.1 birds/km^2 in 1979. The decline in both adult numbers and density was statistically significant. Four waterbodies in the region had significantly lower numbers of adults in 1979 than in 1977 (Table 17), and three of these (Little Scottie Creek [SDC 43], SDC 15, and SDC 16) were in the Scottie Creek Drainage. These declines resulted in a significantly lower density of adults in the Scottie Creek Drainage as a whole in 1979 than in 1977, whereas the decline in the Tanana-Chisana Valley was not statistically significant.

Diving ducks comprised the greatest proportion of the adult population in both 1977 and 1979 (64% and 62%, respectively), but densities were down 40% in 1979, from 130 birds/km^2 in 1977 to 77 birds/km^2 in 1979 (Table 18). Dabbling ducks declined sharply, from 25 birds/km^2 to 7 birds/km^2, a 71% decrease. Shorebirds, gulls, and terns declined 19%, from 35 birds/km^2 to 28 birds/km^2, but their proportion of the total adult waterbird numbers increased from 17% to 22%. The adult population density of loons and grebes remained stable during the two years, at about 13 birds/km^2.

*For comparative purposes, waterbody sizes in this section of the report are those calculated by Spindler and Kessel (1977), using a planimeter on 1:63,360 USGS topographic maps. Sizes differ somewhat from those used above in the section "Waterbird Population and Habitat Productivity of the Scottie-Desper Creek Wetlands," which were calculated more accurately from USGS maps enlarged by projection.

Table 17. Comparative waterbird population statistics for 13 waterbodies censused in the upper Tanana River Valley, Alaska, July 1977 and July 1979. Densities are per unit of wetland habitat (2.59 km^2 = 1 mi^2).

Waterbody	Area (km^2)	1977 Total adults	1977 Adult density (birds/km^2)	1977 Adult species richness	1977 Total young	1977 Young density (birds/km^2)	1977 Young species richness	1979 Total adults	1979 Adult density (birds/km^2)	1979 Adult species richness	1979 Total young	1979 Young density (birds/km^2)	1979 Young species richness
Tanana-Chisana Valley													
Willow Lake*	0.4	44	125.0	12	45	127.8	7	118	335.2	18	19	54.0	7
Midway Lake	6.0	1147	192.5	24	145	24.3	10	927	155.6	18	173	29.0	12
Pond 1271*	0.2	97	431.1	14	13	57.8	4	27	120.0	7	34	151.1	3
Marsh 1267**	0.3	30	106.4	7	14	49.6	4	90	319.1	12	23	81.6	2
Yarger Lake	1.4	200	140.4	15	18	12.6	3	177	124.2	19	18	12.6	3
Deadman Lake	1.4	298	209.1	16	47	33.0	8	225	157.9	7	14	9.8	2
Gardiner Creek	0.1	2	35.1	2	3	52.6	1	0	0	0	0	0	0
Subtotal	9.8	1818	185.5+	26	285	29.1	17	1564	159.6+	28	281	28.7	16
Scottie Creek Drainage													
Desper Creek	1.3	29	22.6	10	6	4.7	1	26	20.3	10	6	4.7	1
SDC 15**	0.8	46	59.2	14	16	20.6	3	5	6.4	3	8	10.3	1
SDC 16**	0.9	334	368.2	15	118	130.1	8	35	38.6	9	44	48.5	5
SDC 17	1.5	579	372.6	16	109	70.1	7	223	143.5	14	27	17.4	5
SDC 43 (L. Scottie Ck)*	0.3	225	663.7	15	110	324.5	5	6	17.7	4	9	26.5	1
SDC 49	0.5	18	37.0	6	6	12.3	2	23	47.2	8	2	4.1	1
Subtotal	5.3	1231	232.3+	25	365	68.9	14	318	60.0+	21	96	18.1	10
Total	15.1	3049	202.3	27	650	43.1	25	1882	124.9	31	377	25.0	16

* Waterbodies which significantly ($P \leq 0.05$) increased in adult numbers between 1977 and 1979.
** Waterbodies which significantly ($P \leq 0.05$) decreased in adult numbers between 1977 and 1979.
\+ Slight differences in density between Tables 17 and 19, due to rounding errors.

Table 18. Species-specific population statistics for waterbirds based on two censuses, July 1977 and July 1979, on 13 waterbodies, upper Tanana River Valley, Alaska. Seven waterbodies were in the Tanana-Chisana Valley and six were in the Scottie Creek Drainage. Densities are birds per unit of wetland habitat (2.59 km^2 = 1 mi^2).

Species	1977 Total adult density ($birds/km^2$)	1977 Freq. of occurrence (%)	1977 Adult density Tanana-Chisana Valley ($birds/km^2$)	1977 Adult density Scottie Creek Drainage ($birds/km^2$)	1979 Total adult density ($birds/km^2$)	1979 Freq. of occurrence (%)	1979 Adult density Tanana-Chisana Valley ($birds/km^2$)	1979 Adult density Scottie Creek Drainage ($birds/km^2$)
LOONS AND GREBES								
Arctic Loon	2.0	62	1.9	2.2	2.7	53	3.5	1.1
Red-necked Grebe	1.8	38	2.6	0.4	1.7	15	2.7	0
Horned Grebe	9.1	62	12.2	3.4	8.1	62	10.5	3.7
Subtotal	12.9		16.7	6.0	12.5		16.7	4.8
DABBLING DUCKS								
Mallards	6.2	100	3.7	10.7	1.7	31	2.3	0.6
Pintails	3.6	38	0.4	9.4	0.1	23	0	0.4
American Wigeon*	7.6	69	4.7	12.9	2.9	77	3.4	2.1
Northern Shoveler	2.2	31	0.2	5.6	0.7	38	0.5	0.9
Green-winged Teal	5.0	69	0.9	12.4	1.8	54	0.3	4.5
Blue-winged Teal	0.5	8	0.8	0	0	0	0	0
Subtotal	25.1		10.7	51.0	7.2		6.5	8.5
DIVING DUCKS								
Canvasback*	22.6	46	3.4	57.4	1.6	31	1.2	2.2
Ring-necked Duck	0	0	0	0	1.0	8	1.5	0
Greater Scaup	0.8	23	1.1	0.2	0.4	15	0.3	0.6
Lesser Scaup	74.0	62	93.8	38.0	47.6	77	63.4	18.9
Goldeneye, sp.	1.8	31	1.8	1.9	1.2	31	1.8	0.2
Bufflehead*	21.9	85	13.8	36.7	8.5	69	8.1	9.2
Oldsquaw	0	0	0	0	1.0	8	1.5	0
White-winged Scoter	4.1	15	6.3	0	11.3	23	16.4	2.1
Surf Scoter	4.3	23	6.5	0.2	4.7	23	6.8	0.9
Subtotal	129.5		126.7	134.4	77.3		101.0	34.1
SHOREBIRDS								
Lesser Yellowlegs	6.6	69	5.0	9.5	5.2	54	7.7	0.8
Solitary Sandpiper*	0.9	31	0.5	1.7	0.1	8	0.2	0
Spotted Sandpiper	0.9	38	0.6	1.5	0.1	8	0.1	0
Northern Phalarope	8.6	31	13.0	0.6	5.8	38	7.2	3.4
Common Snipe	1.2	23	0.7	2.1	0.7	31	1.0	0
Long-billed Dowitcher	0	0	0	0	1.1	8	1.6	0
Semipalmated Sandpiper	0	0	0	0	0.5	8	0.8	0
Least Sandpiper	0.9	8	0	2.6	0.6	15	0.8	0.2
Subtotal	19.1		19.8	18.0	14.1		19.4	4.4
GULLS AND TERNS								
Herring Gull	0	0	0	0	0.1	8	0.1	0
Mew Gull	1.9	62	2.1	1.5	3.5	46	5.5	0
Bonaparte's Gull	4.5	38	4.3	4.7	3.2	38	4.7	0.4
Arctic Tern	9.1	62	6.5	13.8	6.7	62	7.1	6.0
Subtotal	15.5		12.9	20.0	13.5		17.4	6.4
OTHER								
Bald Eagle	0.4	46	0.1	0.9	0.1	15	0	0.4
Belted Kingfisher	0.1	8	0	0.4	0.3	15	0	0.8
Total	202.3		186.9	230.7	124.9		161.0	59.4

*Species that were significantly different ($P < 0.05$) in adult abundance over the entire study area between 1977 and 1979.

Lesser Scaup was the most abundant species of waterbird in both years, occurring in higher densities on the Tanana-Chisana Valley waterbodies than on those of the Scottie Creek Drainage (Table 18). Four of the five next most abundant species in both years were Bufflehead, Horned Grebe, Arctic Tern, and Northern Phalarope. Canvasback was in this abundance grouping in 1977, but was replaced in 1979 by the White-winged Scoter (mostly male flocks)--even though the overall abundance of the White-winged Scoter was not significantly different in the two years. Six species showed a significant decline in 1979: Mallard, Pintail, American Wigeon, Canvasback, Bufflehead, and Solitary Sandpiper.

Five species that were absent in 1977 occurred in small numbers in 1979: Ring-necked Duck, Oldsquaw, Long-billed Dowitcher, Semipalmated Sandpiper, and Herring Gull. One species, the Blue-winged Teal, was present in 1977 but not in 1979--8 birds were counted on the census sites, and broods were seen elsewhere on the study area.

The most ubiquitous species both years (frequency >45%) were Arctic Loon, Horned Grebe, American Wigeon, Green-winged Teal, Lesser Scaup, Bufflehead, Lesser Yellowlegs, Mew Gull, and Arctic Tern (Table 18). The Mallard, which occurred on 100% of these waterbodies in 1977, was present on only 31% in 1979.

Total production on the 15.1 km^2 of wetlands was estimated at 43.±10.5 young birds/km^2 in 1977 (Table 19). Density of young declined 42%, to 25.2±7.9 young birds/km^2 in 1979. Two waterbodies had significantly different production between 1977 and 1979: Willow Lake had higher production in 1979 than in 1977, and Little Scottie Creek experienced almost complete breeding failure in 1979, after having the highest density of young of any waterbody in 1977.

In terms of numbers and densities of young, species with the highest production in 1977 were Bonaparte's Gull, Green-winged Teal, Lesser Scaup, American Wigeon, Pintail, and Bufflehead (Table 19). Lesser Scaup, American Wigeon, Canvasback, and Bufflehead had the highest production in 1979. Total production in dabblers declined sharply between 1977 and 1979, with the number of young dropping 58%. The number of young diving ducks and young loons and grebes remained the same. Mean brood size in both dabblers and divers was the same both years.

Based on estimates of brood density, the 13 most productive waterbodies chosen for censusing in the upper Tanana River Valley were less productive than either Minto Lakes or the Yukon Flats (Table 11).

The primary factor accounting for the differences in waterbird population levels in the upper Tanana River Valley between 1977 and 1979 was undoubtedly the record high numbers of drought-displaced prairie ducks present in 1977. Such drought displacements of prairie ducks, which cause an influx of ducks into subarctic and arctic regions,

Table 19. Species-specific population statistics for young-of-the-year waterbirds based on two censuses, July 1977 and July 1979, on 15.1 km^2 (13 waterbodies), upper Tanana River Valley, Alaska. Densities are per unit of wetland habitat (2.59 km^2 = 1 mi^2).

Species	1977 No. of broods	1977 No. of young	1977 Mean brood size	1977 Density of young (birds/km^2)	1977 Freq. of occurrence (%)	1979 No. of broods	1979 No. of young	1979 Mean brood size	1979 Density of young (birds/km^2)	1979 Freq. of occurrence (%)
Arctic Loon	2	4	2.0	0.3	15	5	7	1.4	0.5	23
Red-necked Grebe	3	9	3.0	0.6	8	4	5	1.2	0.3	8
Horned Grebe	7	11	1.6	0.7	31	9	13	1.4	0.9	23
Mallard	6	25	4.2	1.7	38	2	11	5.5	0.7	15
Pintail	6	35	5.8	2.3	23	0	0	0	0	0
American Wigeon	16	75	4.7	5.0	54	12	72	6.0	4.8	54
Northern Shoveler	2	12	6.0	0.8	8	1	5	5.0	0.3	8
Green-winged Teal	19	77	4.0	5.2	31	4	7	1.8	0.5	8
Canvasback	13	44	3.4	2.9	46	11	52	4.7	3.5	23
Greater Scaup	4	36	9.0	2.4	23	0	0	0	0	0
Lesser Scaup	14	77	5.5	5.2	31	16	119	7.4	7.9	46
Goldeneye, sp.	1	6	6.0	0.4	8	2	8	4.0	0.5	15
Bufflehead	15	70	4.7	4.6	46	11	48	4.4	3.2	38
Surf Scoter	0	0	0	0	0	2	12	6.0	0.8	15
White-winged Scoter	1	7	7.0	0.5	8	0	0	0	0	0
Lesser Yellowlegs	+	45	+	3.0	31	+	4	+	0.3	8
Spotted Sandpiper	+	0	+	0	0	+	1	+	0.1	8
Mew Gull	+	6	+	0.4	15	+	4	+	0.3	8
Bonaparte's Gull	+	78	+	5.2	31	+	8	+	0.5	31
Arctic Tern	+	33	+	2.2	73	+	1	+	0.1	8
All waterbirds	110	650	4.5	43.4		79	377	4.5	25.2	

+Brood numbers not determined for shorebirds and larids.

have been described by Hansen and McKnight (1964), Crissey (1969), Smith (1970), and others. These displaced ducks were present in large numbers in Alaska in 1977 (King and Bartonek 1977), when overall waterfowl densities in the Tanana and Kuskokwim river valleys were 49% higher than the long-term mean for this combined region (J. G. King, USFWS, pers. comm.).

In the upper Tanana River Valley, of the five waterfowl species that showed significantly higher numbers in 1977, four were primarily prairie breeders--Mallard, Pintail, American Wigeon, and Canvasback (Bellrose 1976). Combined adult density of these four species in 1977 was over five times that of 1979, although production was only 34% above 1979. These results corroborate Hansen and McKnight's (1964:125) statement that "Although some individuals can and will nest successfully under displaced circumstances, not enough of them do to maintain an abundance commensurate with that attained in their normal environment."

The significant decline in total densities in the Scottie Creek Drainage, but not in the Tanana-Chisana Valley (see above), can also be explained by the high concentration of prairie ducks in the Scottie Creek Drainage.

In addition to the decline of waterfowl numbers in 1979 caused by the absence of displaced prairie ducks, we suspect that other birds, particularly scaup and Bufflehead, may have left the Scottie-Desper Creek study area because of abnormally high water levels of July 1979.

Aerial Waterfowl Survey

Each spring the U. S. Fish and Wildlife Service has undertaken a waterfowl breeding pair survey by flying a series of standardized transects throughout Alaska. Waterfowl counts have been obtained in early May each year from an 8.0 mi^2 (20.7 km^2) sample in the Tetlin Lakes-Northway area, the most productive portion of the upper Tanana River Valley; and, in 1977 and 1979, James G. King, Waterfowl Supervisor, U. S. Fish and Wildlife Service, also flew an 18.0 mi^2 (46.6 km^2) sample along the Haines Petroleum Pipeline from the Alaska-Canada border to Tetlin Junction (the approximate proposed route of the Northwest Alaska Gas Pipeline). While the statistical reliability of these isolated samples is questionable (fide J. G. King), the data (which are presented on the basis of square miles of surface area or land blocks, compared to our square kilometers of wetland area) show many of the same trends found in our ground surveys (Table 20). Overall densities in the Tetlin Lakes-Northway area were down 62% in 1979 compared to 1977, and densities along the pipeline (the upper Tanana River Valley portion of our comparative ground censuses) were down 52%. Much of the decrease was the result of lower numbers of prairie duck species. King and Conant (1979) also found that there had been a

Table 20. Aerial waterfowl transect data for the upper Tanana River Valley, 1977-1979 (King and Conant, unpubl. data). Data in birds/mi^2 surface area (land block), using standarized USFWS waterfow aerial census procedures.

Species	8.0 mi^2 surface area sample Tetlin Lake-Northway area.			18.0 mi^2 surface area sample along Haines Pipeline, Tetlin Junction to Canada border.		
	1977	1978	1979	1977	1978	1979
Mallard	39.5	34.0	41.9	.7	not flown	.4
American Wigeon	56.7	43.2	24.3			1.8
Green-winged Teal	33.3	16.7	16.7	1.1		
Northern shoveler	14.4	12.5	2.9			.4
Pintail	145.3	40.7	28.1	5.2		.4
Redhead	24.8					
Canvasback	33.4	14.6	14.0			
Lesser Scaup	168.0	78.0	54.1	3.0		1.8
Ring-necked Duck			1.0			
Goldeneye, sp.	26.1	4.1	4.1			.6
Bufflehead	14.4	23.0	22.3	.9		.3
Oldsquaw	26.0	9.8	6.5	.7		
Scoter, sp.	23.7	17.7	15.9	.9		.4
Merganser, sp.			.5			
Unidentified	1.9			.2		
TOTAL	607.5	294.3	232.3	12.7	-	6.1

reduction in overall waterfowl populations Alaska-wide in 1979 compared to 1977, but they noted that both dabbling and diving ducks in 1979 were near their 10-year means in population levels.

The overall densities of waterfowl on the aerial transect along the proposed gas pipeline, in both 1977 and 1979, were very low compared to those of the nearby Tetlin Lakes-Northway wetlands (Table 20).

WATERBIRD SURVEY OF GARDINER CREEK AND GARDINER CREEK FLATS

Preliminary observations in 1976 (Kessel, pers. obs.) and 1977 (Spindler and Kessel 1977) indicated some use of the Gardiner Creek drainage by waterbirds, at least near the Alaska Highway and at its confluence with the Chisana River. Hence, we examined different portions of this system several times during the 1979 field season.

An aerial survey of the entire length of Gardiner Creek, from its mouth to its headwaters, was flown on 6 May 1979; a ground survey along the creek for 1.6 km (1 mi) upstream and 1.6 km downstream of the Alaska Highway crossing was conducted on 15 July; and a boat survey of 3 km (1.9 mi) upstream from the mouth of the creek was undertaken on 11 August and included all the small ponds that were interconnected with this downstream portion of the creek. Aerial surveys of Gardiner Creek Flats were flown five times during spring migration and once in October, and a ground survey was conducted on 11 August.

Gardiner Creek

Along most of its length, the banks of Gardiner Creek were steep and leveed and were vegetated by tall white spruce and scattered paper birch. Several small wet meadow areas occurred north of the Alaska Highway, and numerous oxbow and other small ponds formed an interconnected system with the creek near its mouth. From the Alaska Highway to its mouth, Gardiner Creek is less than 5 km (3 mi) long; and the wetland complex near its mouth was the only significant waterbird habitat along this length.

In July 1977, a survey in the vicinity of the Alaska Highway-Gardiner Creek crossing revealed a female Mallard with a brood of three young, four adult Buffleheads and a brood of three young, and an adult Green-winged Teal (Spindler and Kessel 1977). No waterbirds were observed in this same general area on the 15 July 1979 survey. Except for five unidentified ducks in ponds near the mouth of the creek, no waterbirds were observed along the entire length of Gardiner Creek during the 6 May aerial flight. On the 11 August 3-km survey at the mouth of the creek, seven individuals of four species were observed:

one immature Arctic Loon, two Mallards, 1 Solitary Sandpiper, and three Spotted Sandpipers.

Thus, Gardiner Creek appears of low value to waterbirds, primarily because of the lack of appropriate habitat.

Gardiner Creek Flats

Upstream from its confluence with Gardiner Creek, the Chisana River forms a 13 km^2 (5 mi^2) area of sand and gravel bars, open mudflats, grass and wet meadows, and low willow shrub. This area is commonly referred to as Gardiner Creek Flats, even though it is upstream of the mouth of Gardiner Creek.

The late July 1977 survey of the Gardiner Creek Flats indicated that this area was a relatively important breeding and molting area for Canada Geese (Spindler and Kessel 1977). Spring aerial surveys in 1979 showed that this area was also used extensively by migrant Canada Geese and to a lesser extent by ducks (Table 21). In 1979, however, we found no evidence of breeding, although nesting birds would be difficult to spot from the air. The ground survey on 11 August 1979 revealed only 13 Canada Geese, nine Mallards, and one American Wigeon. High water on the Chisana River throughout most of July and early August, as evidenced by the high watermark, had inundated most of the Flats, and may have been partially responsible for low numbers of geese present in 1979 compared to 1977 (when some 150 were present). We know nothing about the fall use of Gardiner Creek Flats, since most geese had migrated by the time of the 8 October 1979 flight.

In summary, at least in some years, Gardiner Creek Flats appears to provide significant habitat for Canada Geese, both during migration and during the breeding and post-breeding periods. In 1979, it was the only significant stopping area during spring migration east of Delta Junction.

WATERBIRD REACTIONS TO DISTURBANCES

Since so little information is available on the reactions of animals, including waterbirds, to disturbance (see Arctic Gas Biological Report Series, vols 14, 26, and 29, for studies on waterfowl reactions), we recorded disturbance reactions as time and opportunity permitted. We also recorded some noise levels, using a Bruel and Kuaer Sound Pressure Level Meter (Type 2205), hoping to be able to correlate observed reactions with noise levels.

There are so many uncontrolled variables affecting waterbird reactions to disturbance, however, that no reliable conclusions can be drawn from our few data. Some of these variables include differences

Table 21. Total numbers of waterfowl recorded on Gardiner Creek Flats, Chisana River, Alaska, during aerial and ground surveys in 1979.

Date	No. Canada Geese	No. ducks
24 April	400	12
28 April	83	63
2 May	50	0
6 May	13	6
14 May	2	4
11 August	13	10
8 October	0	0

in species-specific tolerance levels (there were over 50 species of waterbirds observed on the Scottie-Desper Creek wetlands in 1979), degree of habituation of individuals to certain stimuli, differences among age groups of the same species, seasonal differences in wariness, past experiences of the individual, and size of the waterbody occupied. In the field, the cause of any disturbance may not be known with certainty, e.g., whether auditory or visual. If auditory, such variables as the intensity, frequency, duration, or suddenness of the sound could effect waterbird reactions.

Our few data are chronicled below:

Human Disturbance (on foot or in boat)

Shorebirds were the most tolerant of the waterbirds to humans. An unobtrusive observer could approach to within 10 m of a flock of shorebirds before they flushed, and in most instances, disturbed birds flew only a short distance. During migration, shorebirds often appeared so exhausted that they would scurry away from the observer on foot rather than fly. Gulls and terns were also relatively unwary, except during the breeding season when intruders were vigorously harassed.

Loons and grebes were wary of humans. They usually submerged and fled underwater quite a distance, rather than flushing from the waterbody. Breeding loons and grebes appeared particularly stressed by the presence of humans.

Ducks were the most easily disturbed by exposure to humans. Flocks of diving ducks on large lakes could not be approached within 500 m (1600 ft) in a canoe with a 6 hp Evinrude outboard motor, or within 250 m (800 ft) with paddles. When disturbed, these flocks usually moved to another section of the lake, although sometimes they left the lake. Except during molt and during the hunting season, dabbling ducks generally were less wary than the diving ducks. However, they were most often on small ponds, and they would flush, because of closeness, as soon as a person appeared and would leave the vicinity of the pond. Females with broods would feign injury and attempt to lure intruders away. Young-of-the-year, even after fledging, were less wary of humans than were adults.

In our few observations of Canada Geese, the birds flushed and dispersed as soon as humans were detected.

Highway Vehicle Disturbance

Vehicular traffic along the Alaska Highway was steady throughout the summer, ranging from motorcycles to 18-wheeled trucks. The effect of this traffic on the waterbird population of the nearby waterbodies is almost impossible to access, however, because historical data on population levels and types of disturbances are unavailable. Also, comparisons of population levels on waterbodies near the road with those more distant was complicated by the fact that the waterbodies near the Alaska Highway were predominantly of the less productive, isolated type of pond (see above).

No birds were ever seen in the vicinity of heavy road equipment when it was working; noise from such equipment registered at 75 dBA at 40 m distance (130 ft) and 62 dBA at 400 m (1310 ft). Dabbling ducks, however, were noted several times at culverts immediately adjacent to the highway (where an 18-wheeled truck, passing at 88 km/hr [55 mph], registered 65 dBA), seemingly ignoring automobile and truck traffic. These birds were apparently habituated to continuously moving traffic, but they would flush if a vehicle slowed down or stopped.

The closest successful nest to the highway that we found was that of a Canvasback, approximately 275 m (900 ft) from the highway in waterbody SDC 50. Background noise at this site was high (30 dBA), due to the generator that ran constantly at Border City Trading Post, 400 m away. A small recreational vehicle and a van, moving at about 88 km/hr along the highway, each registered 42 dBA at the nest site, and a large truck registered 54 dBA.

Aircraft Disturbance

Geese and swans were the most sensitive waterbirds to low flying aircraft. Both would flush from roosting spots when single-engined aircraft approached below 100 m (325 ft). Ducks were less predictable, but were often stressed by aircraft flying below 100 m. Gulls, terns, and shorebirds appeared to ignore low flying aircraft.

Waterbody SDC 49, a 0.53 km^2 lake adjacent to Mile 1224 Alaska Highway, was used as a base for single-engined float planes. In spite of frequent landings and take-offs, Arctic Loon, Mallard, and Green-winged Teal successfully raised broods on this small lake, undoubtedly another case of habituation. Adult ducks were more alarmed by take-offs than landings of planes and would usually flush and leave the lake during take-offs. Gulls and terns, again, appeared undisturbed by landings and take-offs.

CONCLUSIONS

1. Spring breakup occurs first in the upper Tanana River Valley in areas influenced by warm springs, next in the rivers, then in the small, shallow ponds, and finally in the deep, large lakes. Three areas in the vicinity of the Northwest Alaskan Gas Pipeline corridor in this region were used intensively by waterbirds during the period of spring breakup in 1979, all of which thawed early and appeared to have available food: 1) Clearwater Lake and the nearby farm fields on the southeast-facing slopes along Remington Road, 2) Dry Lake, and 3) Gardiner Creek Flats. The Scottie-Desper Creek wetlands, because of their relatively high elevation, did not break up until almost a week later than other parts of the upper Tanana River Valley. Hence, even though breakup was relatively early in 1979 (small ponds opened during the first week of May), the wetlands proved of little use to early spring migrants.

2. Gardiner Creek is of low value to waterbirds, primarily because of the absence of suitable habitat. Gardiner Creek Flats provide locally important habitat for Canada Geese, both during migration and during breeding and postbreeding periods. Because of its distance from the pipeline corridor and its location upstream of the mouth of Gardiner Creek, this latter area is unlikely to be impacted by pipeline construction (except, perhaps, by low-flying aircraft).

3. While annual variations can be expected, densities of waterbirds along the Northwest Alaskan Gas Pipeline corridor between Tetlin Junction and the U.S.-Canada border can be assumed to have been near maximum in 1977 (Spindler and Kessel 1977), since the duck population index for that year in Alaska was the highest ever recorded (King and Bartonek 1977). The high populations in 1977 were apparently caused by an influx of drought-displaced ducks from the prairies. Population levels in 1979 were probably more typical, since King and Conant (1979) found that waterfowl populations in Alaska that year were near their 10-year means.

4. The density of summering waterfowl in the Scottie-Desper Creek wetlands was greater than along the rest of the pipeline corridor in the region, but was considerably lower than those in the Tetlin Lakes area and those of Minto Lakes and the Yukon Flats (Tables 11, 18 and 20).

5. The Scottie Creek and Desper Creek hydrologic systems were fundamental to the structure of the waterbird communities of the associated wetlands. About half of the waterbodies of the Scottie-Desper Creek study area were hydrologically connected with the creeks; the rest were isolated from them. The isolated, compared to connected, waterbodies generally had lower ionic and nutrient levels, apparently had lower primary productivity levels (no phytoplankton blooms and few macrophytes, with most being floating-leafed pond lilies), and supported smaller, less

diverse populations of waterbirds. Differences also existed in the species composition of waterbird populations using the two types of waterbodies.

Among the nutrient-rich connected waterbodies, two types were evident, although there was overlap between them. In general, the larger lakes had few submerged vascular plants, and the primary autotrophs were algae; whereas in the smaller, shallower ponds, primary productivity was dominated by aquatic submergents. The submerged macrophytes contributed to greater environmental diversity of these smaller ponds and provided the base for a divergent macroinvertebrate fauna. These macroinvertebrates, in turn, apparently accounted in large part for the high waterfowl densities and productivity observed on these macrophytic ponds.

6. The preponderance of isolated waterbodies in Stratum 1 ($\leq$1.6 km from the Alaska Highway) was apparently the main factor in the lower density of waterbirds in general and ducks in particular in that stratum compared to Stratum 3 ($>$3.2 km from Alaska Highway).

7. Since the hydrologic system is so fundamental to the productivity of the waterbodies of the Scottie-Desper Creek wetlands, increased levels of siltation or any pollution by pesticides, petroleum products, etc., caused by construction-related activities could have a deleterious effect on the wetland resources. Any of these substances could adversely impact the more productive, hydrologically connected waterbodies all the way down to SDC 15, 16, and 17.

8. Any permanent impoundment of water above the pipeline could have at least two effects. First, the habitat of Little Scottie Creek, which supported the highest density of waterbirds in the area in 1977, could be destroyed. Second, flooding would increase the amount of wetland in the area and could increase, at least temporarily, the nutrient levels in the currently isolated waterbodies; such changes could result in an increased density of waterbirds in the area.

9. Since most of the waterbodies close to the pipeline corridor in the Scottie-Desper Creek wetlands are of the oligotrophic, isolated type, a relatively small number of waterbirds would be affected by pipeline construction. While most species of waterbirds, especially waterfowl, loons, and grebes, could be expected to desert nearby ponds during preconstruction and construction activities, the species most adversely affected would probably be the Arctic Loon, since it is a relatively long-lived bird that usually nests just one pair per pond on the isolated type of pond. If habitat was not destroyed, however, all species, including the Arctic Loon, would probably repopulate the ponds after construction activities ceased.

RECOMMENDATIONS

Adverse impacts from construction of the Northwest Alaskan Gas Pipeline can come from two main sources, destruction or degradation of habitat and direct disturbance to individual birds. Generally, habitat destruction or degradation causes the most severe, permanent damage to an avian population, but direct disturbance to birds can also be serious with rare or endangered species or with those that are long-lived with relatively low breeding potentials. With these tenets in mind, the following precautions are recommended:

1. Special care should be taken to preserve the habitat at Little Scottie Creek and vicinity. It should be protected from direct damage by construction equipment and from indirect damage by either draining or flooding.

2. In general, avoid draining lakes and avoid any permanent changes in water levels downstream on either Scottie Creek or Desper Creek.

3. Extreme care should be taken at the two creek crossings to keep siltation levels at a minimum during construction and to avoid all forms of chemical pollution, such as petroleum products, pesticides, etc.

4. Single-engined, fixed-winged aircraft flights over the Scottie-Desper Creek wetlands should be kept above 150 m (500 ft), a height at which many duck species begin to show stress. Helicopters should be kept above at least 460 m (1500 ft), and preferrably above 600 m (2000 ft).

5. Canada Geese, generally, appear to be more sensitive than ducks; hence, heights of aircraft flights over Gardiner Creek Flats should be kept above at least 460-600 m (1500-2000 ft) for single-engined, fixed-winged aircraft, and even higher for noisier helicopters and multi-engined planes. (Migrant Canada Geese using the farm fields near Delta Junction seem to have adapted to the air traffic in that area, where flights even below 300 m [1000 ft] do not appear to stress them.)

6. Flight routes should avoid the natural "water level" route along the wetlands of the Tanana and Chisana rivers and over the Scottie-Desper Creek wetlands, and instead should be over the uplands at the northeast edge of the valley.

7. To minimize short-term impacts, it should be noted that appropriate scheduling of construction across the Scottie-Desper Creek wetlands could alleviate direct impacts on waterbirds. The main use of the wetlands is between the first week of May and the third week of September, so it is obvious that direct impact on individual birds would be avoided if construction occurred outside of these dates. Likewise, since Little Scottie Creek is important primarily for breeders, construction after about 1 August would minimize direct disturbance to the birds of this potentially productive unit of habitat.

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APPENDICES

Appendix A-1. Waterbird statistics for each of the waterbodies of the Scottie-Desper Creek study area, Alaska, censused in 1979. Waterbodies 1-20 were in Stratum 3, waterbodies 21-34 were in Stratum 2 (censused only in July), and waterbodies 35-51 were in Stratum 1.

Waterbody No.	Area[+] (km^2)	May A / R / D*	June A / R / D	July A / R / D	August A / R / D	September A / R / D	Average A / R / D
1	0.728	133/14/ 182	38/ 8/ 52	22/ 5/ 30	63/ 7/ 86	29/ 8/ 40	57.0/ 8.4/ 78.3
2	0.010	15/ 3/1500	3/ 2/ 300	5/ 3/ 500	31/ 3/3100	1/ 1/ 100	11.0/ 2.4/1100.0
3	0.028	15/ 3/ 536	8/ 3/ 286	0	0	8/ 3/ 286	5.6/ 1.8/ 221.4
4	0.010	7/ 4/ 700	4/ 3/ 400	3/ 2/ 300	17/ 3/1700	2/ 2/ 200	6.6/ 2.8/ 660.0
5	0.016	5/ 3/ 312	46/ 9/2875	1/ 1/ 62	10/ 2/ 625	0	12.4/ 3.0/ 775.0
6	0.026	11/ 5/ 423	17/ 6/ 654	2/ 1/ 77	13/ 1/ 500	15/ 3/ 577	11.6/ 3.2/ 446.1
7	0.044	27/ 7/ 614	18/ 4/ 409	7/ 4/ 159	42/ 7/ 954	8/ 4/ 182	20.4/ 5.2/ 463.6
8	0.005	7/ 4/1400	5/ 2/1000	2/ 2/ 400	3/ 2/ 600	0	3.4/ 2.0/ 680.0
9	0.202	94/14/ 465	35/ 5/ 173	2/ 2/ 10	219/ 8/1084	83/ 7/ 411	86.6/ 7.2/ 428.7
10	0.083	131/ 8/1578	51/10/ 614	82/ 7/ 988	52/10/ 626	15/ 5/ 181	66.2/ 8.0/ 797.6
11	0.034	8/ 5/ 235	9/ 4/ 265	16/ 4/ 471	5/ 3/ 147	1/ 1/ 29	7.5/ 3.4/ 229.4
12	0.010	4/ 3/ 400	5/ 3/ 500	3/ 3/ 300	5/ 2/ 500	0	3.4/ 2.2/ 340.0
13	0.026	31/ 6/1192	7/ 4/ 269	2/ 2/ 77	2/ 2/ 77	2/ 1/ 77	8.8/ 3.0/ 338.5
14	0.005	11/ 4/2200	9/ 3/1800	5/ 4/1000	5/ 2/1000	0	6.0/ 2.6/1200.0
15	0.539	107/19/ 198	34/9/ 63	5/ 3/ 9	31/ 4/ 58	89/ 6/ 165	53.0/ 8.2/ 98.7
16	0.761	178/15/ 234	90/12/ 118	35/ 9/ 46	207/10/ 272	157/ 8/ 206	133.0/10.6/ 175.3
17	1.435	341/19/ 238	381/12/ 266	226/13/ 158	245/11/ 171	226/10/ 158	283.8/13.0/ 197.8
18	0.023	19/ 8/ 826	20/ 8/ 870	6/ 4/ 261	2/ 1/ 87	1/ 1/ 44	9.6/ 4.4/ 417.4
19	0.034	23/10/ 676	21/ 9/ 618	3/ 2/ 88	0	3/ 1/ 88	9.8/ 4.2/ 294.1
20	0.202	112/15/ 554	64/12/ 317	32/12/ 158	36/ 7/ 178	24/ 4/ 118	53.6/10.0/ 265.3
21	0.225	-	-	5/ 4/ 22	-	-	-
22	0.044	-	-	0	-	-	-
23	0.034	-	-	19/ 2/ 559	-	-	-
24	0.005	-	-	1/ 1/ 200	-	-	-
25	0.023	-	-	7/ 6/ 261	-	-	-
26	0.290	-	-	7/ 3/ 24	-	-	-
27	0.016	-	-	2/ 2/ 125	-	-	-
28	0.023	-	-	4/ 2/ 174	-	-	-
29	0.028	-	-	7/ 4/ 250	-	-	-
30	0.016	-	-	8/ 5/ 500	-	-	-
31	0.005	-	-	3/ 3/ 600	-	-	-
32	0.036	-	-	12/ 3/ 333	-	-	-

Appendix A-1 (Continued).

Waterbody No.	Area+ (km^2)	May A / R / D*	June A / R / D	July A / R / D	August A / R / D	September A / R / D	Average A / R / D
33	0.145	-	-	8/ 2/ 55	-	-	-
34	0.005	-	-	3/ 3/ 600	-	-	-
35	0.049	9/ 3/ 184	50/10/1020	5/ 2/ 102	1/ 1/ 20	0	13.0/ 3.2/ 265.3
36	0.070	10/ 5/ 143	8/ 4/ 114	41/ 9/ 586	13/ 5/ 186	3/ 3/ 43	15.0/ 5.2/ 214.3
37	0.060	6/ 5/ 100	1/ 1/ 17	1/ 1/ 17	10/ 1/ 167	0	3.6/ 1.6/ 60.0
38	0.010	7/ 5/ 700	3/ 2/ 300	0	2/ 1/ 200	1/ 1/ 100	2.6/ 1.8/ 260.0
39	0.010	0	0	0	0	0	0
40	0.010	9/ 5/ 900	2/ 2/ 200	8/ 4/ 800	11/ 5/1100	0	6.0/ 3.2/ 600.0
41	0.005	3/ 2/ 600	30/ 2/6000	1/ 1/ 200	1/ 1/ 200	0	7.0/ 1.2/1400.0
42	0.039	32/ 7/ 821	9/ 3/ 231	4/ 3/ 103	14/ 4/ 359	0	11.8/ 3.4/ 302.6
43	0.158	42/ 6/ 266	20/ 6/ 126	2/ 1/ 13	141/ 6/ 892	2/ 1/ 13	41.4/ 4.0/ 262.0
44	0.091	38/ 2/ 418	13/ 7/ 143	15/ 7/ 165	6/ 3/ 66	16/ 3/ 176	17.6/ 6.4/ 193.4
45	0.033	30/ 9/ 909	12/ 6/ 364	24/ 7/ 727	9/ 5/ 273	4/ 3/ 121	15.8/ 6.0/ 478.8
46	0.005	0	0	0	0	1/ 1/ 200	0.2/ 0.2/ 40.0
47	0.057	7/ 4/ 100	4/ 4/ 57	4/ 4/ 57	2/ 2/ 29	10/ 2/ 143	5.4/ 3.2/ 77.0
48	0.006	3/ 2/ 500	0	0	0	0	0.6/ 0.4/ 100.0
49	0.526	67/10/ 127	43/ 9/ 82	23/ 8/ 44	7/ 2/ 13	51/ 8/ 97	38.2/ 7.4/ 73.0
50	0.111	66/12/ 595	50/10/ 450	41/12/ 369	4/ 2/ 36	1/ 1/ 9	32.4/ 7.4/ 292.0
51	0.060	12/ 5/ 200	6/ 3/ 100	5/ 3/ 50	2/ 1/ 33	1/ 1/ 17	5.2/ 2.6/ 86.7

* A = Abundance (Total number of adult and fledged young birds)
R = Species Richness (Number of species)
D = Density (Number of adult and fledged young/km^2)

\+ Areas were obtained with a planimeter from an enlarged, corrected map based on a U.S. Geological Survey 1:63,300 quadrangle map and thus vary somewhat from those given in Spindler and Kessel (1977) and in Table 17.

Appendix B-1. Combined limnolgic statistics obtained from 15 waterbodies, Scottie-Desper Creek wetlands, during an early summer and a fall sampling period, 1979. Waterbodies 19, 41, 44, 47, 49, and 50 were hydrologically isolated.

Waterbody No.	Water transparency rank (1 = low)	Temperature (C°)	pH	Total alkalinity (mg $CaCO_3$/liter)	Hardness (mg $CaCO_3$/liter)	Maximum depth (m)	Area (ha)	Nitrite (µg-at/liter)	Nitrate (µg-at/liter)	Phosphate (µg-at/liter)	Ammonia (µg-at/liter)	Silicon (µg-at/liter)	Combined nitrite, nitrate & ammonia (µg-at/liter)
1	1	13.8	7.45	50	56	4.2	72.8	0.22	0.60	0.54	4.56	13.37	5.38
7	1	14.0	7.44	89	84	1.0	4.4	0.29	0.58	0.75	5.75	18.02	6.60
9	1	13.8	7.74	71	71	2.3	20.2	0.28	0.83	0.83	3.28	12.94	4.40
10	2	14.6	7.23	84	84	1.6	8.3	1.38	4.92	0.60	5.18	26.85	11.98
15	2	11.6	7.51	72	72	2.5	53.9	0.32	3.18	0.40	3.63	35.60	7.12
16	2	12.2	7.35	145	145	1.5	76.1	0.38	3.24	0.83	4.40	67.10	8.02
17I	3	13.3	7.45	148	148	10.4	26.9	0.52	2.97	0.64	4.48	72.83	7.96
19	3	12.4	6.95	50	44	2.0	3.3	0.12	1.54	0.19	2.84	24.48	4.38
35	1	14.2	7.32	66	67	2.5	4.9	0.46	2.94	0.78	5.53	31.58	8.93
41	2	15.3	7.01	45	42	1.1	0.5	0.20	0.55	0.18	2.97	12.06	3.70
42	1	14.3	8.07*	77	86	2.0	3.9	0.22	0.14	0.54	2.52	20.34	2.88
44	3	13.6	6.90	26	15	3.5	9.1	0.16	0.19	0.12	2.85	8.54	3.20
47	3	16.8	6.65	20	16	4.4	5.7	0.16	2.22	0.25	2.56	29.91	4.78
49	2	17.2	7.07	26	16	2.3	52.6	0.14	1.63	0.22	3.58	18.40	5.25
50	3	17.2	7.54	46	44	1.5	11.1	0.18	2.22	0.22	2.64	21.65	5.04

* Possibly faulty reading

Appendix B-2. Limnologic statistics obtained from 15 waterbodies, Scottie-Desper Creek wetlands, during an early summer sampling period, 19 June - 4 July 1979. Waterbodies 19, 41, 44, 47, 49, and 50 were hydrologically isolated.

Waterbody no.	Water transparency rank (1 = low)	Temperature (C°)	pH	Dissolved oxygen (% saturation)	Total alkalinity (mg $CaCO_3$/liter)	Hardness (mg $CaCO_3$/liter)	Maximum depth (m)	Area (ha)	Nitrite (μg-at/liter)	Nitrate (μg-at/liter)	Phosphate (μg-at/liter)	Ammonia (μg-at/liter)	Silicon (μg-at/liter)	Combined nitrite, nitrate, & ammonia (μg-at/liter)
1	1	16.2	7.55	58.5	54	54	4.2	72.8	0.18	0.28	0.25	2.28	7.85	2.74
7	1	16.9	7.80	65.7	110	86	1.0	4.4	0.14	0.00	0.52	1.98	7.64	2.08
9	1	17.6	8.25	81.0	92	82	2.3	20.2	0.21	0.03	1.35	2.57	7.07	2.81
10	2	18.0	7.40	63.8	104	90	1.6	8.3	1.92	5.32	0.68	5.40	14.34	12.64
15	2	14.5	7.65	55.7	64	60	2.5	53.9	0.18	2.76	0.40	2.48	26.12	5.42
16	2	15.0	7.30	42.0	149	153	1.5	76.1	0.25	0.99	0.62	2.70	67.79	3.94
17I	3	16.5	7.55	42.0	154	160	10.4	26.9	0.47	1.42	0.55	3.72	104.30	5.61
19	3	15.4	7.20	40.1	55	37	2.0	3.3	0.12	0.24	0.22	2.03	13.80	2.27
35	1	19.4	7.60	49.5	77	77	2.5	4.9	0.35	3.12	0.55	3.84	29.30	7.31
41	2	19.6	7.27	48.4	50	36	1.1	0.5	0.20	0.00	0.22	4.02	10.16	4.18
42	1	19.0	9.05*	77.7	97	106	2.0	3.9	0.19	0.00	0.74	3.02	6.90	3.21
44	3	15.4	6.70	61.5	20	10	3.5	9.1	0.14	0.32	0.14	2.82	8.52	3.28
47	3	22.2	7.30	80.3	19	10	4.4	5.7	0.18	3.12	0.34	3.25	41.76	6.37
49	2	23.1	7.30	68.2	27	11	2.3	52.6	0.10	2.86	0.30	3.84	26.76	6.70
50	3	21.5	7.55	68.8	36	33	1.5	11.1	0.22	3.16	0.27	2.93	22.75	6.31

* Possibly faulty reading

Appendix B-3. Limnologic statistics obtained from 15 waterbodies, Scottie-Desper Creek wetlands, during a fall sampling period, 29 August - 11 September 1979. Waterbodies 19, 41, 44, 47, 49, and 50 were hydrologically isolated.

Waterbody no.	Water transparency rank (1 = low)	Temperature (C°)	pH	Total alkalinity (mg $CaCO_3$/liter)	Hardness (mg $CaCO_3$/liter)	Maximum depth (m)	Area (ha)	Nitrite (μg-at/liter)	Nitrate (μg-at/liter)	Phosphate (μg-at/liter)	Ammonia (μg-at/liter)	Silicon (μg-at/liter)	Combined nitrite, nitrate, & ammonia (μg-at/liter)
1	1	11.4	7.35	47	57	4.2	72.8	0.26	0.92	0.82	6.84	18.90	8.02
7	1	11.2	7.10	68	82	1.0	4.4	0.44	1.15	0.98	9.52	28.39	11.11
9	1	10.0	7.27	53	60	2.3	20.2	0.36	1.63	0.31	3.99	18.81	5.98
10	2	11.2	7.07	77	78	1.6	8.3	0.83	4.53	0.53	5.96	39.36	11.32
15	2	8.8	7.37	80	84	2.5	53.9	0.46	3.59	0.40	4.78	45.08	8.83
16	2	9.5	7.40	112	137	1.5	76.1	0.50	5.50	1.04	6.10	66.40	12.10
17I	3	10.1	7.35	132	137	10.4	26.9	0.56	4.52	0.74	5.24	41.36	10.32
19	3	9.5	6.70	44	50	2.0	3.3	0.12	2.83	0.16	3.66	35.16	6.49
35	1	9.0	7.05	55	57	2.5	4.9	0.58	2.76	1.02	7.22	33.86	10.55
41	2	11.0	6.75	40	49	1.1	0.5	0.20	1.10	0.14	1.92	13.95	3.22
42	1	9.6	7.20	57	67	2.0	3.9	0.25	0.28	0.34	2.03	33.78	2.56
44	3	11.7	7.10	33	20	3.5	9.1	0.18	0.06	0.10	2.88	8.54	3.12
47	3	11.5	6.50	22	21	4.4	5.7	0.13	1.33	0.16	1.86	18.06	3.19
49	2	11.3	6.85	25	22	2.3	52.6	0.18	0.40	0.14	3.32	10.04	3.80
50	3	12.8	7.52	56	54	1.5	11.1	0.13	1.28	0.17	2.35	20.55	3.76
Desper Ck	-	9.4	7.00	49	64	-	-	0.16	2.23	0.29	2.69	40.15	5.08
Scottie Ck	-	6.9	7.20	44	52	-	-	0.30	3.80	0.29	3.00	32.15	7.10

Appendix C-1. Systematics of the invertebrates found in samples from SDC 10 and Pond 17I, Scottie-Desper Creek wetlands, Alaska, 1979.

PHYLUM COELENTERATA
- Class Hydrazoa (hydras)

PHYLUM PLATYHELMINTHES (flatworms)
- Class Turbellaria

PHYLUM NEMATODA (roundworms)

PHYLUM ANNELIDA
- Class Oligochaeta (earthworms)
- Class Hirudinea (leeches)

PHYLUM MOLLUSCA
- Class Gastropoda
  - Order Basommatophora
    - Family Lymnaeidae (pond snails)
    - Family Planorbidae (orb snails)
  - Order Mesogastropoda
    - Family Valvatidae (round-mouthed snails)
    - Family Sphaeridae (fingernail clams)

PHYLUM ARTHROPODA
- Class Insecta
  - Order Ephemeroptera (mayflies)
    - Family Baetidae*
  - Order Odonata
    - Suborder Zygoptera (damselflies)
      - Family Coenagroinidae*
      - Family Lestidae*
    - Suborder Anisoptera (dragonflies)
      - Family Aeshnidae*
      - Family Libellulidae
  - Order Hemiptera
    - Family Corixidae (water boatmen)
  - Order Trichoptera (caddisflies)
    - Family Leptoceridae**
    - Family Limnephilidae*
    - Family Phryganeidae
    - Family Polycentropodidae*
  - Order Lepidoptera** (aquatic caterpillars)
  - Order Coleoptera
    - Family Dytiscidae* (diving beetles)
    - Family Gyrinidae* (whirligig beetles)
    - Family Haliplidae* (crawling beetles)
  - Order Diptera
    - Family Ceratopogonidae (no-see-ums)
    - Family Chaoboridae (phantom midges)
    - Family Chironomidae (midges)
- Class Crustacea
  - Order Conchostraca* (clam shrimps)
  - Order Cladocera (water fleas)
  - Order Eucopepoda (copepods)
    - Suborder Calanoida
    - Suborder Cyclopoida
    - Suborder Harpacticoida*
  - Order Amphipoda (scuds)
    - Family Talitridae
      - Genus *Hyalella*
    - Family Gammaridae
- Class Arachnoidea
  - Order "Hydracaria" (water mites)

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* Present only in SDC 10
** Present only in Pond 17I
All other groups occurred commonly in both ponds.

Appendix D-1. Factor loadings for each variable used in the principal component analysis illustrated in Figure 10.

Variable	Factor 1	Factor 2	Factor 3
Temperature	-0.577	-0.337	0.050
pH	0.818	-0.124	-0.172
Alkalinity	0.723	0.558	0.293
Hardness	0.761	0.529	0.277
Depth	-0.080	0.778	0.038
Area	0.288	0.454	-0.141
Nitrite	0.192	0.013	0.904
Nitrate	-0.011	0.392	0.825
Phosphate	0.850	0.083	0.334
Ammonia	0.495	0.038	0.629
Silicon	0.278	0.865	0.294

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