BIRD POPULATIONS AND HABITAT USE IN THE OKPILAK RIVER DELTA AREA ARCTIC NATIONAL WILDLIFE RANGE ALASKA 1978

BY:
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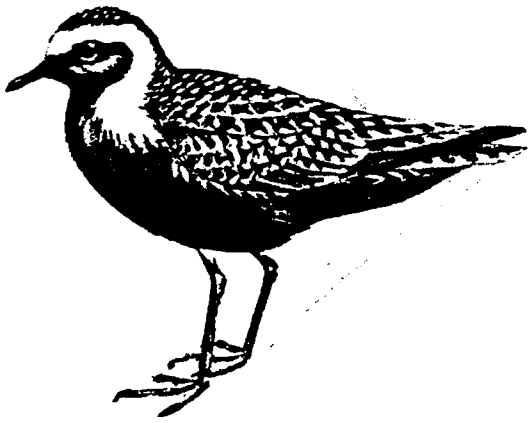

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ABSTRACT

Bird census plots totalling 1.75 km^2 in area on the Okpilak River delta, Arctic National Wildlife Range, Alaska, were sampled to determine nesting bird density and total breeding and non-breeding population during the summer of 1978. A total of 57 bird species were observed on the study area, while 23 species were recorded as breeding. The most abundant species were (in descending order): Lapland Longspur, Pectoral Sandpiper, Red Phalarope, Northern Phalarope, and Semipalmated Sandpiper. Bird populations varied about two-fold between the most productive and least productive habitat types censused. Ranked in descending order of total bird population, the four habitat types censused were Flooded Tundra, Mosaic Wet Sedge/Dry Sedge Tundra, Upland Sedge-Tussock Tundra, and Wet Sedge Tundra. Total population ranged from 111.9 to 245.2 birds/km^2. Nesting density ranged from 45 to 87 nests/km^2. Features such as wetland characteristics and interspersion of microhabitat and micro-relief, to a large extent, best characterize coastal plain habitats, and combined with a knowledge of snow melt-off pattern, are likely the best predictors of avian density and productivity. On the Okpilak area, flooded polygonal tundra, and mosaic wet/dry-high/low polygonal tundra will generally support more birds than drier tundras with lesser relief, a pattern which has been observed in other areas of the Alaska and Yukon North Slope.

Large-bird populations were censused in a much larger, 50 km^2 area. The most abundant species were Oldsquaw, Brant, Glaucous Gull, Red-throated and Arctic Loon and Whistling Swan. Total density of large-birds was 21.7/km^2 but nesting density was low, at 3.5 nests/km^2. On two wetland areas regularly censused, total bird populations were lower but stable early in the summer (June); later, numbers were occasionally high, but sporadic.

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Patterns of large-bird use were quite similar to those observed at Storkerson Point, with the areas receiving highest use including diverse wetland complexes (drained basins) and large, deep Carex, Shallow Arctophila and deep Arctophila wetlands. All are quite recongnizeable and separable during aerial surveys or from aerial photography taken in August.

Chronology of bird use includes an intense migratory period during the first week of June, high populations during courtship in mid-to-late June, and generally declining populations through July as nesting is completed and adults depart from mainland areas. A shift of bird use from generally dispersed in June to locally concentrated in July and August was noted, especially with respect to shorebirds moving to wetland areas, and waterfowl moving to larger wetlands and coastal lagoons during mid-July and early-August.

A total of seven mammal species were observed on the study area, including a large migration of caribou on the Fourth of July weekend, and an Arctic Fox den which may have been moved due to the researcher's presence. A total of 104 plant species were recorded on the study area; detailed phenological ground cover, and frequency of occurrence data are presented for the major habitat types.

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INTRODUCTION

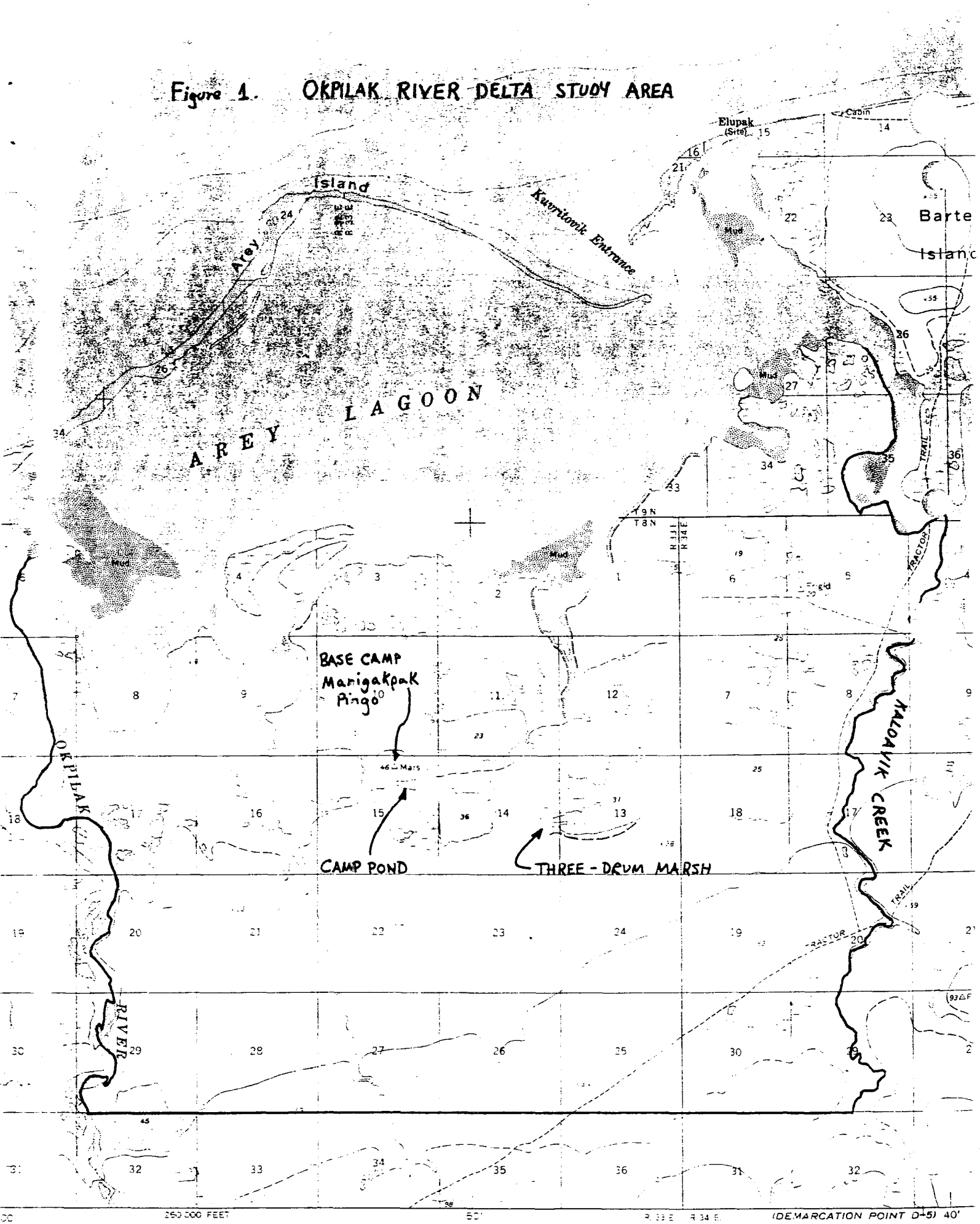
The coastal plain of the Arctic National Wildlife Range contains over two million acres of breeding bird habitat which varies tremendously in productivity. Certain habitat types on the coastal plain have been identified as critical because of their ability to sustain or produce high bird populations (Magoun and Robus 1977). Several areas along the Beaufort Sea coast have been identified as high density bird habitat, mainly because of extensive wetland areas, interspersion of differing wetland types, and proximity to the coast. Among the more important high-density bird habitats are the Canning River delta, the Hulahula-Okpilak River deltas, the Barter Island Lakes area, the Jago River delta, Beaufort Lagoon, and Demarcation Bay (Schmidt, 1976, Spindler 1978a). Of these major bird areas, only one, Beaufort Lagoon, has received intensive study and inventory (Anderson 1973, Schmidt 1973).

The objectives of this study were to (1) determine the nesting and non-breeding populations utilizing several habitat types (2) determine the patterns of habitat use during the breeding season and (3) determine arrival and nesting chronology for the bird community of the Okpilak River delta and Barter Island lakes areas.

STUDY AREA

The study area is a 50 km^2 area immediately SW of Barter Island comprised of arctic tundra habitats. The area is bounded on the N by Arey Lagoon, on the W by the Okpilak River, on the E by Kaloavik Creek emptying into Kaktovik Lagoon, and on the S by an imaginary line 1.0 km N of 70^{o} N latitude (fig. 1). Physical features include a major coastal plain river, the Okpilak; deltaic

Figure 1. OKPILAK RIVER DELTA STUDY AREA



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mudflats and wetlands; Beaufort Sea coastal lagoons; large, deep, oriented lakes; large and small wetlands of diverse types and origins[1]; typical outer coastal plain vegetation; and limited riparian and inner coastal plain vegetation. Vegetation types are predominantly Wet Sedge Tundra[2], Upland Sedge-Tussock Tundra, Mosaic Wet Sedge/Dry Sedge Tundra, Coastal Vegetated Mudflats, and Flooded Tundra (fig. 2). Riparian Shrub Thickets, River Terrace, Dry Sedge Tundra, Dryas-Heath Tundra and River Gravel occur on the study area but are of limited extent.

Climate is typical arctic coastal. The Eskimo village of Kaktovik and a military Distant-Early-Warning site are less than 15 km from the center of the study area. Subsistence hunting by Kaktovik Eskimos occurs on the area--primarily migratory bird hunting in May and June from two camps, one on the Okpilak delta and one on the tip of mainland just S of Barter Island. More than two-thirds of the land is owned by the Kaktovik Inupiat Village Corporation.

METHODS

Census Plots

Small bird populations were censused on one 0.25 km^2 and three o.50 km^2 plots which were established in differing tundra habitat types. Criteria for selecting the location of a census plot were 1) sufficient size in a homogeneous area of one habitat type; 2) distinctive vegetation types as classified

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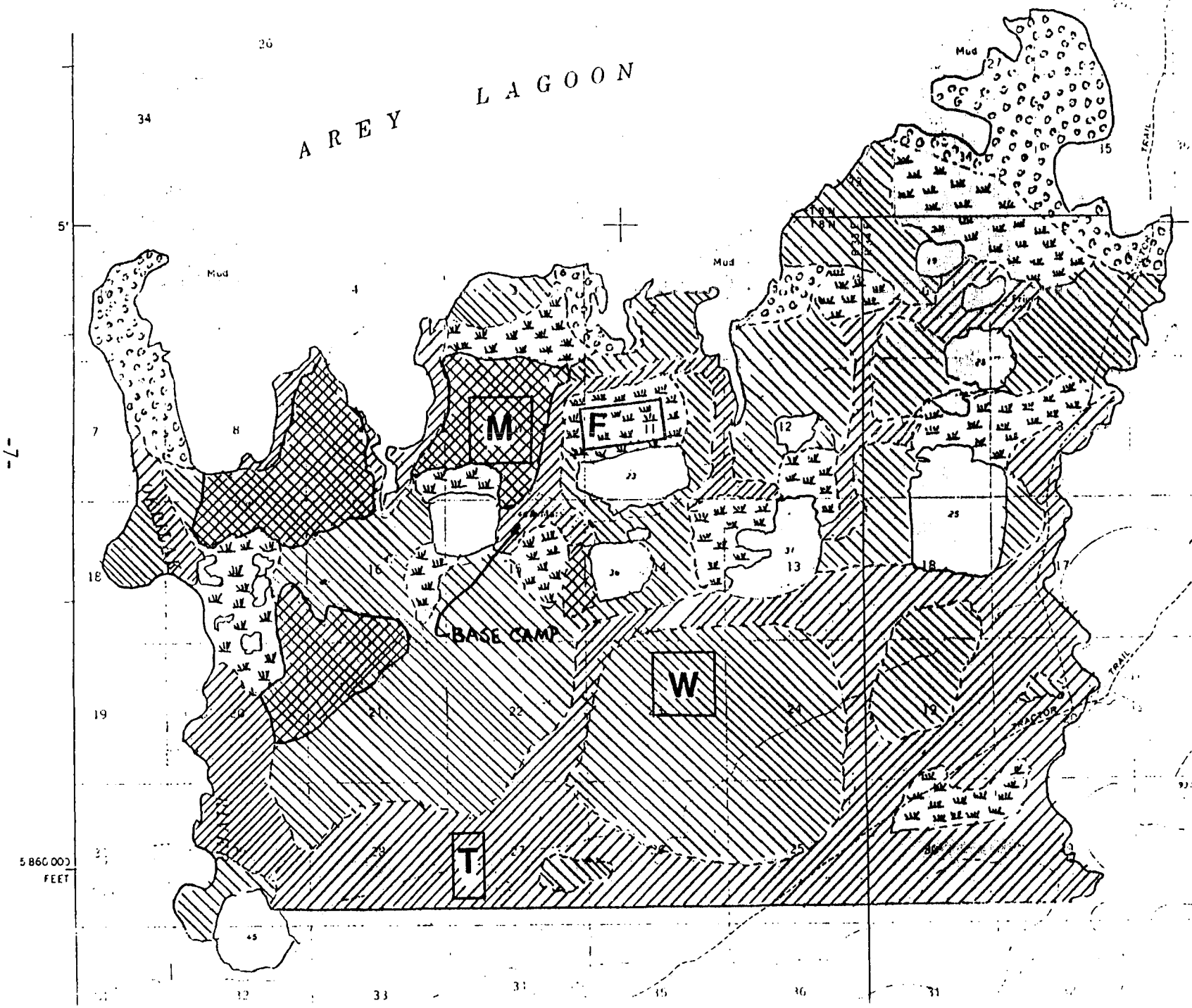
1/ Wetland classification follows Bergman et al. (1977).

2/ Vegetation classification follows Nodler (1977), except for the Mosaic, which is called Intermediate-Wet-Moist tundra by Nodler. Descriptions of all ANWR North Slope habitats may be found in Nodler (1977) and Magoun and Robus (1977).

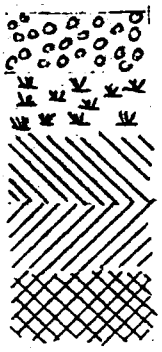
Figure 2 . Habitat type map for ...e Okpilak River Delta study area, Arctic National Wildlife Range, Alaska.



LEGEND

Figure 2

Habitat type map for the Okpilak River Delta study area



Coastal Vegetated Mudflats

Flooded Tundra (F = census plot)

Wet Sedge Tundra (W = census plot)

Tussock Tundra (T = census plot)

Mosaic Wet Sedge/Dry Sedge Tundra (M = census plot)

in ground truth and cluster analyses of satellite imagery (Nodler 1977); 3) proximity to base camp; and 4) minimal amounts of edge effect. Plots were surveyed with a Silva Ranger Compass and a 30.5 m (100 ft) steel tape. A 50 m x 50 m grid system was used to facilitate location determination for observations of birds and nests and to take a systematic sample of vegetation, micro-relief, and micro-habitat type. Intersections of the grid system were marked with bamboo wands and surveyor's flagging.

Plots were censused for two major purposes -- to obtain a count of the total numbers of birds present on the plot during the census (total population) and to find as many nests as possible (to determine nesting density). Plots were censused three to five times during the breeding season, 18 June to 19 July. Censuses were conducted at any time of day, depending on weather conditions. During cooler weather, plots were censused between 0900 and 2100 ADT. During warm, buggy, weather, plots were censused at night time, when the temperature was cooler and incubating birds were more attentive, hence flushing closer (also the mosquitoes were not as bothersome to the observers). Each census was performed by two to seven observers who walked abreast between grid lines, systematically searching for birds and bird nests. With less observers, censuses required more time. Some censuses with two observers required over 11 hours to thoroughly search a 0.5 km^2 plot, however, usually four observers assisted and most censuses were completed in about eight hours. The species, sex, behavior, location, and direction of flight were recorded for all birds seen. Special note was made of any behavior suggesting a nearby nest, and extra effort was made to find nests in such situations. During censuses, a scaled map of the plot was used to record locations of observations, territorial activities, courting activities, nest sites, and feeding sites.

For each nest discovered, the following information was recorded: microhabitat type; distance to nearest water; type of nearest water; height above water; distance to nearest hummock or ridge; percent cover of plant species within a 15 cm radius of the nest (50 cm radius for waterfowl, ptarmigan, and gull nests); percent plant cover over nest; coordinate location of nest; number of eggs or young; sex of adult as it flushed from nest (if determinable); and status of nest when re-checked.

Total population for each species was estimated as mean number of birds observed on the plot (per km^2), with each census considered a sample; it may be considered as an estimate of the total number of birds using the plot during the mid-June to mid-July census period. Nest density was estimated as the total number of nests found on the plot. It also includes 1) nests which were highly suspected as occurring on the plot because of repeated defensive behavior of a bird at a particular coordinate, and 2) nests highly suspected and not found for Semipalmated Sandpipers and Lapland Longsuprs but corroborated by territory mapping (Williams 1939). Nest density may be considered a minimum estimate of the number of nests per km^2.

Large-Bird Surveys

Large-bird species which could not adequately be censused on small plots were counted regularly by routing surveys, on foot, of wetland areas, river deltas, rivers, lagoons, and mudflats within the 50 km^2 study areas. In addition, a major wetland immediately south of camp (Camp Pond) was surveyed daily, to assess temporal variability in bird use. The areas regularly checked on the repeated surveys were: the coastal vegetated mudflats S of Barter Island, Arey Lagoon and small bays, Okpilak River and its delta; Camp Pond, Three-drum Marsh, extensive wet sedge tundra SW of camp, the network

of lakes E of camp, and Kaloavik Creek. The dates on which large bird surveys were conducted are: 1, 2, 3, 5, 7, 9, 11, 12, 15, 16, 17, 26, 27, June; 1, 2, 4, 5, 10, 14, 16, 17, 18, 19, 20, 21, July. Surveys of wetlands generally included a spotting scope or binocular count, followed by a walk around the margins or shoreline to search for nests and tight-sitting molting birds.

Habitat Description

All habitat surveys on the plots were based on a systematic sample of the census plots. On every intersection of grid lines, microhabitat was classified according to ten possible catagories: center, high-center polygon; center, intermediate-center polygon; center, low-center polygon; apex, polygon ridge; polygon trough; intersection polygon trough; features not associated with polygons -- hummock or mound, peat ridge, wetland, river terrace. Also on every intersection of grid lines, micro-relief was measured as the greatest elevational difference within a 5 m radius of the sample point. Vegetation was sampled for per cent frequency and per cent ground cover for each species occuring within a 0.5 m x 0.5 m quadrat systematically located along the grid lines. Plots with rather heterogeneous vegetation (Flooded Tundra, Upland Sedge-Tussock Tundra, and Mosaic Wet Sedge/Dry Sedge Tundra were sampled with twice the intensity as a plot with homogeneous vegetation (Wet Sedge Tundra). A quadrat was sampled at every other intersection on every line on the former plots, and every other intersection on every other line on the latter plot.

We arrived on the study area on 30 May and remained continuously until 23 July. Base camp was established atop a pingo, called "Manigakpak" by Kaktovik residents and indicated on U.S.G.S. maps as "VABM Mars", elevation 14 m (46 ft.).

RESULTS AND DISCUSSION

SMALL BIRD CENSUSES

To adequately estimate bird populations in the different tundra habitat types, it was necessary to gather data on both total population and nesting population. Censuses for these two characteristics were performed simultaneously; the dates and times of censuses are given in table #1.

Population

Flooded Tundra supported the greatest total bird population, followed by Mosaic Wet Sedge/Dry Sedge, and Upland Sedge-Tussock Tundra. Wet Sedge Tundra supported the lowest total bird population (table 2). The pattern for nesting density was slightly different, with Mosaic Wet Sedge/Dry Sedge supporting the highest, followed by Flooded Tundra, Upland Sedge-Tussock Tundra, and Wet Sedge Tundra. In terms of biomass, however, Flooded Tundra supported the greatest total biomass during the breeding season, and the greatest biomass of nesting birds. The Mosaic plot showed a higher nest density than the Flooded plot because of an extremely high nest density of small-bodied Lapland Longspurs. The Flooded Tundra supported the greatest number of resident and breeeding species. Number of species (both resident and nesting) generally corresponded with total population and nesting population. (r^s = 0.80, n = 4, Spearman's Rank, Steel and Torrie 1960).

A comparison of population levels at the Okpilak delta study area with census plot data from other Alaska North Slope areas (table 3) indicates that nesting density in 1978 was similar to, or slightly lower than densities estimated at Prudhoe Bay by Norton et al. (1975). Nesting densities at Okpilak in 1978 were much lower than at Demarcation Bay (Burgess 1978), Barrow (Myers and Pitelka 1976, 1977, 1978a) and Atkasook (Myers et al. 1978).

Table #1. Dimensions, area, and times of coverage for the four bird census plots. Okpilak River delta study area, Arctic National Wildlife Range, 1978.

	Flooded Tundra	Mosaic Wet Sedge/ Dry Sedge Tundra	Wet Sedge Tundra	Upland Sedge Tussock Tundra
Dimensions	900 x 556 m	707 x 707 m	707 x 707 m	743 x 336 m
Area	0.5 km^2	0.5 km^2	0.5 km^2	0.25 km^2
Census Coverage (Date/Time)	25 JN/10:00-16:45 3 JL/12:45-18:45 9 JL/13:00-18:30 13 JL/14:00-19:00 19 JL/13:00-19:00	23 JN/14:15-19:30 24 JN/12:45-18:00 30 JN/13:15-18:35 6-7 JL/22:00-03:41 11 JL/12:30-18:00	18-19 JN/23:30-08:35 29 JN/13:55-19:37 7-8 JL/21:30-02:30 12 JL/13:20-18:30	1 JL/15:45-18:00 10 JL/15:00-19:00 14 JL/12:50-17:40
Total Man-hours of Census	109	96	92	43

Table #2. Mean bird population in four coastal tundra habitats, based on plot censuses mid-June to mid-July, 1978, Okpilak River Delta study area, Arctic National Wildlife Range. (Densities expressed in birds/km^2, figures in parentheses indicate number of nests found/km^2).

Species	Flooded Tundra	Mosaic Wet Sedge/ Dry Sedge Tundra	Wet Sedge Tundra	Upland Sedge-Tussock Tundra
Arctic Loon	5.2 (2)			
Red-throated Loon	6.4 (6)	1.0		
Whistling Swan	0.8			
Pintail	1.2	2.0		
Oldsquaw	4.0	1.0	2.0 (2)	4.0 (1)
Common Eider	0.4 (2)			
King Eider	0.4 (2)			4.3 (2)
Willow Ptarmigan				4.0 (2)
Rock Ptarmigan		2.0 (4)		
Sandhill Crane	0.8	1.0		
Golden Plover	1.6	2.0 (1)		8.3 (4)
Long-b. Dowitcher	6.0	1.0	3.0 (2)	4.0
Pectoral Sandpiper	86.4 (4) (10)[1]	45.0 (8) (10.5)[1]	31.4 (6) (8)[1]	6.7 (2)[1]
Least Sandpiper		0.5	1.0	
Semipalmated Sand.	8.4 (2)	14.0 (6)		2.7
Buff-breasted Sand.		5.0 (3)		
Red Phalarope	68.0 (14)	5.0 (4)	0.5 (2)	
N. Phalarope	38.4 (18)	9.5 (6)	6.5 (4)	4.0 (2)
Pomarine Jaeger	0.8			
Parasitic Jaeger	0.8	1.5	2.0	
Long-tailed Jaeger	0.8	1.5	2.0	4.0
Glaucous Gull	2.0 (1)		0.5	
Sabine's Gull	0.4			
Arctic Tern	2.4			
Snowy Owl	0.4			
Short-eared Owl			0.5	
Lapland Longspur	9.6 (10)	96.0 (55)	62.5 (29)	97.3 (40)
Total No. of Species	22	16	11	10
Total Birds/km^2	245.2	188.0	111.9	139.3
Total Nests/km^2	61	87	45	51
Plot Area (km^2)	0.5	0.5	0.5	0.25
Species Diversity (H')	1.870	1.572	1.275	1.258

1/ Indicates number of territorial males.

Table #3. Comparisor of avian populations estimated in several arctic coastal plain studies in Alaska, during the breeding season 1971 - 1978.

Locality	Reference	Density	
		Total birds/km^2	Nests/km^2
Arctic NWR Okpilak delta	(this study)	112 - 245	45 - 87
Arctic NWR Demarcation Bay	(Burgess 1978)		137
Prudhoe Bay	(Norton et al. 1975)		75 - 93
Barrow	(Myers & Pitelka 1976, 1977, 1978)		109 - 167
Atkasook	(Myers et al., 1978)		284
Meade River	(Derkson et al., 1977)[1]	134	
Singiluk	(Derkson et al., 1977)[1]	146	
Teshekpuk lake	(Derkson et al., 1977)[1]	178	
Storkerson Point	(McDonald and Kenyon, 1978)[1]	153	

1/ Figures presented are means for censuses made during the peak of the breeding season mid-June to mid-July, and not the entire season of study.

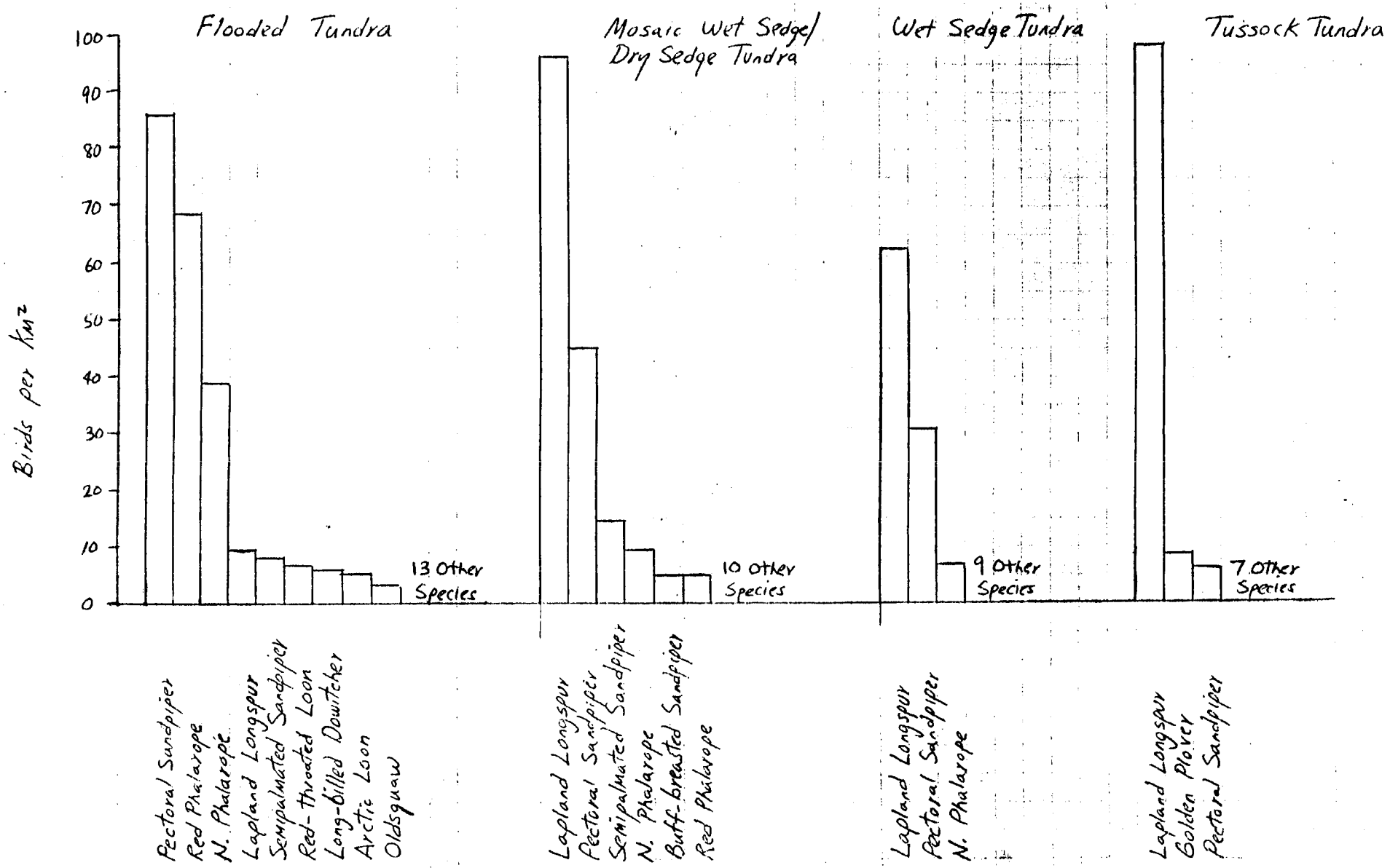


Figure 3. Density-dominance structure for total bird population on census plots, Okpilak River Delta study area, Arctic National Wildlife Range, Alaska, June-July 1978.

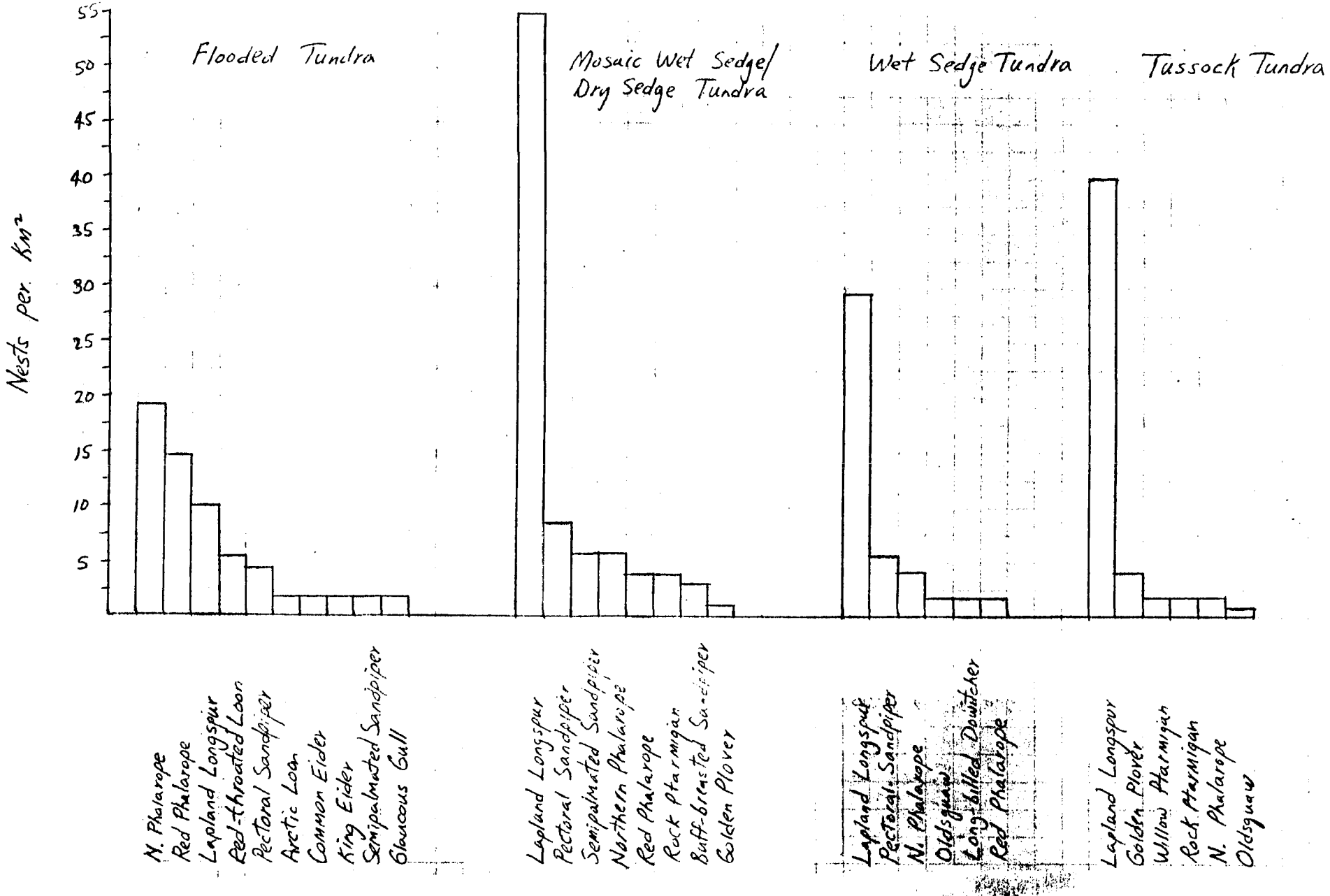


Figure 4. Density-dominance structure for nesting bird population on census plots, Okpilak River Delta study area, Arctic National Wildlife Range, Alaska, June-July 1978.

Such differences in nesting density may be a result of (1) habitat and geographic differences, as consistently high densities were reported from the Barrow area, (2) annual variability, and (3) differences in sampling technique. Probably (1) and (2) are the primary causes for differences between Okpilak and Barrow. The nest searching intensity on the Okpilak area area was lower than at Demarcation Bay and Meade River. Estimates of total resident population, however, were quite similar between the Okpilak area, and Meade River, Singiluk, and Teshekpuk Lake (Derkson et al. 1977) and Storkerson Point (McDonald and Kenyon 1978). This suggests that differences in census and extrapolation technique may be more critical when estimating nesting density than when estimating total breeding season population density; or that nesting density varies spatially to a greater degree than does total breeding season population.

Number of nesting species (nesting diversity) on the Okpilak area varied from a low of six on the Wet Sedge and Upland-Tussock Tundra plots to a maximum of ten on the Flooded Tundra plot. Nesting diversity at Barrow and Atkasook was considerably higher, at 10-17, and 18, species respectively (Myers and Pitelka 1976, 1977, 1978 and Myers et al. 1978). At Demarcation Bay and Prudhoe Bay, nesting diversity was lower than at Okpilak study area, with only seven species (Norton et al. 1975, Burgess 1978).

Community Structure

The plot with the highest total population and greatest number of species, Flooded Tundra, had the most even distribution of total population (fig. 3) and nesting density (fig. 4). Pectoral Sandpipers were the most abundant summer resident, followed by Red Phalarope and Northern Phalarope. The most abundant nesting species were Northern Phalarope, Red Phalarope, Lapland Longspur, Red-throated Loon and Pectroal Sandpiper. The Flooded Tundra had the highest populations of loons, eiders, swans, phalaropes and gulls.

Large numbers of Phalaropes and Pectoral Sandpipers used the plot for foraging and flocking after mating. In the other three plots, nesting density and total population generally followed the same density-dominance structure, however, species composition was different (figs. 3 and 4, table #2). In the Mosaic, Wet Sedge, and Upland Sedge-Tussock Tundra plots, Lapland Longspur was the most abundant species, and reached greatest dominance in the Upland Sedge-Tussock Tundra. The longspur also dominated nesting density in the Mosaic plot. Pectoral Sandpiper was second-most abundant in the Mosaic and Wet Sedge plots. Semipalmated Sandpiper, Northern Phalarope, Rock Ptarmigan, and Buff-breasted Sandpiper were of intermediate abundance in the Mosaic plot.

Other North Slope census data show that Red Phalarope, Lapland Longspur, Pectoral Sandpiper and Semipalmated Sandpiper are consistently among the most abundant breeding species (Norton et al. 1975, Myers and Pitelka 1976, 1977, 1978, Myers et al. 1978, Derkson et al. 1977, and Burgess 1978). Major differences occur in some areas, with Dunlin and Steller's Eider quite abundant at Barrow; Western Sandpiper and Oldsquaw abundant nesters near Atkasook; Savannah Sparrow and Bar-tailed Godwit more abundant inland at Singiluk, and Northern Phalarope more abundant eastward at Okpilak delta and Demarcation Bay.

Habitat Type and Bird Abundance

Several census studies have concentrated on establishing baseline data on avian populations or examining behavioral and trophic aspects of North Slope avian commintites, but fewer studies have elucidated the populational and community structural aspects of differing habitat types. Myers and Pitelka (1976, 1977, 1978) have compared two similar, adjacent communities near Barrow, where three years of data indicated substantial population and specie

Table #4. Comparison of bird abundance according to habitat type. Habitat types are listed in descending order of total bird populations (breeding and non-breeding).

Arctic NWR Katakturuk to Jago River (Magoun and Robus 1977)	Yukon North Slope-Mackenzie Delta (Patterson et. al. 1977)	Arctic NWR Okpilak River delta (this study)
Wet Sedge Meadow	High-Low Polygonal Tundra	Flooded Tundra
Riparian Willow Thickets	Dry Sedge Tundra	Mosaic Wet Sedge/Dry Sedge Tundra
Coastal Vegetated Mudflats	Sedge Marsh	Upland Sedge-Tussock Tundra
Upland Dryas-Heath Tundra	Open Dwarf Shrub/Dry Sedge	Wet Sedge Tundra
Very Wet Sedge Meadow	Wet Sedge Tundra	
Wet Sedge/Dry Sedge Meadow		
Moist Sedge Meadow		
Riparian Dryas Terrace		
Dry Sedge Meadow/Dryas-Heath Tundra		
Riparian Gravel Bars		
Dry Sedge Meadow		
Tussock Meadow		

composition differences over time and space. The pattern of snow-melt as determined by microhabitat and climatic differences were thought to be a primary causal factor in the Barrow study (above) and also at Prudhoe Bay (Norton et al. 1975). Additionally, regional differences in species distribution and abundance and habitat preferences were identified by Derkson et al. (1977) for NPR-A. Two studies concentrating on determination of bird population as related to differences in habitat type produced contrasting results (table #4). Magoun and Robus (1977) found the highest bird populations in Wet Sedge Meadows, Riparian Willow Thickets, and Coastal Vegetated Mudflats. Flooded (very wet) Sedge Meadow and Wet Sedge/Dry Sedge Meadow had intermediate populations, while these two habitat types showed the highest populations at the Okpilak delta. On the Yukon North Slope - Mackenzie Delta, High-Low Polygonal Tundra and Dry Sedge Tundra had the highest populations, while Wet Sedge Tundra and Sedge Marsh had lower bird populations. With such variation in population-habitat relationships, it is clear that such comparisons should include microhabitat, snow-melt, and climatic data preferably over a period including several breeding seasons.

Microhabitat and Micro-Relief

The Flooded Tundra plot had the lowest diversity of microhabitat, and was comprised of primarily low-center polygons, and micro-relief was intermediate, with a large area of almost no relief and 0.2-0.3 m relief between flooded polygon centers and polygon ridges (fig. 5 and table 5). Wetlands on the plot were ice-covered longer than on any other plot (until June 7) and bird use reached a peak a week later than other plots, in early July as post-breeding flocking increased.

The Mosaic Wet Sedge/Dry Sedge plot had a diverse microhabitat, with a mixture of high-center and low-center polygons. Due to extensive polygonization, diversity of micro-relief was high, ranging from 0.2 to 1.4 m with a mode of 0.3. The high-center polygons and polygon ridges were snow-free by June 1 and were used by Lapland Longspurs and shorebirds immediately as the snow receeded. Polygon troughs and low-center polygons were ice-free by June 6. Bird use reached a distinct peak in late June, and dropped off sharply by early July.

The Wet Sedge Tundra plot had a low diversity of micro-habitat, dominated primarily by low-center polygons. Range of micro-relief was the lowest, 0.2-0.7 m, with a mode 0.3 m. The Wet Sedge Tundra was one of the last habitats to clear of snow and thaw. Bird use of this plot was of the shortest duration -- not until late June were many birds observed, and by the second week of July the plot was vacated, except for the sparse nesters.

The Upland Sedge-Tussock Tundra plot had the highest diversity of microhabitat types, but was dominated by high-center polygons. Micro-relief was also very diverse, with a wide range and even distribution. The Upland Sedge Tussock Tundra was one of the earliest snow-free areas, with Eriophorum

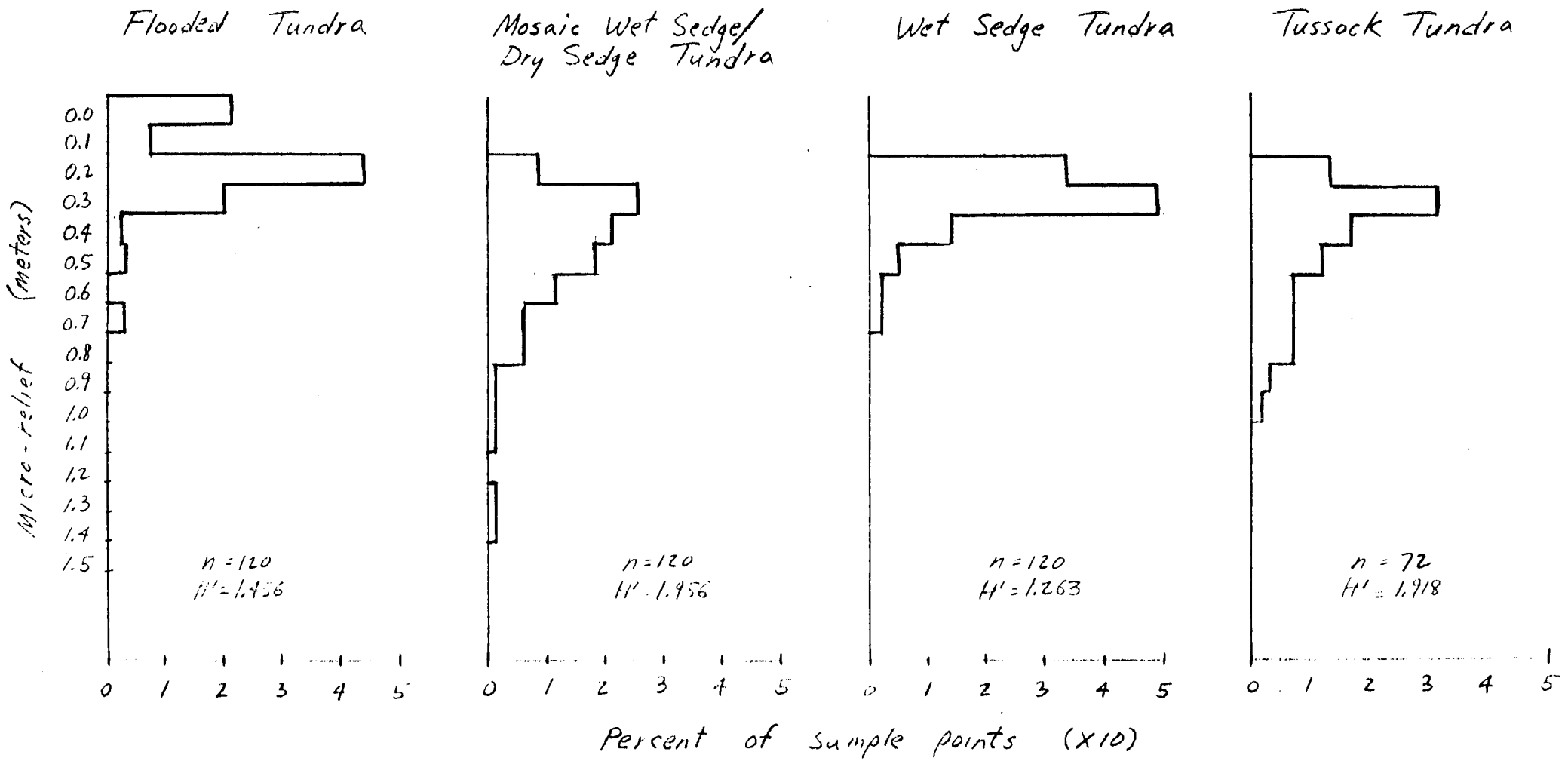


Figure 5. Histograms for micro-relief of four Okpilak River Delta avian habitats, based on a systematic grid sample of bird census plots. Arctic National Wildlife Range, Alaska, July 1978. Relief was measured as the greatest elevational difference between high and low points within a 5 m radius of the sample point.

Table #5. Microhabitat description of four Okpilak River delta avian habitats, based on a systematic grid sample of bird census plots, Arctic National Wildlife Range, Alaska, July 1978. Figures represent percent frequency of each microhabitat catagory.

Microhabitat Catagory	Flooded Tundra	Mosaic Wet Sedge/ Dry Sedge Tundra	Wet Sedge Tundra	Upland Sedge-Tussock Tundra
Center high-center polygon	3.3	30.0	0.8	40.3
Center intermediate-center polygon	2.5	12.5	10.0	9.7
Center low-center polygon	68.6	16.7	54.3	5.6
Apex polygon ridge	6.6	15.0	13.3	11.1
Polygon trough		11.7	8.3	13.9
Intersection polygon trough		8.3	0.8	1.3
Hummock or mound	0.8	0.8	0.8	
Peat Ridge			9.2	12.5
Wetland	22.0	5.0	2.5	
River Terrace				5.6
N	120	120	120	72
H'	1.014	1.727	1.464	1.750

flowers observed as early as June 5, yet most of the polygon troughs were not ice-free until a week later. Birds used the Upland Sedge-Tussock Tundra at low-densities for a long time period, from early June until late July.

Other relations between microhabitat and bird use were general correlations (all plots considered together) indicating lower nesting diversity with higher microhabitat diversity (r^S = .80, n = 4) and lower nesting density with higher micro-relief diversity (r^S = 0.80, n = 4). These correlations occurred because of the extremely low nest diversity and density in the Upland Sedge-Tussock Tundra plot, which had high micro-relief and microhabitat diversity. A much wider range of habitat types would likely yield different results, as would a breakdown and detailed analysis of micro-features on a large array of small sample units. Description of individual species relationships with microhabitat is given in the annotated species list below. Description of the plots relative to vegetation pattern and plant species is given in Appendix B.

1978 Phenology and Annual Variability

Description of bird populations during a single breeding season at the Okpilak delta would be deceptive without consideration of inherent annual variability in total population and particular species abundances, as well as the climatic and phenological conditions present during the period of study. Nesting densities for most species were probably lower in 1978 than in other years on the study area due to a later break-up and the occurrence of an unusually long and severe snowstorm in late June. Snow-melt and break-up of rivers near Kaktovik was about a week later than usual in 1978, according to local residents. Average temperature in May and June was below normal, by 3.7° F and 1.0° F, respectively (N.O.A.A. 1978). The freak late June "Summer Solstice" snow storm lasted for three days, June 21-23,

deposited snow drifts to 1 m deep over nearly every tundra depression and behind every ridge, and caused most shallow tundra wetlands to re-freeze for the duration of the storm. Although the snow melted rapidly following the storm, many species were forced to abandon nests due to burial in snow drifts (e.g. phalaropes nesting in polygon troughs and low-centers) or exposure on ridges (e.g. Golden Plovers). The storm also could have delayed arrival of late nesters, such as Long-billed Dowitchers, and caused early departure of would-be breeders. The storm left significant accumulations of snow E of the Canning River, caused light snow at Prudhoe Bay and Storkerson Point, and only flurries and trace accumulations westward (Dave McDonald and Walt Audi, pers. comm.). In short, 1978 was probably not a "normal" breeding season. Phenological data on snow-melt and break-up is given in Appendix A and on plant species flowering dates in Appendix B.

Available census data for a series of years indicates that total community nesting density has varied 30-36% over three years (111-150 nests/km^2 and 109-148 nests/km^2) at Barrow (Myers and Pitleka, 1976, 1977, 1978), and up to 43% over two years (161-230 nests/km^2) on the Seward Penninsula (Shields and Peyton 1977). Using Myers' and Pitelka's data, the most variable nesters over three years of study were (in descending order of variability) Oldsquaw, Steller's Eider, Pomarine Jaeger, Ruddy Turnstone, Snow Bunting, Pectoral Sandpiper, and Red Phalarope.

Annual variability in Myers and Pitelka's data was slightly correlated with nesting density ($r = -0.48$, linear regression, and $r^s = -0.45$, Spearman's Rank Correlation). Spindler and Kessel (1979) also found a negative correlation between annual variability and population density for interior Alaska habitats.

With the above knowledge of phenological conditions in 1978 relative to "normal", and the degree of annual variability found in other arctic tundra bird populations, I concluded that total community nesting populations may be 30-45% higher in other years, and in particular, Oldsquaw, Red Phalaropes, Pectoral and Semipalmated Sandpipers, and Jaegers would likely show higher nesting density in other years at the Okpilak delta study area.

LARGE-BIRD POPULATIONS AND WETLAND HABITAT USE

Because of the patchy occurence of wetland areas on the small bird census plots, and the comparatively low nesting density of large birds, the entire study area was surveyed for breeding and total large bird population. A total of 176 nesting pairs of large birds was observed on the study area, yielding an estimated nesting density of 3.54/km^2 (table #6). Mean large bird density was estimated at 21.7 birds/km^2. Oldsquaw were the most abundant nesting species, while Brant were the most abundant non-breeding species. Other common species were Glaucous Gull, Arctic Loon, and Red-Throated Loon.

Repeated counts at Camp Pond, a 0.2 km^2 Shallow-Carex/Shallow-Arctophila (types II/III) wetland complex, indicated a mean bird density of 128.3 birds/km^2 $\pm$ 52.8 birds/km^2 (95% confidence limit) (table #7). During the first half of the period (June 11-27), total bird populations were lower, but more stable, averaging 53.6 birds/km^2 $\pm$ 11.5 birds/km^2. The second

Table 6. Nesting density and peak numbers of large birds observed in the 50 km^2 Okpilak River delta study area, Arctic National Wildlife Range, mid June - late July 1978. Parentheses indicate estimated numbers.

Species	Number of nesting pairs	Nesting density (nests/km^2)	Peak numbers	Density (birds/km^2)
Arctic Loon	20	0.40	(80)	(1.60)
Red-throated Loon	16	0.32	(50)	(1.00)
Whistling Swan	6	0.12	22	0.44
Canada Goose	2	0.04	6	0.12
Brant	15 (1 success)	0.30	276	5.52
Common Eider	2	0.04	(10)	(0.20)
King Eider	2	0.04	(30)	(0.60)
Oldsquaw	(100)	2.0	(500)	(10.0)
Sandhill Crane	0	0	6	0.12
Glaucous Gull	14	0.28	(100)	2.00
Snowy Owl	0	0	5	0.10
Total	176	3.54	1085	21.70

Table #7. Repeated survey of birds on Camp Pond, a 0.2 km^2 Shallow-Carex/Shallow-Arctophila wetland on the Okpilak River delta study area, Arctic National Wildlife Range, Alaska June 11 - July 22, 1978.

SPECIES \ DATE	11	12	13	14	18	20	21	24	25	26	27	28	29	30	2	3	4	7	11	14	18	19	20	22
Arctic Loon									2		2	2	2	2	2	2	2	2	2	2	2			3
Red-throated Loon	2	4	2	2	2	4	2	2	4	4	6	6	6	4	4	6	6	2	2	3	3	2	2	3
Whistling Swan				2	1		1										2	2						
Greater Scaup	3					2	2	2		2	2													
Pintail	3	2	3	2										2										1
Oldsquaw	5	2	3	3	4	2	3	3	3	3		3	2	3	3	5	3							
Long-billed Dowitcher												14	8							2				4
Pectoral Sandpiper	+																		10		16			50
Semipalmated Sandpiper	+																		5					
Red Phalarope	4		1						2	2		4	6		12		30	8	20	15	3	8	5	25
Northern Phalarope			?		?					3	4	10		6	8		30	2		15		7	5	25
Glaucous Gull	2																							
Arctic Tern													16			2								
TOTAL BIRDS	19	8	11	9	9	8	8	7	11	14	14	39	40	17	29	15	73	16	39	67	24	17	12	110

half of the count period averaged 191.5 birds/km^2 ± 83.8 birds/km^2. Bird use changed dramatically for some species and was consistent for others during the 41-day (June 11-July 22) count period. Red-throated Loons were present consistently for all 24 daily counts of the survey, varying from two to four birds. Arctic Loons were also as consistent, except they were not observed until June 25. Whistling Swans were observed sporadically, as were Pintail, Greater Scaup, Long-billed Dowitchers, Glaucous Gulls and Arctic Terns. Oldsquaw were seen in small numbers (2-5) from melt-off until July 4, by which time most females were nesting and most males had begun the molt-migration. Small numbers (2-10) of Red and Northern Phalaropes nested in the area in June, and groups of 10-30 flocking non-breeders began foraging on the area on July 4. Flocks of Pectoral and Semipalmated Sandpipers were seen on the area beginning July 11, and occurred regularly until the end of the survey.

At Three-drum Marsh, a larger but deeper wetland complex (a majority of Deep-Arctophila and Shallow-Arctophila with some Shallow-Carex at the margins) mean population was lower than at Camp Pond, with 89.1 birds/km^2 ± 39.4 birds/km^2 (table 8). Numbers of large birds at Three-drum, however, were higher, expecially for Arctic and Red-throated Loons.

Table #8. Repeated survey of birds on Three-drum Marsh, a 0.75 km^2 Shallow-Carex/Shallow-Arctophila/Deep-Arctophila wetland complex on the Okpilak River delta study area, Arctic National Wildlife Range, Alaska, June 24 - July 18, 1978.

	JUNE		JULY					/Estimated
SPECIES / DATE	24	26	4	6	12	15	18	Nests
Arctic Loon	5	5	2	2		4	2	2
Red-throated Loon	14	17	13	8	7	6	6	7
Whistling Swan	1		4	1	2	2w/2yg		1
King Eider		2		2				2?
Oldsquaw	6	13	2					
Pintail	8	11		8		5	4	
Sandhill Crane					2			
Pectoral Sandpiper				35				
Red Phalarope		30			25			
Northern Phalarope		30	30		50	75		
Glaucous Gull		4		4	3	4	2	2
Arctic Tern	4	4			4			
TOTAL	38	116	51	60	93	96	14	14

ANNOTATED SPECIES LIST

BIRDS

Yellow-billed/Common Loon

Several groups of large-bodied loons were observed migrating eastward over the Okpilak delta on June 1.

Arctic Loon

The first Arctic Loon was observed on June 7 on overflow waters in Arey Lagoon. The first tundra wetland observation was of one bird at the flooded tundra census plot on June 10. A single bird was observed sitting on a nest at Camp Pond on June 27. The first hatched young were observed on July 20 at the Okpilak River delta wetlands. Most flooded Arctophila wetlands (classes III, and IV) harbored a breeding pair or at least a few non-breeding individuals during late June and July. Nesting density was estimated at 0.4/km^2 and total density at 1.6 birds/km^2 for the entire study area (table #6) but reached 2.0/km^2 and 5.2/km^2, respectively, in Flooded Tundra habitats (table #2).

Red-throated Loon

Red-throated Loons were first observed on the study area on June 6, when an individual flew over the Mosaic census plot. A pair on the Okpilak River delta wetlands on June 7 represented the first tundra wetland observation. By June 12 groups of 4-6 birds were courting on Camp Pond, and by June 22 individuals appeared to be incubating. The first nest was discovered on June 26 about 2 km NE of camp. Six other nests were found on the study area one each on June 29, July 3, 13, and 23, and two on July 19. All the nests

consisted of built-up mounds of dead and live vegetation and muck located at the edge of a pond (5) in the center of a flooded low-center polygon (1) and along a small stream (1). (Figures in parentheses indicate number of nests found.) All the nests were about 5 cm above water level, and were surrounded by emergent Carex vegetation, if any. It appeared that Red-throated Loons used smaller wetlands than Arctic Loons, and were much more gregarious. Nesting density was estimated at 0.32/km^2 and total density at 1.0 bird/km^2 for the entire study area (table #6). On the flooded tundra census plot, however, nesting density was 6.0/km^2 and total density was 6.4 birds/km^2 (table #2).

Whistling Swan

On June 4 two pairs were observed flying E near camp, the calls of several others could be heard in the distance. During June, observations were mostly of pairs scattered throughout the study area. One June 10 copulation was observed at Camp Pond. A nest containing three incubated eggs was discovered on June 12 at Three-drum Marsh. Other nesting areas discovered were at the Okpilak delta (2 pairs). The first cygnets were observed on July 14. During July, observations of swans were of pairs or of flocks numbering up to 16 adult-sized birds (July 4 at Flooded Tundra census plot). The influx of flocked birds could represent scattered movements of non-breeding subadult birds. On July 21 a neck-collared adult female (A312) was observed in the mudflats South of Barter Island with one cygnet and an adult mate. The bird was banded on August 6, 1971 by Dr. Bill Sladen and Tommy Gordon at the Okpilak River delta. Nesting density on the study area was estimated at 0.12km^2, with a total density of 0.44 birds/km^2 (table #6).

Canada Goose

On June 4 two Canada Geese were observed flying E over camp, and on June 5, 10 flying E over the Okpilak River delta. A group of 12 birds was observed migrating W over camp on June 22. Two pairs probably nested on the study area, one in the wetlands on the E side of the Okpilak River delta, and the other on the E side of the Flooded Tundra census plot. The latter pair was observed incubating on July 2, and was within an active Brant and Glaucous Gull nesting colony.

Brant

Brant were observed migrating eastward when we arrived on the study area, May 30. An estimated 7 - 10,000 birds migrated eastward along the coastal plain past the study area in the first week of June. Peak movement probably occurred between June 4 and 6. Major routes of travel were within 3 km of the inshore coastline, but vee's of birds were observed several km inland through the spotting scope. During the second week of June, migration ceased but a few hundred Brant remained on the study area, primarily in the littoral zone of the coastal lagoons. Between 10 and 14 June, groups of up to 85 Brant were observed grazing on thawing Puccinellia and other grasses as the lagoon ice receeded from shore. A non-breeding segment of the Brant population remained on the study area through June, as 198 birds remained in the coastal vegetated mudflats S of Barter Island as late as June 26. A pattern of repeated feeding flights between inland tundra wetlands and the coastal lagoons was apparent in mid-June, but it was not observed after late June when nesting must have started. On June 21, a breeding colony of 15 pairs was located 100 m E of the Flooded Tundra census plot in a deep Arctophila wetland with numerous raised mounds (hydrolaccoliths). The breeding colony of 15 nests was situated within a Glaucous Gull colony of 2 nesting

pairs and over 10 non-breeders. Such association of Brant among Glaucous Gull colonies was also observed at Teshekpuk Lake in 1978 (Derkson, pers. comm.). Brant nesting success was extemely low, as only one out of twelve nests checked on July 15 contained egg membranes (this nest contained five membranes). Nesting density was 0.3/km^2, while total density was 5.5 birds/km^2 (Table #6).

White-fronted Goose

Scattered pairs or small groups were dispersing over the study area in the first week of June -- one pair on June 1 and June 7, three on June 2, a pair grazing near camp on June 8. Five birds were observed migrating W over the flooded tundra census plot on July 3 (possibly a molt-migration of non-breeders headed towards Teshekpuk Lake). During September Snow Goose surveys on the coastal plain, 25 birds were observed migrating E on September 5, 155 on September 13, and 160 on September 14.

Snow Goose

Small movements of Snow Geese were observed on the study area during June -- a total of 61 birds flew E between June 3 and June 7, passing the camp in groups of 10 - 20; a total of 72 birds flew W between June 10 and 13; on June 11, 34 birds were observed grazing on lowland Wet Sedge Tundra 2 km SE of camp; and on June 19, 14 birds flew E over camp. These small movements probably represented those of late-arriving non-breeders of either the Banks Island/Anderson delta or Howe Island colonies. The group of 34 Snow Geese observed grazing on June 11 left a grazed area several hectares in size -- nearly every live Carex plant was uprooted and the tuber and green shoots eaten, leaving only the actual roots and dead or dying leaves in the scattered feeding sites several meters in diameter. Goose scats

were interspersed among the uprooted areas. In addition, many such feeding areas which appeared to have been grazed the year before were observed S of camp. Fall staging of Snow Geese on the coastal plain is described in another report (Spindler 1978b).

Pintail

The first Pintails observec were a flock of six flying E over the Okpilak delta on June 2. Throughout June groups of up to 10 males were observed scattered in wetlands and flying over the study area. One pair was observed on July 3, on the Flooced Tundra census plot, however, I was unable to document breeding on the study area. On July 8 flocks as large as 23 birds were observed moving about the study area. A molting bird incapable of flight was observed on July 16 at Three-drum Marsh. Both Three-drum Marsh and Camp Pond were used as molting areas during late July.

Green-winged Teal

A single male was observed on June 7 in a small pond on the Okpilak River delta.

European Wigeon

A pair was observed at Three-drum Marsh on June 12.

Greater Scaup

A flock of four males and one female was observed flying west near camp on June 6. A group of three birds (2 males, 1 female), first observed on June 11 at Camp Pond, remained there until June 27. The same birds or perhaps others were observed later in June at Three-drum Marsh.

Oldsquaw

Oldsquaws were migrating eastward along the coastal lagoons upon our arrival to the study area, May 30. Several hundred per day were observed migrating

during the first week of June. In addition, 50 birds were observed in overflow waters where the Okpilak empties into Arey Lagoon On June 5. The first major use of tundra wetlands was observed on June 7 at the Okpilak delta and on June 8 at Camp Pond -- both observations coincided with widespread availability of open wetlands just after break-up. Courtship chases were observed as late as June 19. In late June Oldsquaw numbers appeared to decline rapidly as males left the tundra breeding areas and moved to inshore molting areas. Two nests were found on the census plots, one each in Wet Sedge Tundra (June 29) and Upland Sedge-Tussock Tundra (July 1). These nests were located in quite different situations, the former on a sedge-covered polygon ridge 0.25 m from a flooded polygon center, the latter on a moss-covered lump surrounded by tussocks, 6.0 m from a small pool. The latter nest had hatched by July 10, when two egg membranes were found. Nesting density on the study area was estimated at 2.0/km^2 while total bird density was about 10 birds/km^2 (table #6).

On July 5 over 1000 Oldsquaw were observed migrating west along the coast at Barter Island. Densities of resting and molting Oldsquaw in the coastal lagoons from the Canning River delta to Demarcation Bay started building in early July, reached a maximum in early August, and gradually declined through mid-September. Mean densities for Oldsquaws in the lagoons were as follows, (birds/km^2): July 5, 36.5; July 22-25, 75.5; August 5, 112.7; September 5, 49.4; and September 14, 22.1, (Spindler 1978a).

Common Eider

Migrating eiders were numerous along the coast during the first few days of June, however, no clear observations of Common Eiders were made during this time. Pairs were observed during mid-June, one pair on June 18, 0.5 km E of camp, and one pair on June 21 on the Flooded Tundra census plot. A lone

female was observed on the mudflats S of Barter Island on July 21. Nesting density was estimated to be very low, 0.04/km^2 (Table #6).

King Eider

One male was observed in the open waters of Arey Lagoon due N of camp on June 7. One June 21, one pair was observed on the Flooded Tundra plot; two pairs were observed in a small pond 1.5 km due N of camp, near Arey Lagoon. Nesting density was estimated at 0.04/km^2 (Table #6).

White-winged Scoter

Four birds were observed flying W over the Upland Sedge Tundra census plot on July 1. On July 22, three birds were observed on the coastal lagoon aerial transects.

Rough-legged Hawk

Two birds were observed flying over the flooded tundra census plot on June 4.

Golden Eagle

On June 16 one immature bird was observed soaring above the Okpilak River, 14 km inland from the coast. One immature was observed buzzing and swooping over two caribou calves along the Okpilak River 26 km inland on June 16. Another immature bird was observed 10 km inland along the Okpilak on June 17.

Willow Ptarmigan

Willow Ptarmigan were present on the study area upon our arrival, May 30, however, they were observed most frequently inland along the Okpilak River. Several displaying males were observed on June 16, 20 km inland along the Okpilak River. Willow Ptarmigan and Rock Ptarmigan were nearly equal abundance on the Upland Sedge - Tussock Tundra census plot (Table #2).

Rock Ptarmigan

Rock Ptarmigan were present on the study area upon our arrival, May 30. During the first two weeks of June males were conspicuous staking and defending territories from higher mounds and ridges in their white winter plumage. Usually a molted-brown female, nearly in summer plumage, could be found nearby. Males were just beginning to show brown mottling to their plumage by June 15. The first Rock Ptarmigan nest was found on June 15, with seven cold eggs indicating the hen was still laying. Other nests were found on June 30 and July 6. Two nests were on the edge of a high-center polygon, one was at the edge of a small creek bank. None of the nests had vegetative cover concealing them. The eggs of the nest found on July 6 were pipping on the afternoon of July 7, and the entire clutch of 11 eggs had hatched by July 8. Rock Ptarmigan nest density was highest on the Mosaic Wet Sedge/Dry Sedge Tundra plot (4.0/km^2), but total density was highest on the Upland Sedge-Tussock Tundra plot (4.0 birds/km^2), (Table #6). Rock Ptarmigan apparently preferred the drier of tundra habitats available on the coastal plain.

Sandhill Crane

On June 2, four birds were observed flying E over Okpilak River delta. Maximum count occurred on June 5, when ten birds were observed at the Okpilak delta. Throughout June two to four birds were observed regularly on the study area, and estimated summer resident population was six birds (0.12 birds/km^2, table #6). On June 30 a weathered crane eggshell was found 0.5 km E of the Flooded Tundra plot, and probably presented the successful hatching of a young crane in 1977. In 1978, however, we did not observe any nesting or juvenile birds, indicating that breeding is erratic.

Semipalmated Plover

One Semipalmated Plover was observed on July 17 in the coastal vegetated mudflats and brackish ponds, 1.5 km W of the channel between the southern tip of Barter Island, and the mainland.

Golden Plover

Golden Plovers probably arrived on the study area one or two days before our arrival on May 30. One June 1, 20 birds were observed migrating eastward past the base camp. Several flocks of 20-30 birds were seen migrating eastward over the Okpilak delta on June 2, and migration in such numbers continued until about June 6. Territorial behavior was first observed on June 10. The first nest was discovered on June 16, about 27 km inland from the delta of the Okpilak River. Two nests were found on the study area, one on June 23, near the SE corner of the Mosaic Tundra plot, and one on July 1, on the Upland Sedge-Tussock Tundra census plot. All nests were located in Tussock-Heath Tundra in rather dry and exposed sites. The nest near the Mosaic plot probably hatched on or about July 15 and chicks were observed in the vicinity on July 18. This nest also provided us with some interesting data on survival of Golden Plover eggs after having been buried for a minimum of several hours in drifting snow. Prior to discovery of the nest on June 23, territorial birds were observed near the nest site from June 10 to June 21. One June 21 the summer solstice snow storm hit the study area and lasted until noon on June 23, depositing snow drifts in every polygon trough and behind every ridge. At 1800 on July 23 the pair of plovers were defending the top of a snow drift 15-20 cm deep. We dug through the drift below an area having the greatest amount of footprints in the snow and found a nest containing four cold eggs. After exposing the nest and leaving it, we ob-

served one plover immediately return to the nest and begin incubating. The nest must have been buried in the drift at least since the morning of June 23, and possibly longer. Through the breeding season we continually checked the nest and found the birds to be incubating as late as July 11, and the nest to be hatched by July 15, with chicks found in the vicinity on July 18. This episode, although primarily circumstantial in evidence, represents a remarkable feat of perseverance.

By July 18, groups of up to eight Golden Plovers were seen flying eastward. The highest nesting density was observed on the Upland Sedge-Tussock Tundra plot, with 4.0 nests/km^2 and a total population of 8.3 birds/km^2, (table 2). Golden Plovers also nested, in lower densities, on the Mosaic Wet Sedge/ Dry Sedge Tundra plot, and foraged on the Flooded Tundra plot.

Black Bellied Plover

On June 4 one bird was seen flying E over the Flooded Tundra plot. On July 21 a flock of about 20 individuals was seen flying W over the coastal vegetated mudflats south of Barter Island.

Ruddy Turnstone

On June 2, two birds were observed flying E over the Okpilak River delta. During June, individuals were seen on the coastal vegetated mudflats, the Okpilak River delta, and 24 km inland from the delta along the river gravel bars. On July 17 a flock of 16 adult Ruddy Turnstones and a defensive adult, possibly with young, were seen on the coastal vegetated mudflats S of Barter Island. A defensive adult was again seen in the same location on July 21, suggesting the likelihood of a brood in the area. All Turnstone observations were confined to the immediate lagoon beach and mudflat, river delta, and river gravel bar habitats.

Common Snipe

One Common Snipe was heard winnowing 22 km inland from the coast along the Okpilak River on June 16.

Lesser Yellowlegs

One Lesser Yellowlegs was observed on the coastal mudflats S of Barter Island on June 26.

Long-billed Dowitcher

Two birds were observed at the Okpilak River delta on June 5. We did not see any other dowitchers until a major influx occurred in late June. On June 28, a total of 45 birds was observed, 20 near camp, 5 at the Okpilak delta, and 20 at Three - drum Marsh. On June 29, a flock of 18 was observed on the Wet Sedge Tundra census plot. During July, most observations of this species were comprised of small flocks feeding and flying about the study area, apparently mostly non-breeders. On July 16, one nest was found containing two incubated eggs. The nest was located on the Wet Sedge Tundra census plot, in a grass-sedge clump within a dried-up low-center polygon center, 10 cm above and 100 m away from the nearest water. The greatest densities of Long-billed Dowitchers were observed on the Flooded Tundra census plot (6.0 birds/km^2, Table #2). Dowitchers preferred Flooded Tundra and shallow Carex (types I and II) wetlands for foraging.

Pectoral Sandpiper

Pectoral Sandpipers probably arrived on the study area during the last few days of May although they were not numerous and frequent until the first week of June. On June 1, 30 birds were observed; on June 2, 10; on June 3, 1. On June 4, after 22:00, large numbers of Pectorals arrived, and the male courtship display was first seen. Male courtship was prominent and

intense by June 5, but probably peaked in mid-June, with a secondary peak occurring shortly after the solstice snow storm. The last time a male courtship display was seen was early morning on July 7. Copulation was observed on June 6. The first sign of post-breeding flocking was observed on July 6, with flocks of up to 35 birds seen. Flocking of adults in groups typically numbering about 20 birds continued through mid-July and tapered off in late July, when few Pectorals could be found.

The first Pectoral Sandpiper nest found on the study area was on July 6, but the observation of another clutch in the process of hatching on July 12, suggests that at least one nest was initiated as early as June 19, (assuming an incubation period of 23 days, Pitelka, 1959). Other nests were found on July 7, 9, and 11 (one nest each day). The first chicks were found on July 9, on the Flooded Tundra plot. Pectoral nests were exceedingly difficult to find due to elusive and inconsistent behavior of incubating females. The discovery of all five nests within a week, however, suggests an increased degree of defensive behavior late in incubation which may have increased the success of nest searchers. Nests were found on both ridges (3) and in centers (2) of either high or low center polygons. Nests averaged 5 m from the nearest water (range 2-10 m), which consisted of a polygon trough (4) or flooded polygon center (1). Mean distance from ridge or hummock was 4 meters (range 0-8 m). Ground cover surrounding the nest consisted of 58% sedge, 19% moss and lichen, 13% Salix and 6% Dryas.

The highest nesting density observed was 8.0 nests/km^2 on the Mosaic Wet Sedge/Dry Sedge Tundra census plot, but the highest total population observed was 86.4 birds/km^2 on the Flooded Tundra census plot (table #2). Such a pattern indicated the females show a nesting preference of higher more

well drained sites in diverse wet/dry tundras, but the species in general prefers to feed in flooded tundra situations. The Pectoral was the most abundant shorebird species occurring on the study area in 1978.

White-rumped Sandpiper

One bird was observed on June 10 in wet sedge tundra near the coast of Arey Lagoon. On July 17, and again on July 21, one adult was seen acting defensively in the coastal vegetated mudflats S of Barter Island, near VABM Frigid. White-rumped Sandpipers probably bred sparsely along the coastal mudflats-high tide line in 1978.

Baird's Sandpiper

On June 7, four birds were observed feeding on grassy sand dunes at the Okpilak River delta. On July 17 three pairs were observed acting defensively in the coastal vegetated mudflats S of Barter Island. On July 20, one bird was seen acting defensively on the Okpilak delta, 5 km inland from the mouth. Apparently in 1978 Baird's Sandpipers bred in low numbers, but regularly, along tundra habitats immediately adjacent to the lagoon coastline and lower reaches of the river delta.

Least Sandpiper

Three birds were observed foraging on the Wet Sedge Tundra census plot on June 19. On June 20, and again on June 23, one bird was observed foraging on the Mosaic Wet Sedge/Dry Sedge Tundra census plot.

Dunlin

On June 10 one bird was observed flying E near the coast of Arey Lagoon. On June 26 one bird was observed feeding in coastal vegetated mudflats S of Barter Island. On July 17, a group of 30 was seen in a mixed flock of shorebirds, and on July 21 a group of seven was seen in the mudflats S of

Barter Island. All observations were of apparent non-breeders loafing in or passing through coastal habitats.

Stilt Sandpiper

On June 12, a nest containing three warm eggs was found on a dry mound surrounded by Wet/Dry Mosaic Tundra. On July 10, downy young were observed near Camp Pond. Based on sightings of adults with downy young July 10-16, there were at least five successful Stilt Sandpiper nests within a 2 km radius of camp, none of which occurred on a census plot, however.

Semipalmated Sandpiper

Semipalmated Sandpipers were present on the study area upon our arrival, May 30. Courtship flight displays were frequently observed on June 1 and continued on the less windy days until mid-June. A total of eight nests were found on the study area, the first on June 15, with four warm eggs. Other nests were found on June 17, 18, 23, 24, 30, and July 2 and 16. All nests were in Mosaic Wet Sedge/Dry Sedge Tundra on polygon ridges (4) or in polygon centers (4). Nests were generally less than 5 m from open water, which was either a polygon trough or small pool. The first downy young were observed on July 5; the nest found on June 30 was observed hatching on July 8 (which with a 17 day incubation period (Bent 1927), suggests the clutch was completed on June 21). On July 16, fully-feathered and flight-capable young were observed, yet adults were still incubating eggs on the same date. Flocking of adults was observed as early as July 19.

The nest found on June 23 provides data for a Semipalmated Sandpiper clutch surviving the June 21-23 solstice snow storm. From the field notes:

> "We found a Semipalmated Sandpiper nest that was completely drifted over with snow, except that the incubating bird had remained on the

nest so as to prevent its freezing. A complete 'Mini-Cavern' had formed around the bird as the snow drifted over it, except for a small air hole. The hole was just barely large enough for the small bird to fit through, about 1.75 inches in diameter. As we found the nest, the incubating bird flushed off the nest emerging from the hole thus revealing the nest's exact location. The nest was in a low spot between Eriophorum tussocks."

The nest was rechecked in early July, and had apparently hatched. The nest hatching on July 8, which must have been laid by June 21, also survived the solstice storm.

I am not sure how many of the other nests we found survived the storm, or were destroyed as a result of the storm. Certainly, Semipalmated Sandpipers seemed less abundant on the study area following the solstice storm.

Maximum nesting density observed was 6.0 nests/km^2, and maximum total population was 14.0 birds/km^2, both of which occurred on the Mosaic Wet Sedge/Dry Sedge Tundra census plot (table #2). Semipalmated Sandpipers also bred and foraged on the Flooded Tundra census plot.

Buff-breasted Sandpiper

On June 2, eight birds were observed resting and foraging on the Okpilak River delta. The first courtship displays were observed on June 4. Throughout the period of June 5-18, displays were observed whenever winds were fairly calm and the sun was shining directly or through thin clouds. Displays seemed to be given most frequently in the evening hours. The peak of courtship display was probably June 7-11, although individual birds were seen in courtship as late as June 25 and 26.

Three Buff-breasted Sandpiper nests were found on the study area, one each on June 30, July 4, and July 11. Two nests were located at the edge of a high-center polygon and one was located on an upland ridge. Nests were quite far from open water (averaging 15 m, range 4-20 m), which consisted of polygon trough (2) and open marsh (1). Average height above water was 0.6 m (range 0.2-1.0 m), and mean distance from ridge or hummock was 3 m (range 0-5 m). Ground cover over the nests averaged 3%, and vegetation surrounding the nests was comprised of 47% sedge, 21% Dryas, 20% moss and lichen, and 12% Salix. The nest found on July 11 probably hatched by July 17, and the nest found on June 30 was still incubated on July 22. Nesting density was estimated at 3.0 nests/km^2 and total density at 5.0 birds/km^2 on the Mosaic Wet Sedge/Dry Sedge Tundra census plot (table #2).

Sanderling

Three Sanderlings were observed resting and foraging on the Okpilak River delta on June 2.

Red Phalarope

Three Red Phalaropes were observed on June 5 in the wetlands along the Okpilak River 3 km upstream from the mouth. On June 7 two birds were observed in a tundra pond near camp. Numbers gradually increased on the study area through mid-June, probably reaching a peak in late June. On June 21 courtship chases were observed on the Flooded Tundra plot. Copulation was observed on June 25 and 28. On July 3, flocks of up to 20 birds were seen. On July 5, flocks of up to several hundred birds were observed on flooded tundra wetlands during aerial surveys between Demarcation Bay and the Canning River delta.

Nine Red Phalarope nests were found on the census plots, the first on June

19, four on July 3, one on July 7 and July 9, and two on July 13. About half the nests were located on a sedge tuft or clump within a flooded low center polygon, the others were located on the ridges or edges of low-center polygons, always close to flooded sedge tundra. Nests averaged 0.33 m from the nearest water (range 0.1-1.0 m) and 0.23 m above that water (range 0.03-1.0 m). Nests were an average of 6.6 m from the nearest hummock or ridge (range 0-25 m) and had a mean vegetative cover of 23% directly over the nest. Vegetation surrounding the nests averaged 68% sedge, 13% moss, 8% Salix, 4% water/mud, and 1% Dryas. Females were flushed from the nest a majority (71%) of the time. On July 19, the first downy young were observed. Has more of the early nests (clutches completed by July 1) been successful, downy young would surely have been observed before July 19. This suggests that many of the early nests may have been abandoned because of the solstice snow storm. Phalaropes in particular should have been affected severely because most of the flooded polygon troughs and low-center polygons re-froze and were drifted over during the three day storm. In fact, the one nest we found prior to the storm was abandoned after the storm.

Nest density was estimated at 14.0 nests/km^2 with a total density of 68.0 birds/km^2 on the Flooded Tundra census plot (table #2). A maximum density of 172 birds/km^2 occurred on the same plot in early July as both breeding and large flocks of apparently non-breeding birds used the habitat. The Red Phalarope was the single most abundant species occurring on a plot (Flooded Tundra) for a short duration (one census). Red Phalaropes nested and foraged on the Mosaic Wet Sedge/Dry Sedge and Wet Sedge census plots in much lower densities than on the Flooded Tundra plot.

Northern Phalarope

On June 7, two birds were observed in a small pond in Wet Sedge Tundra near camp. The first Northern Phalarope nest on the study area was found on June 12. Nesting, however, occurred over a wide time period, with incubated clutches found as late as July 19, and fully-feathered young observed as early as July 16. As with the Red Phalarope, Northern's built up in numbers through mid-June and probably reached a maximum in late-June. Maximum count on the Flooded Tundra census plot occurred on July 3. From June 20-28 mating was probably at a peak; copulation was observed on June 28. Flocking was evident by June 28 and increased through July 5; thereafter numbers on the study area were noticeably lower. Downy young were first observed on July 9.

A total of 13 nests were found on the census plots. One nest was found on June 20, 30, and July 3, 4, 6, 7, and 10, three on July 9, and two on July 19. Most nests were located on a sedge tuft or clump within a flooded polygon center (6) or at the edge of a sedge-lined pool (4). Polygon ridges (2) and edges of ridges (1) were used to a lesser extent. Nests averaged 0.31 m from the nearest water (range 0.05-4.0 m) and 0.11 m above that water (range 0.07-0.2 m). The most frequent types of water adjacent to the nests were polygon center (8), followed by pond (4), and polygon trough (1). Nests were an average of 11 m from the nearest hummock or ridge (range 0-30 m), and had a mean vegetative cover of 30% (range 10-75%). Vegetation surrounding the nests averaged 71% sedge, 11% moss, 6% willow, 5% litter, 2% mud, 1% Pedicularis, 1% Dryas, and 1% each of Vaccinium, Pyrola, and Cassiope.

In contrast to the Red Phalarope it appears that Northern's were not as severely affected by the solstice snow storm, since a fair number of young

were observed in early July. The wide period of nesting, however, probably was related to the storm (late nests = renesting attempts?) and the later break-up in 1978. Nesting density for Northern Phalaropes was higher than for any other shorebird species, (18.0 nests/km^2, table #2). Both maximum nest density and population density (38.4 birds/km^2) were observed on the Flooded Tundra census plot, but the species did nest in lower densities on the other three plots.

Jaegers

During migration in early June, Pomarine Jaegers were by far the most numerous, while Long-tailed Jaegers slightly out-numbered Parasitic Jaegers. Pomarine Jaegers were migrating E upon our arrival to the study area, May 30. The peak movement of Pomarines occurred from June 4-7, when an estimated 2000-5000 migrated eastward over the outer coastal plain. A migration of Long-tailed and Parasitic Jaegers was not discernable, rather it appeared that the two species took up summer residence on the study area about the same time during the first week of June. The following are maximum counts for each species during the first week of June:

DATE	Long-tailed Jaeger	Parasitic Jaeger	Pomarine Jaeger
1			5
3	2	1	6
4	10	2	100
5	10	5	several hundred
6	10	1	several hundred
7	5	2	2

We did not observe evidence of any Jaeger species breeding on the study area. There is a possibility that some Long-tailed Jaegers may have bred as we saw a pair of birds chasing a Parasitic Jaeger on June 29, and observed a pair in the same area during three censues of the Wet Sedge Tundra plot. Lemmings were present on the study area in low numbers, they were

neither scarce or abundant. On any day of solid walking we may have observed one or two, perhaps up to five lemmings.

Glaucous Gull

Glaucous Gulls were first observed at Kaktovik on May 8 by Jake Jacobson (pers. comm.). By mid-May they were numerous at the whale carcass near Kaktovik, with over 100 birds seen on May 17. On June 2, five birds were observed at the mouth of the Okpilak River. Territorial adults were first seen on June 10. On July 9, a week-old downy young was observed within a colony of two active nests and 12-20 non-breeding gulls. A total of 14 active nests were found on the study area. Nests were located on small mounds or islets within Flooded Tundra, shallow Carex, and shallow Arctophila (classes I-IV) wetlands, usually less than 1.0-1.5 km inland from the lagoon coastline. One colony of two nests and many non-breeders was coincident with a Brant colony. Nesting density on the study area was estimated at 0.28 nests/km^2 and total populations at 2.00 birds/km^2 (table #6).

Sabine's Gull

On June 26 and July 3, one bird was observed flying over the Flooded Tundra census plot.

Arctic Tern

Four birds were seen flying E over the wetlands along the Okpilak River 3 km upstream from the mouth on June 5. Throughout June and early July flocks numbering 2-16 were observed in Flooded Tundra shallow Carex, shallow Arctophila and deep Arctophila (classes I-IV) wetland types. On July 23, at least one bird was still present on the study area, but numbers were considerably lower than a few weeks earlier. We found no evidence

of breeding on the study area, but were not able to search the barrier island (Arey Island), where nesting was likely to occur.

Snowy Owl

Snowy Owls were present on the study area upon our arrival, May 30. On June 4, a pair was seen in what was presumed to be a courtship chase. Five birds were determined to regularly use the study area. Perhaps there were two mated pairs, judging from behavior and observations of pairs in June, but we were not able to document breeding on the study area. Estimated population density was 0.10 bird/km^2 (table #6). Based on aerial surveys over the coastal tundra 0.5 km inland from the shoreline, Canning River to Demarcation Bay, density averaged 0.15 bird/km^2 in early July and 0.24 bird/km^2 in late July.

Short-eared Owl

Two birds were observed S of camp on June 1. Individuals were seen regularly throughout the study, usually hunting solitarily.

Gray Jay

One bird was observed at Kaktovik on July 22 by Jake Jacobson.

Common Raven

Two birds were observed at the Okpilak River delta on June 5. Common Ravens are a permanent resident at Kaktovik.

Yellow Wagtail

On June 16, a total of ten individuals were observed in river terrace tundra and willow thickets along 16 km of river bank, 10-16 km inland from the coast, Okpilak River. One male was seen giving a flight display. On June 19 one individual was seen at camp.

Water Pipit

One bird was seen on June 5 on the Upland Sedge-Tussock Tundra census plot.

Brown-headed Cowbird or Rusty Blackbird

A bird described as a Brown-headed Cowbird was reported from Kaktovik on July 5 by Walt Audi, however, I cannot rule out the possibility of a Rusty Blackbird.

Common Redpoll

On June 5 one Common Redpoll was observed near camp.

Hoary Redpoll

On June 16, about 15 Hoary Redpolls were observed in riparian willows along the Okpilak River, 20 km upstream from the mouth.

Savannah Sparrow

On June 15 and 16, several birds were observed on a trip 20-26 km inland along the Okpilak River. On July 1, one bird was observed singing near camp. On July 20, one bird was seen along the Okpilak River 5 km inland from the coast. The latter two observations probably represent the usual extent of Savannah Sparrow distribution on the outer Coastal plain, however, they are quite common only a short distance inland, expecially along rivers.

Lapland Longspur

Courtship and territoriality were observed upon our arrival to the study area, May 30. The first Lapland Lonspur nest on the study area was found on June 8 and contained one cold egg. On June 12 a nest containing five incubated eggs was found. Five nests were found from June 10-15, four from June 16-20, seven from June 21-25, five from June 26-30, and one on July 7. The first hatched young were seen on June 23. On July 4, the first

fledglings were observed, and starting on July 10, fledglings were commonly seen. A total of 17 nests were found on the census plots. A majority (10) of the nests were located on sedge-covered polygon ridges, with smaller numbers in the centers of high-center polygons (4), at the edges of high-center polygons (2), and in the center of low-center polygons (2). Nearly all the nests were located on or under the south side of a sedge tussock -- the only exceptions being a few nests within dwarf willow patches. The nests averaged 0.23 m above water (range 0.5-5.0 m) and 3.4 m distant from water (range 0.2-20 m). The most frequent adjacent water areas were polygon trough (11). Mean distance to nearest hummock or ridge was low (2.0 m, range 0-20 m), a reflection of the longspur's use of upland microhabitats for nest sites. Vegetative cover over the nest was high, 68% which resulted from placement of nests under tussocks. Vegetative ground cover surrounding the nests averaged 21% Eriophorum vaginatum, 54% other sedges, 10% Salix, 7% moss and lichen, 4% Cassiope tetragona and 3% Dryas integrifolia.

Lapland Longspurs were the most abundant species on all but the Flooded Tundra census plot. They achieved the highest nesting density on the Mosaic Wet Sedge/Dry Sedge census plot (55.0 nests/km^2, table #2), and the highest total density on the Upland Sedge-Tussock Tundra plot (97.3 birds/km^2).

Snow Bunting

Snow Buntings were first observed in Kaktovik on April 18 by Jake Jacobson. On June 7, one pair was observed along the coast of Arey Lagoon. About 5-10 pairs nested in the driftwood piles and debris along the shoreline of Arey Lagoon, where territorial displays were first observed on June 12. The first fledglings were seen on July 17.

MAMMALS

Grizzly Bear

A Grizzly Bear with two cubs of the year was seen along the Okpilak River 21 km inland from the coast on June 16. We noticed that several lemming mounds N and E of camp had been excavated on July 4. On July 8, we observed a Grizzly Bear walking along the stream flowing on the E boundary of the Upland Sedge-Tussock Tundra plot. On July 13, a Grizzly Bear was seen excavating lemming mounds along the N boundary of the Flooded Tundra plot. Judging from the proximity of recently excavated lemming mounds, the bear had approached to within 0.5 km of our camp but never bothered our camp or food stores.

Arctic Fox

Three active fox dens were discovered on the study area, including one den 100 m S of our camp. Adults were present at the dens upon our arrival to the study area, May 30. The first pups were observed at the den entrance on June 30. The pups of the den were moved to a new site 1.6 km to the SW on July 4, an action that may have been a result of human activity near the den. Foxes on the study area apparently fed primarily on lemmings; few bird remains were observed near the den site but lemming remains were numerous. Den density was estimated at 1 den/13.0 km^2. Detailed information on fox derning in 1978 at Okpilak is presented elsewhere (Spindler 1978 c).

Arctic Ground Squirrel

Arctic Ground Squirrels were numerous in the well drained soils of the river terrace along the Okpilak River, but did not occur elsewhere on the study area.

Brown Lemming

Brown Lemmings were observed regularly near the coast and up to 1 km inland. Each day we walked for several hours in wet tundra near the coast we would see one or two, rarely more, Brown Lemmings. On July 11, a nest was found with four just-born young (naked with eyes closed). The nest was discovered after an adult fled from underneath a moss-peaty lump, stood on hind legs and showed its teeth, then rolled over on its back and chattered its teeth.

Collared Lemming

Like the Brown Lemming, Collared Lemmings were observed regularly on the study area, but were not abundant. It seemed like we saw more Collared Lemmings on the two inland plots (Wet Sedge Tundra and Upland Sedge-Tussock Tundra).

Moose

One bull Moose with small antlers (less than 30 inch spread) was observed on the Flooded Tundra census plot on July 16. The moose was foraging in wetlands and was slowly moving eastward.

Caribou

On June 5, about 500 caribou were visible from camp, spread evenly from the Okpilak River, eastward to the Jago River. Most of the groups were about 5-8 km inland from the coast. On June 6, 11 caribou, mostly females and one young bull foraged and rested near the lake 0.5 km SW of camp. The first calf of the year was seen on June 9, among a group of 15 animals feeding in Eriophorum tussock-Heath tundra 1 km SE of the Upland Sedge-Tussock Tundra census plot. On June 15, we again determined that most of the caribou near the study area were at least 4-5 km inland from the coast -- on a hike up the Okpilak River, the number of caribou seen increased dra-

matically at about 8 km inland (13 km upriver from mouth). We estimated about 2000-3000 caribou in a 3 km radius of our spike camp (Sec. 35, T7N, R33E, U.M.), and there seemed to be segregation by cow-calf and bull groups. Most cow groups were much more wary than bull groups, especially when calves were present. The calf:cow ratio was 50:100 and 20:100 for two different groups totalling 700 animals. On June 16 another estimated 2000 caribou were seen along the river 20-25 km inland from the coast. Caribou finally reached the coastal areas on June 18 when over 100 caribou were observed between base camp and the coastline. Small numbers of caribou were seen on the study area between June 18 and July 3.

A major migration comprised of mostly cows, calves, and yearlings, moved past our base camp starting about 1800 on July 4. At 1900 a total of 7165 caribou were counted through a spotting scope situated atop the 14 m pingo on which our base camp was located. Caribou moved past our camp, spread from coast to 5-8 km inland, at an estimated rate of 4000 per hour from 1900 on July 4 until 0400 on July 5. By late evening on July 5 most of the herd had migrated by our camp, but at least 2000 animals were milling around the study area. On an aerial survey between 1200 and 1700 on July 5, most of the caribou appeared to be S and E of camp, dispersed rather evenly over the coastal plain. Small and medium-sized groups of bulls were distributed W of the Hulahula River all the way to the Canning River.

From July 5 until July 19 only small groups of caribou were seen on the study area. On July 19, a group of 2000 caribou was seen moving N from Three-drum Marsh to the coast. Upon reaching the coast, they remained one-half hour and then headed SW toward camp, but suddenly began running E back toward Three-drum Marsh, disappearing over a ridge. The group consisted

of cows and calves with a few bulls. One cow or yearling had a red-collar with white or yellow numbers (unreadable through binoculars at our distance). This was later determined to be an animal collared in the Trans-Alaska oil pipeline corridor by Dr. Ray Cameron of Alaska Dept. of Fish and Game.

Appendix A. Chronology of snow melt, break-up, and green-up at the Okpilak River delta study area, Arctic National Wildlife Range, Alaska, 1978.

Date	Events
1 June	Snow cover 95%, snow getting soggy in sun on a clear day but refreezing at night.
2 June	Snow cover less than 10% on river terraces and wetlands immediately surrounding Okpilak delta, thus attracting the majority of birds on the study area. Lagoon and inland ponds and lakes are completely ice-covered and may be walked across.
4 June	Snow melt accelerated due to warm rain. Snow cover 80%.
5 June	Rapid snow melt due to clear skies. Snow cover less than 70%.
6 June	Snow cover less than 20%, due to more rain.
7 June	First sizeable open water in lagoon, immediately at mouth of Okpilak.
8 June	First sizeable open wetlands on tundra -- shallow ponds and marshes about one third ice free. Snow cover less than 5%.
10 June	Wetlands mostly ice-free, considerable bird usage. First sizeable open water in lagoon near shoreline.
12 June	First appearance of greening sedges and willows.
19 June	Some areas of tundra appear faintly green with Dryas, sedges, and willow.
23 June	Most wetlands have re-frozen and drifted over with snow due to a three day snow storm.
28 June	Ice on large lakes near camp still safe for landing aircraft.
29 June	Plant growth accelerating, tundra noticeably greener.
1 July	Tundra mostly green.
5 July	Lagoon about one-half ice-free
6 July	Mosquitoes out in full force.
8 July	Moat around large lakes near camp now 50 m wide. Lake ice blue, saturated with water, sinking.
10 July	Lake ice one-fourth melted.
11 July	Lake ice one-half melted.

Appendix A. Chronology (continued).

Date	Events
12 July	Lake ice three-quarters melted.
15 July	Large lakes near camp ice-free.
21 July	First significant bird use of lakes -- by swans, loons, oldsquaws.
22 July	Lagoons ice-free.

Appendix B

BOTANICAL DESCRIPTION OF THE MAJOR TUNDRA HABITATS ON THE OKPILAK RIVER DELTA STUDY AREA ARCTIC NATIONAL WILDLIFE RANGE, ALASKA 1978

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INTRODUCTION

Vegetation observations and quantitative data collections were made from early June to the third week in July in the Okpilak River delta study area. Objectives were to 1) compile a checklist for the study area based on personal observations and collections, 2) gather phenological data, and 3) describe the vegetation communities found in each habitat type.

Whenever the plots were censused for birds, notes were made on the plant taxa in and around the plot in relation to general land forms. Specimens collected were deposited in the University of Alaska Herbarium. Vascular taxa were keyed out as they appeared, and flowering dates were noted. Quantitative data on frequency and per cent cover was gathered during mid-July using methods previously described (see methods, Habitat descriptions). Ground cover data for individual plots is presented in tables B-1, B-2, B-3, and B-4. Because the micro-relief was such a determining factor in species abundance and distribution, attempts were made to describe microhabitats that occurred and the plant community types of each. The greater the diversity in micro-relief and microhabitat, the greater the plant species diversity.

One hundred and four species were observed on the study area (table B-5) not all of which were noted as flowering. In table B-5, species are listed phylogenetically by family and alphabetically within families and genera. Several species, especially graminoids, may be missing from the checklist since we were not present in the area during the height of the flowering season. Of the many species of grasses to be found on the arctic coastal plain, only three were observed flowering -- Hierochloe alpinus[1], Hierochloe pauciflora, and Alopecurus alpinus ssp. alpinus. The dates

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1/ Taxonomic nomenclature follows Hulten (1968) with the exception of the genus Salix, which follows Viereck and Little (1973).

on which species were first observed flowering on the study area are presented in table B-6.

Flooded Tundra Plot

The Flooded Tundra plot was poorly drained and covered by water throughout the growing season. The area was comprised of, in descending order, low-center polygons, wetlands (land and pond margins) and high-center polygons (table #5). Two-thirds of a pingo was within the northern boundary of the plot. Plant species usually not found in wet habitats, but observed on the pingo, greatly increased the total number of species accounted for in this plot. Because micro-relief and microhabitat affect vegetation community types, they will be discussed separately. Litter contributed the highest per cent cover besides water in all microhabitats (table B-1).

Several combinations of sedges occupied polygon centers. Carex aquatilis, Eriophorum angustifolium, and Eriophorum russeolum were the most abundant sedges. Carex rariflora and Carex saxatilis ssp. laxa were also very common. Other important but not abundant taxa included; mosses, alga, Salix reticulata, Pedicularis sudetica ssp. albolabiata, and Caltha palustris ssp. arctica.

Arctophila fulva, Carex aquatilis, and Hippuris vulgaris grew in the shallow waters of ponds and lake margins. Potentilla palustris was usually present in the shallower waters but in small localized amounts. Ranunculus pallasii was a common floating forb on the surface of small wetlands.

Salix reticulata, mosses and sedges (mostly Carex bigelowii) made up the predominant cover of the better drained polygon ridges. Plants sharing the same microhabitat included Salix planifolia ssp. pulchra, Dryas integrifolia ssp. integrifolia, Poa arctica, Salix arctica, lichen, Luzula confusa and Polygonum bistorta ssp. plumosum.

Mosaic Wet Sedge/Dry Sedge Tundra Plot

The Wet Sedge/Dry Sedge Tundra plot was generally poorly drained with locally well-drained sites and contained peaty high-center polygons, frost boils, low-center polygons and wetlands. The peaty high-center polygons offered a drier microsite which supported low shrubs (Dryas integrifolia ssp. integrifolia, Salix reticulata, Cassiope tetragona ssp. tetragona, Salix planifolia ssp. pulchra, Salix arctica, and Salix phylebophylla), sedges (Eriophorum vaginatum, Carex misandra, and Carex bigelowii), lichens, mosses, and herbs (Astragalus umbellatus, Silene acaulis ssp. acaulis, and Pyrola grandiflora). Eriphorum vaginatum tussocks were usually 0.1-0.2 m in diameter and made up 3.9% of the total cover of high-center polygons.

Frost boils were sparsely vegetated with lichens, mosses and vascular taxa including Juncus sp., Saxifraga oppositifolia ssp. oppositifolia, Carex sp., Senecio atropurpureus ssp. frigidus, Artemisia sp., Papaver macounii, Chrysanthemum arcticum ssp. arcticum, Dryas integrifolia ssp. integrifolia, Eriophorum sp., Arctagrostis latifolia ssp. latifolia, Salix arctica, and Pedicularis sp.

Carex aquatilis and Eriophorum angustifolium dominated the marshy polygon troughs. Hippuris vulgaris was observed growing in a few polygon troughs over 1 m deep.

Shallow ponds or wetlands less than 0.5 m deep were occupied almost exclusively by Carex aquatilis.

Wet Sedge Tundra Plot

The Wet Sedge Tundra plot was located farther from the coast and at a higher elevation than the Flooded Tundra plot. The site was better drained and, though very wet in June, dried out considerably by mid-July. The plot was flat with the exception of a few hummocks, peat ridges, and mounds unrelated to polygonization, especially on the SE portion. The area contained mostly low-center polygons surrounded by low ridges. Shrubs and herbs comprised a higher per cent of total cover than on the wetter plots. Sedges including Carex saxatilis ssp. laxa, Carex aqua-

tilis, Eriophorum angustifolium, and Carex chordorrhiza grew in the wetter sites along with mosses, Salix reticulata, Salix planifolia ssp. pulchra, and Pedicularis sudetica. On the drier polygon ridges the dominant sedges (Eriophorum vaginatum and Carex bigelowii) were associated with willows found in wetter sites. Hummocks were dominated by mosses, lichens, Salix planifolia ssp. pulchra, Luzula confusa, Poa arctica, and Vaccinium vitis-idaea. Frequently occurring but not abundant taxa included Rubus chamaemorus, Arctagrostis latifolia, Stellaria sp., and Carex misandra. Peat ridges were covered by a high per cent of Ericaceae shrubs growing through mats of moss.

Upland Sedge-Tussock Tundra

The Upland Sedge-Tussock Tundra plot was drier on the E side where a narrow upland river terrace was adjacent to and 1-2 m above a small stream. The terrace portion of the plot was covered by a moss-low shrub vegetation type. The predominant shrubs were Salix phlebophylla, Salix planifolia ssp. pulchra, Vaccinium vitis-idaea, Cassiope tetragona ssp. tetragona, and Dryas integrifolia ssp. integrifolia. Eriophorum vaginatum tussocks were poorly developed and scattered. Proceeding S across the plot, the vegetation type changed along a gradient of increasing moisture. Eriophorum vaginatum tussocks are replaced by Carex bigelowii, the predominant sedge on the plot. The moss-low shrub vegetation type grades into a moss-sedge-low shrub meadow and hummocky tundra. Mats of Salix phlebophylla are replaced by Salix reticulata and Salix planifolia ssp. pulchra. The moister portion of the plot was occupied mostly by polygons of varying relief, hummocks, and peat ridges. Peat ridges and hummocks were dominated by acid-loving Ericaeae shrubs -- Cassiope tetragona ssp. tetragona and Vaccinium vitis-idaea making up 47% of total ground cover. Also growing on peat mounds were mosses, lichens, Salix phlebophylla, Betula nana, Polygonum bistortum, and Ledum palustre decumbens. Wet poorly drained portions of the plot were dominated by Carex-Eriophorum meadows. The plot also contained a few almost unvegetated frost boils.

Table B-1. Per cent and frequency of occurrence of ground cover that occurred on the Flooded Tundra plot. Based on 52 quadrat samples, July 1978, Okpilak River delta, Alaska.

Ground Cover	Per Cent Cover	Per Cent Frequency
Water	32.2	73.0
Litter	19.9	84.5
Sedge	18.9	98.1
Moss	7.5	44.9
Mud	4.6	27.6
Salix reticulata	2.9	17.2
Salix planifolia ssp. *pulchra*	2.0	20.7
Salix fuscescens	1.5	5.2
Dryas intergrifolia ssp. *integrifolia*	0.9	15.5
Poa arctica	0.7	5.2
Pedicularis sudetica ssp. *albolabiata*	0.6	12.1
Salix polaris	0.5	6.9
Salix arctica	0.5	5.2
Salix rotundifolia	0.4	3.5
Algae	0.4	6.9
Lichen	0.4	6.9
Hierochloe pauciflora	0.4	1.7
Pedicularis langsdorffii ssp. *arctica*	0.4	10.4
Luzula confusa	0.3	3.5
Arctophila fulva	0.3	1.7
Stellaria sp.	0.2	5.2
Saxifraga foliosa	0.1	1.7

Table B-1 continued.

Ground Cover	Per Cent Cover	Per Cent Frequency
Saxifraga cernua	0.1	3.5
Caltha palustris	0.1	1.7
Juncus sp.	0.1	1.7
Silene acaulis	0.1	1.7
Polygonum sp.	T	1.7
Saxifraga hirculus	T	1.7

Table B-2 Per cent and frequency of occurrence of ground cover on Mosaic Wet Sedge/Dry Sedge plot. Based on 60 quadrat samples, Okpilak River Delta, Alaska.

Ground Cover	Per Cent Cover	Per Cent Frequency
Litter	34.9	100
Dryas integrifolia ssp. *integrifolia*	11.5	71.7
Carex sp.	7.0	68.0
Moss	5.8	85.0
Salix reticulata	5.7	68.3
Carex aquatilis	5.0	35.0
Water	4.8	26.7
Salix planifolia ssp. *pulchra*	3.3	33.3
Lichen	2.8	55.0
Eriophorum vaginatum	2.3	31.6
Cassiope tetragona ssp. *tetragona*	2.3	30.0
Eriophorum angustifolium	1.4	23.3
Salix arctica	1.3	15.0
Mud	1.2	18.3
Pedicularis sudetica ssp. *albolabiata*	0.9	20.0
Polygonum bistorta	0.9	25.0
Silene acaulis	0.9	15.0
Salix lanata ssp. *richardsonii*	0.5	1.7

Table B-2 continued.

Ground Cover	Per Cent Cover	Per Cent Frequency
Salix phebophylla	0.5	6.7
Pyrola grandiflora	0.4	6.7
Eriophorum sp.	0.4	10.0
Pedicularis langsdorffii ssp. *arctica*	0.3	3.3
Astragalus umbellata	0.3	5.0
Luzula confusa	0.3	8.3
Arctagrostis latifolia	0.3	5.0
Salix polaris	0.3	3.3
Saxifraga hirculus	0.1	5.0
Pedicularis capitata	0.1	5.0
Pedicularis kanei ssp. *kanei*	0.1	3.3
Poa arctica	0.1	3.3
senecio atropurpurea	0.1	3.3
Saussurea angustifolia	0.1	1.7
Stellaria	T	6.7
Draba sp.	T	1.7
Hierochloe pauciflora	T	1.7
Saxifraga oppositifolia	T	1.7

Table B-3. Per cent and frequency of occurrence of ground cover on the Wet Sedge Tundra plot. Based on 32 quadrat samples, July 1978, Okpilak River delta, Alaska.

Ground Cover	Per Cent Cover	Per Cent Frequency
Litter	31.6	100.0
Sedge	30.6	96.9
Moss	10.3	71.9
Water	7.2	68.8
Salix planifolia ssp. *pulchra*	6.7	75.0
Salix reticulata	4.5	37.5
Pedicularis sudetica ssp. *albolabiata*	2.7	25.0
Mud	1.6	25.0
Lichen	1.4	18.8
Salix fuscescens	1.1	6.3
Arctagrostis latifolia	0.6	9.4
Pedicularis langsdorffii ssp. *arctica*	0.3	9.4
Dryas integrifolia ssp. *integrifolia*	0.3	12.5

Table B-3 continued.

Ground Cover	Per Cent Cover	Per Cent Frequency
Poa arctica	0.3	3.1
Polygonum bistortum	0.3	15.6
Vaccinium vitis-idaea	0.3	6.3
Cassiope tetragona ssp. *tetragona*	0.3	6.3
Andromeda polifolia	0.2	3.1
Cardamine hyperborea	0.2	3.1
Pyrola grandiflora	0.2	3.1
Rubus chamaemorous	0.2	6.3
Salix polaris	0.2	3.1
Saxifraga foliosa	T	6.3
Saxifraga cernua	T	6.3
Saxifraga hirculus	T	3.1
Pedicularis capitata	T	3.1
Draba sp.	T	3.1

Table B-4. Per cent and frequency of occurrence of ground cover on Upland Sedge-Tussock Tundra plot. Based on 36 quadrat samples, July 1978, Okpilak River delta, Alaska.

Ground Cover	Per Cent Cover	Per Cent Frequency
Litter	32.1	94.4
Moss	17.0	88.9
Carex sp. (predominantly *C. bigelowii*)	13.1	97.2
Salix planifolia ssp. *pulchra*	8.8	77.8
Salix reticulata	3.8	61.1
Lichen	3.2	36.1
Vaccinium vitis-idaea	3.1	25.0
Cassiope tetragona ssp. *tetragona*	2.4	22.2
Dryas integrifolia ssp. *integrifolia*	2.2	36.1
Eriophorum angustifolium	1.9	16.7
Water	1.5	27.8
Salix phlebophylla	1.4	19.4
Eriophorum vaginatum	1.3	22.2
Polygonum bistora	1.0	36.1
Mud	1.0	13.9
Betula nana	1.0	11.1
Ledum palustris ssp. *decumbens*	0.6	11.1
Salix rotundifolia	0.6	5.6
Pedicularis sudetica ssp. *albolabiata*	0.6	16.7
Saussurea angustifolia	0.5	8.3

Table B-4 continued.

Ground Cover	Per Cent Cover	Per Cent Frequency
Pyrola grandiflora	0.4	11.1
Vaccinium uliginosum ssp. *microphyllum*	0.4	2.8
Pedicularis langsdorffii ssp. *arctica*	0.3	8.3
Saxifraga punctata ssp. *nelsoniana*	0.3	5.6
Saxifraga cernua	0.3	8.3
Rubus chamaemorous	0.3	2.8
Arctagrostis latifolia	0.1	2.8
Poa arctica	0.1	2.8
Juncus biglumis	0.1	5.6
Salix fucescens	0.1	2.8
Cardamina bellifolia	0.1	2.8
Cardamine hyperborea	0.1	13.9
Pedicularis sp.	0.1	11.1
Stellaria sp.	T	13.9
Astragalus umbellata	T	2.8
Petasites frigidus	T	2.8
Senecio atropurpureus	T	2.8
Hierochloe alpinus	T	5.6
Pedicularis capitata	T	2.8
Draba sp.	T	2.8

Table B-5. Plant species observed on the Okpilak River delta study area in the Arctic National Wildlife Range, Alaska, 1978.

Location refers to small bird census plots: F - Flooded Tundra; M - Mosaic Wet Sedge/Dry Sedge Tundra; W - Wet Sedge Tundra; U - Upland Sedge-Tussock Tundra; A - Areas adjacent to plots.

Species	Location				
	F	M	W	U	A
Equisetum variegatum ssp. *variegatum*		X			X
Hierochloe alpinus	X		X	X	X
Hierochloe pauciflora		X			X
Alopecurus alpinus ssp. *alpinus*	X				X
Arctagrostis latifolia		X	X	X	X
Poa arctica					X
Arctophila fulva	X				X
Eriophorum angustifolium	X	X	X	X	X
Eriophorum russeolum	X				X
Eriophorum vaginatum	X	X	X	X	X
Carex aquatilis	X	X	X	X	X
Carex bigelowii	X	X	X	X	X
Carex chordorrhiza			X		X
Carex misandra		X	X	X	X
Carex rariflora	X				X
Carex saxatilis ssp. *laxa*	X		X		X
Juncus arcticus ssp. *alaskanus*	X				X
Juncus biglumis	X			X	X
Luzula confusa	X	X	X	X	X

Table B-5 continued.

Species	Location F	M	W	U	A
Luzula tundricola	X			X	X
Salix alaxensis	X		X		X
Salix arctica	X	X	X	X	X
Salix brachycarpa ssp. *niphoclada*	X				X
Salix fuscescens	X	X	X	X	X
Salix lanata		X		X	X
Salix phylebophylla	X	X		X	X
Salix planifolia ssp. *pulchra*	X	X	X	X	X
Salix polaris ssp. *pseudopolaris*	X	X	X		X
Salix reticulata	X	X	X	X	X
Salix rotundifolia	X			X	X
Betula nana ssp. *exilis*	X		X	X	X
Oxyria digyna	X		X	X	X
Polygonum viviparum	X				X
Polygonum bistorta ssp. *plumosum*	X	X	X	X	X
Stellaria crassifolia			X	X	X
Stellaria edwardii				X	X
Stellaria laeta			X		X
Cerastium beerinianum Var. grandiflorum	X				X
Minuartia arctica	X				X
Silene acaulis ssp. *acaulis*	X	X		X	X
Melandrium apetalum ssp. *arcticum*	X				X
Caltha palustris ssp. *arctica*	X		X		X
Anemone parviflora					X

Table B-5 continued.

Species	Location F	M	W	U	A
Ranunculus nivalis	X		X	X	X
Ranunculus pallasii	X		X		X
Ranunculus pedatifidus ssp. *affinis*	X		X		X
Papaver macounii	X	X		X	X
Papaver lapponicum ssp. *occidentale*					X
Corydalis pauciflora					X
Cochlearia officinalis ssp. *arctica*	X				X
Eutrema edwardsii	X		X		X
Cardamine bellidifolia		X		X	X
Cardamine hyperborea			X	X	X
Draba alpina					X
Draba barbata					X
Draba fladnizensis					X
Draba pseudopilosa		X			X
Parrya nudicaulis ssp. *nudicaulis*				X	X
Parrya nudicaulis ssp. *septentrionalis*				X	X
Sedum rosea ssp. *integrifolium*					X
Saxifraga caespitosa					X
Saxifraga cernua	X		X	X	X
Saxifraga foliosa Var. foliolosa	X		X	X	X
Saxifraga foliosa Var. multiflora				X	X
Saxifraga hieracifolia	X		X	X	X
Saxifraga hirculus	X	X	X	X	X
Saxifraga oppositifolia		X		X	X

Table B-5 continued.

Species	Location				
	F	M	W	U	A
Saxifraga punctata ssp. *nelsoniana*	X		X	X	X
Rubus chamaemorous			X	X	X
Potentilla hyparctica	X		X	X	X
Potentilla palustris	X		X		X
Potentilla pulchella				X	X
Dryas integrifolia ssp. *integrifolia*	X	X	X	X	X
Astragalus alpinus ssp. *alpinus*					X
Astragalus umbellatus	X	X	X	X	X
Oxytropis maydelliana	X			X	X
Oxytropis nigrescens ssp. *bryophila*	X				X
Geranium bicknellii				X	X
Hippuris vulgaris	X	X	X		X
Pyrola grandiflora	X	X	X	X	X
Ledum palustre ssp. *decumbens*				X	X
Cassiope tetragona ssp. *tetragona*		X	X	X	X
Andromeda polifolia			X	X	X
Vaccinium uliginosum ssp. *microphylum*	X		X	X	X
Vaccinium vitis-idaea			X	X	X
Primula borealis					X
Androsace chamaejasme ssp. *lehmanniana*	X				X
Dodecatheon frigidum					X
Polemonium acutiflorum		X		X	X
Polemonium boreale ssp. *boreale*	X				X
Lagotis glauca ssp. *minor*	X			X	X

Table B-5 continued.

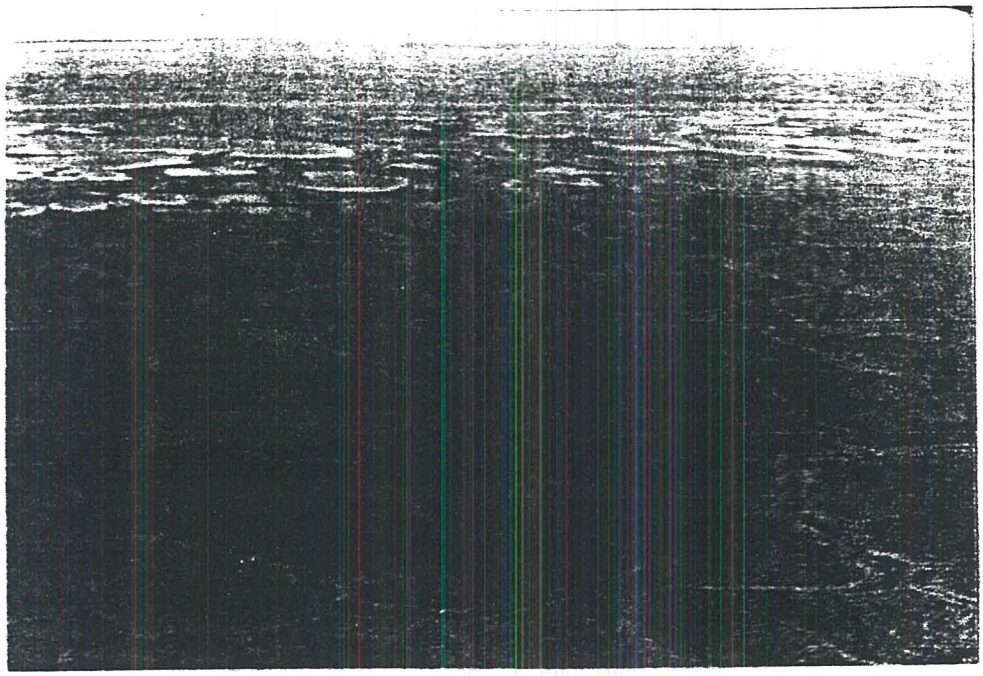
Species	Location F	M	W	U	A
Pedicularis capitata	X	X	X	X	X
Pedicularis kanei ssp. *kanei*	X	X	X	X	X
Pedicularis langsdorffii ssp. *arctica*	X	X	X	X	X
Pedicularis sudetica ssp. *albolabiata*	X	X		X	X
Valeriana capitata	X		X	X	X
Chysanthemum arcticum ssp. *arcticum*		X			X
Artemisia sp.		X			X
Petasites frigidus	X			X	X
Senecio atropurpureus ssp. *frigidus*		X	X	X	X
Senecio congestus	X				X
Senecio yukonensis			X	X	X
Saussurea angustifolia		X		X	X
Taraxacum lacerum	X				X

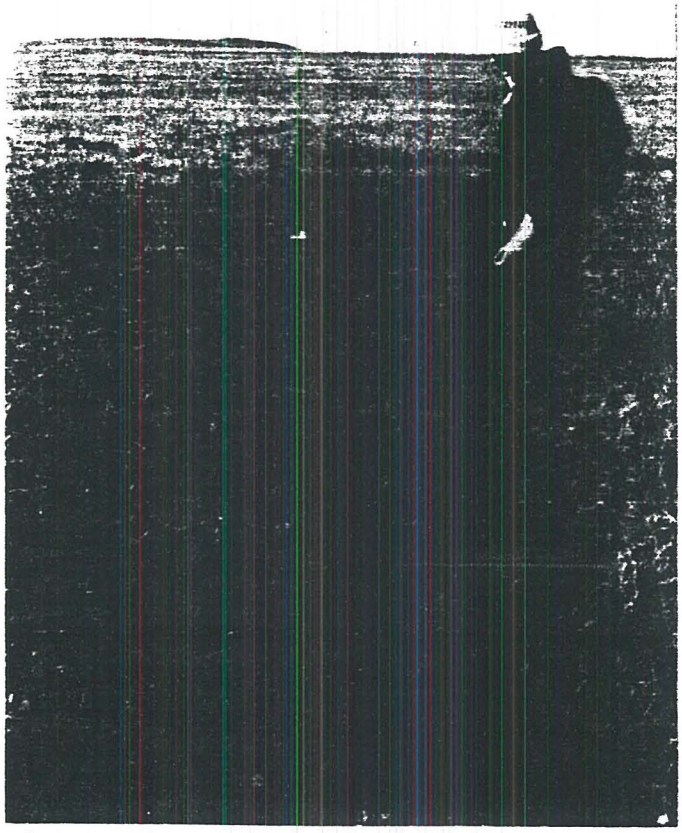
Table B-6. First flowering dates of plant species, Okpilak River delta study area, Arctic National Wildlife Range, Alaska, June-July 1978.

June 5	*Eriophorum sp.*
June 8	*Salix sp.*
June 10	*Saxifraga oppositifolia*
June 15	*Ranunculus pedatifidus* ssp. *affinis*
June 22	*Pedicularis kanei* ssp. *kanei* *Ranunculus nivalis*
June 28	*Oxytropis nigrescens* ssp. *bryophila* *Parrya nudicaulis*
June 29	*Potentilla paulstris* *Salix lanata* *Salix phlebophylla* *Stellaria laeta*
June 30	*Carex bigelowii* *Cochlearia officinalis* *Salix planifolia* ssp. *pulchra* *Salix polaris* *Salix reticulata*
July 1	*Caradimine belliflora* *Cassiope tetragona* ssp. *tetragona* *Draba barbata* *Dryas integrifolia* ssp. *integrifolia* *Lagotis glauca* *Oxyria digyna* *Papaver macounii* *Petasites frigidus* *Primula borealis* *Saxifraga punctata* ssp. *nelsoniana*
July 2	*Alopecurus alpinus* ssp. *nelsoniana* *Androsace chamaejasme* ssp. *lehmanniana* *Draba pseudopilosa*
July 3	*Caltha palustris* ssp. *arctica* *Cerastium beeringianum Var. grandiflorum* *Polemonium boreale* ssp. *boreale* *Potentilla palustris* *Potentilla pulchella*
July 4	*Anemone parviflora* *Oxytropis maydelliana* *Papaver lapponicum* ssp. *occidentale*

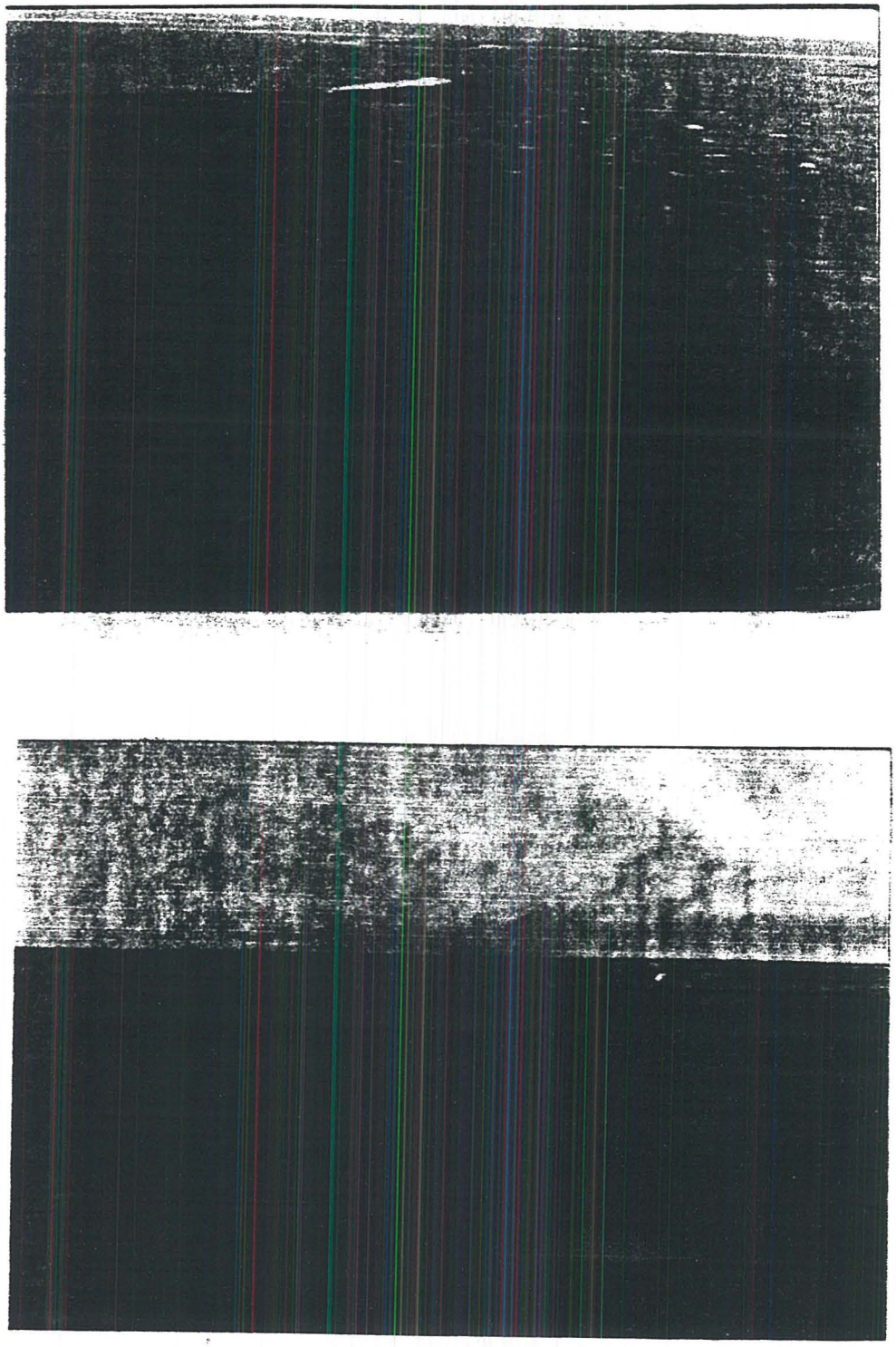
Table B-6 continued.

July 5	*Astragalus umbellatus*
	Draba fladnizenis
	Pedicularis langsdorffii ssp. *arctica*
	Silene acaulis ssp. *acaulis*
	Vaccinium uliginosum
	Valeriana capitata
July 6	*Betula nana*
	Corydalis pauciflora
	Draba alpinus
	Minuartia arctica
	Polygonum bistortia
	Rubus chamaemorous
	Senecio yukonensis
July 7	*Salix fuscescens*
July 8	*Cardamine hyperborea*
	Hierochloe alpinus
July 9	*Astragalus alpinus* ssp. *alpinus*
	Saxifraga foliosa Var. foliosa
	Stellaria crassifolia
July 13	*Dodecathon frigidus*
	Melandrium apetalum ssp. *arcticum*
	Senecio atropurpureus ssp. *frigidus*
July 14	*Andromeda polifolia*
	Saxifraga foliosa Var. multiflora
	Stellaria edwardii
July 15	*Polemonium acutiflorum*
July 16	*Eutrema edwardsii*
	Hierochloe pauciflora
	Juncus arcticus ssp. *alaskanus*
	Luzula confusa
	Luzula tundricola
	Polygonum viviparum
	Senecio congestus
	Taraxacum lacerum
July 17	*Chysanthemum arcticum* ssp. *arcticum*
	Equisetum variegatum
	Salix brachycarpa ssp. *niphoclada*
July 18	*Saxifraga caespitasa*
July 20	*Sedum rosea*

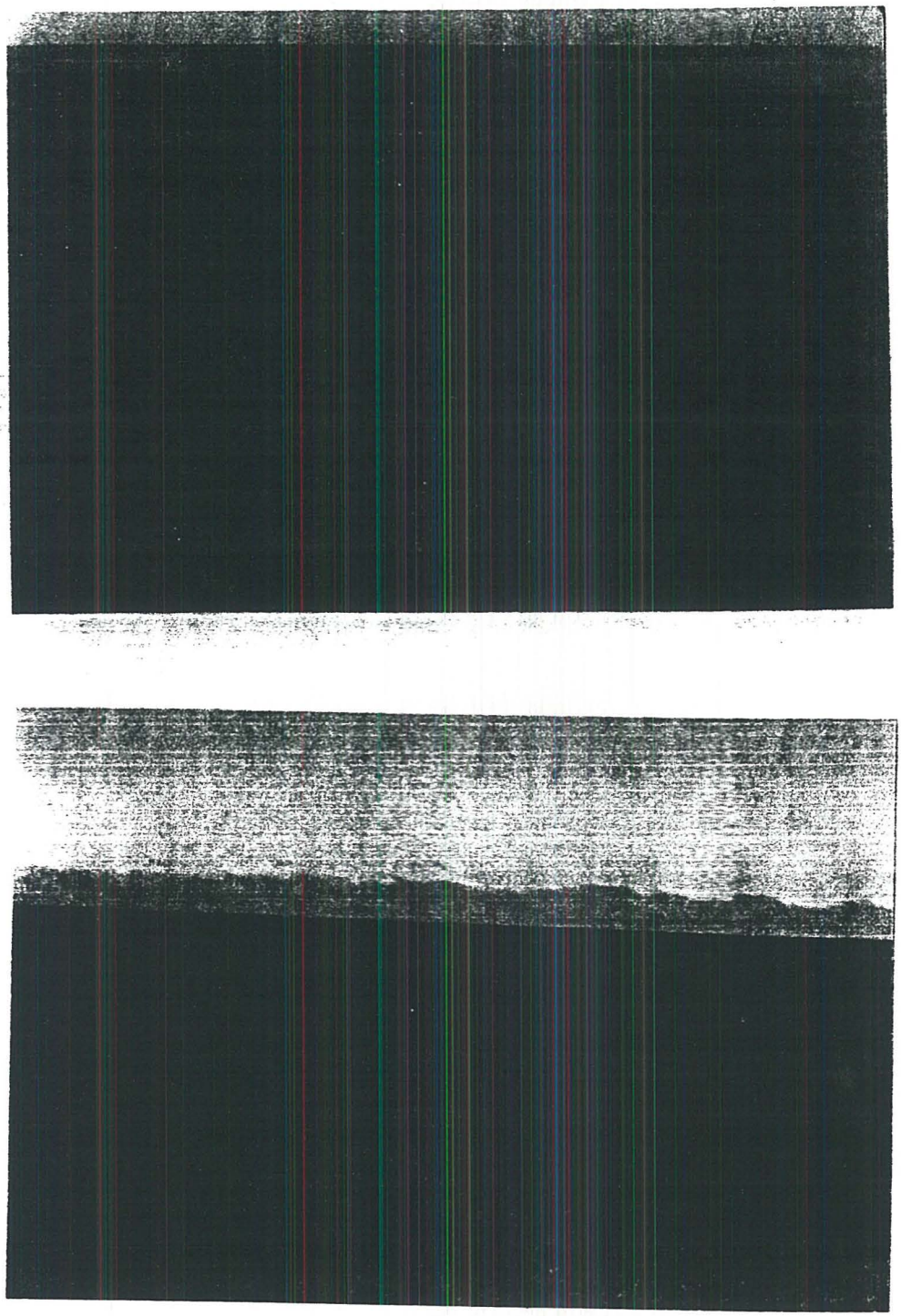




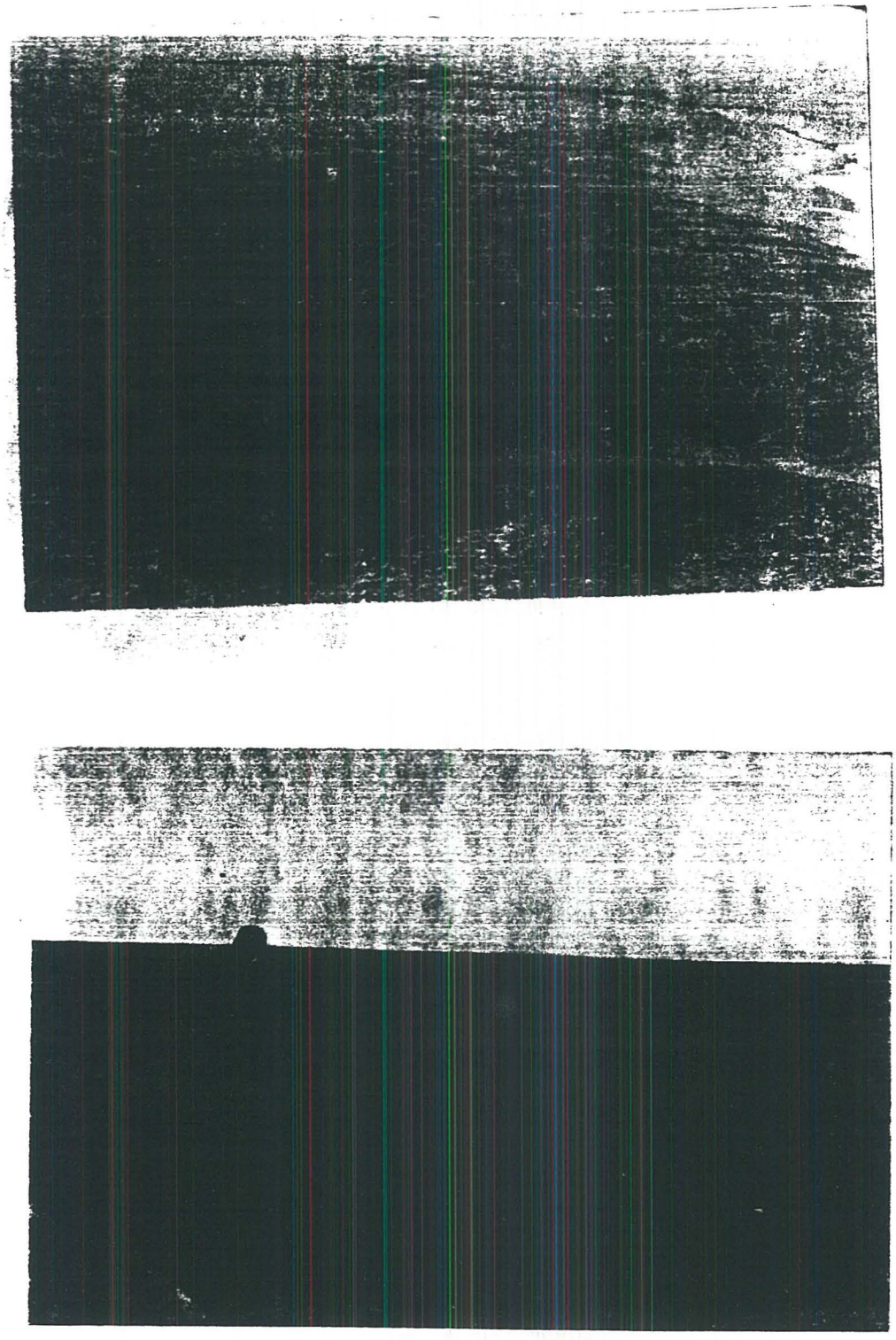
Appendix C-1. Aerial and ground views of Flooded Tundra bird census plot, Okpilak River delta study area, Arctic National Wildlife Range, Alaska, July 1978.



Appendix C-2. Aerial and ground views of Mosaic Wet Sedge/Dry Sedge Tundra bird census plot, Okpilak River delta study area, Arctic National Wildlife Range, Alaska, July 1978.



Appendix C-3. Aerial and ground views of Wet Sedge Tundra bird census plot, Okpilak River delta study area, Arctic National Wildlife Range, Alaska, July 1978.



Appendix C-4. Aerial and ground views of Upland Sedge-Tussock Tundra bird census plot, Okpilak River delta study area, Arctic National Wildlife Range, Alaska, July 1978.

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