WILDLIFE STUDIES ON THE COLVILLE RIVER DELTA, ALASKA, 1995

Fourth Annual Report

Prepared for

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and

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EXECUTIVE SUMMARY

The Colville River drains 53,000 km^2 or about 29% of the Arctic Coastal Plain of Alaska and forms a large (551 km^2) delta where it meets the Beaufort Sea. Oil reserves on the central portion of the Colville Delta currently are being evaluated for commercial development by ARCO Alaska, Inc. and the Kuukpik Unit Owners. In preparation for development and production, studies on the biological resources of the delta were initiated in 1992. Although the study areas and, to a lesser degree, the focal species have varied over the four years of studies, the basic goal has remained unchanged: to accumulate baseline information on the distribution and abundance of selected wildlife during pre-breeding through post-breeding seasons. In 1995, the primary species of concern were Spectacled Eiders, Tundra Swans, Brant, Yellow-billed Loons, caribou, and arctic foxes. Other species that were included as secondary species were King Eiders, Pacific and Red-throated loons, Greater White-fronted Geese, muskoxen, and red foxes.

The study area was divided into four survey areas that reflected levels of concern for development impacts as well as different habitat associations. The delta includes the area between the East Channel of the Colville River and the western most distributary from Nuiqsut to the Beaufort Sea. The Facility Area, which is where potential direct impacts from construction and production most likely will occur, comprises 14 km^2 in the southcentral portion of the delta and is composed of a buffer around the proposed production facility, airstrip, drill sites, and a road connecting these sites together. The Development Area (169 km^2) occupies the southern portion of the delta between the main channels and includes the Facility Area, but is the general area where oil extraction activities may produce indirect impacts to wildlife. The Outer Delta (352 km^2), extends from the Development Area north to the coast. It contains marine influenced habitats and probably will be the least affected by development. The Transportation Corridor (343 km^2) spans between the delta and DS-2M in the Kuparuk Oilfield and includes potential routes for pipelines and roads. It contains no coastal habitat and small amounts of river and stream habitat.

The study objectives were: 1) to classify and map wildlife habitats on the delta and in the Transportation Corridor, 2) to monitor the distribution, abundance, and habitat use of selected waterbird species, 3) to monitor the abundance and distribution of caribou, 4) to locate fox dens and evaluate their habitat associations, and 5) to describe the distribution of other large mammals in the study area.

A combination of aerial and ground surveys and aerial photogrammetry were used to collect field data for analysis in a geographical information system. Wildlife habitats were classified and mapped to identify those habitats that were selected by the focal species. An ecological land classification identified 195 classes that were combined into 24 wildlife habitats. The delta and Transportation Corridor contained different amounts of these habitats, reflecting differences in salinity and riverine processes between the two areas. The most abundant habitats in the delta were Wet Sedge-Willow with Low-relief Polygons (18.5% of the area), River or Stream (14.8%), Barrens (14.3%), and Tidal Flats (10.1%). Habitats unique to the delta included Brackish Waters, Tapped Lakes with Low-water Connections, Salt Marshes, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons. The most abundant habitats on the Transportation Corridor were Moist Tussock Tundra (27.6%) and Moist Sedge-Shrub Meadows (24.7%).

Spectacled Eiders—In four years of surveys, Spectacled Eiders have not been found any further than 14 km from the coast during pre-nesting or nesting. Densities of Spectacled Eiders during pre-nesting have differed little (0.13–0.17 birds/km^2) on a common area of the delta surveyed for three years (1993–1995). The Facility and Development areas were used infrequently by eiders during pre-nesting. Low densities of Spectacled Eiders (0.03–0.06 birds/km^2) also were found in the Transportation Corridor during 1993 and 1995. No nests of Spectacled Eiders were found in the Facility Area in 1995. Spectacled Eiders typically nest close to the coast on the delta; 20 nests positively identified as belonging to Spectacled Eiders were found on the Outer Delta in 1992–1994. Although broods had a distribution similar to nests, fewer have been found;

in 1993, only one brood was located in the Development Area compared to 10 located on the Outer Delta. In 1995, only one brood was found on the Outer Delta, and one was found in the Transportation Corridor. From pre-nesting to brood-rearing, Spectacled Eiders on the delta showed a strong preference for coastal habitats and waterbodies, especially Aquatic Sedge with Deep Polygons, Salt-killed Tundra, Brackish Water, and Nonpatterned Wet Meadow. In the Transportation Corridor, Spectacled Eiders preferred Young Basin Wetland Complex, Wet Sedge-Willow Meadow with Low-relief Polygons, and Nonpatterned Wet Meadow.

King Eiders—King Eiders also have a strong affinity for the coast, but are even more numerous in the Transportation Corridor. Pre-nesting densities on the delta declined over three years (1993–1995) from 0.14 to 0.07 birds/km^2, whereas densities in the Transportation Corridor climbed from 0.23 to 0.88 birds/km^2 from 1993 to 1995. Only five positively identified King Eider nests have been found in two years, because we concentrated on finding nests of Spectacled Eiders. Only one King Eider brood was found on the delta in 1995 compared to 51 broods found in the Transportation Corridor. Prior to 1995, one brood was found in the Development Area. During pre-nesting, the majority of King Eiders on the delta had not yet settled in nesting habitat, but had selected open water habitats: Rivers and Streams, Barrens, and Open Nearshore Waters. During nesting and brood-rearing they preferred the same habitat on the delta as did Spectacled Eiders, Aquatic Sedge with Deep Polygons. On the Transportation Corridor, King Eiders generally selected Aquatic Sedge Marsh, Deep Open Water (with and without Islands), Barrens, Shallow Open Water (with and without Islands), and Young Basin Wetland Complex.

Tundra Swans—In 1995, we found 38 Tundra Swan nests on the Colville Delta, the highest number found during three years of aerial surveys. From 1993 to 1995, the number of swans nesting on the delta increased 90% and in the Transportation Corridor it increased 80%. Nest densities in 1995 were the same (0.07 nests/km^2) in the Development Area and Outer Delta, but slightly lower (0.05 nests/km^2) in the Transportation Corridor. Of the areas we surveyed from the air, the Facility Area contained the highest density of nests (5 nests, 0.37 nests/km^2). During brood surveys on the delta in late August 1995, we counted 25 broods with more than twice as many young swans as in 1992 or 1993. Mean brood size in 1995 was 3.7 young and the density was 0.05 broods/km^2. In 1995, the Facility Area contained the highest density of broods (0.15 broods/km^2), compared to the densities found in the Outer Delta (0.05 broods/km^2), Development Area (0.04 broods/km^2), and Transportation Corridor (0.03 broods/km^2). Although 295 swans were counted on the delta during a fall-staging survey in 1993, annual numbers have been highly variable; only 64 swans were seen on a similar date in 1995. Swans on the delta preferred to nest in Aquatic Grass Marshes, Salt Marshes, Salt-killed Tundra, Wet Sedge-Willow Meadows with Low-relief Polygons, Moist Sedge-Shrub Meadows, Aquatic Sedge with Deep Polygons, Nonpatterned Wet Meadows, and Deep Open Waters with Islands or Polygonized Margins. In the Transportation Corridor, swans selected Aquatic Sedge Marsh, Deep Open Water with Islands or Polygonized Margins, Aquatic Grass Marsh, Young Basin Wetland Complex, Shallow Open Water with Islands or Polygonized Margins and Nonpatterned Wet Meadow. During brood-rearing, swans on the delta preferred Brackish Waters, Tapped Lakes with Low-water Connections, Deep Open Waters with Islands or Polygonized Margins, Salt Marshes, and Deep Open Waters without Islands. Similar habitats were selected in the Transportation Corridor, except that Aquatic Grass Marsh, Aquatic Sedge Marsh, and Riverine or Upland Shrub were selected in place of saline habitats, which were not available.

Yellow-billed Loons—Twelve nests and 40 adult Yellow-billed Loons were found on aerial surveys in 1995, which was one more nest but fewer adults than were found in 1993. The Facility Area had the highest density of nests in 1993 and 1995 (0.07 nests/km^2), whereas the Outer Delta had slightly lower densities (0.01 and 0.02 nests/km^2) than did the Development Area (0.04 and 0.03 nests/km^2). In both these years, brood densities were nearly the same (0.01–0.02 broods/km^2) in all the aforementioned survey areas except the Facility Area, where there were no broods. No nests or broods were seen in the Transportation Corridor.

Yellow-billed Loons preferred to nest in both types of Deep Open Waters, Tapped Lakes with High-water Connections, and Aquatic Sedge with Deep Polygons. With the exception of Aquatic Sedge with Deep Polygons, these same habitats were preferred by brood-rearing Yellow-billed Loons.

Brant—More than 900 pairs of Brant nest in the Anachlik Colony-complex at the mouth of the East Channel, which is the largest concentration of nesting Brant on the Arctic Coastal Plain of Alaska. These nests are monitored by the U.S. Fish and Wildlife Service however, so we did not include them in this study. Elsewhere on the delta in 1995, we counted 37 nests at 12 locations, which was 38% of the number of nests counted in 1993. Most of the nesting occurred on the Outer Delta, although four nesting locations were found in the Development Area in 1995. Two of these nesting locations, containing ≥11 nests, were in the Facility Area. In the Transportation Corridor, only 2–3 nesting locations with <5 nests have been seen each year of survey. More Brant (768 adults and 712 goslings) were counted during brood-rearing in 1995 than any year previously. All brood-rearing groups were seen in coastal areas of the Outer Delta; no brood-rearing groups were seen in the Development Area, Facility Area, or in the Transportation Corridor. During fall-staging in 1995, Brant again used coastal areas of the delta, although 150 Brant also were seen in the Development Area. Brant had a preference for coastal habitats during both nesting and brood-rearing. During nesting, Brant preferred Brackish Water, Aquatic Sedge with Deep Polygons, Salt Marsh, Salt-killed Tundra, and Nonpatterned Wet Meadow. During brood-rearing, only two of these habitats were preferred: Brackish Water and Salt Marsh.

Other Waterbirds—Other species of waterbirds that were recorded opportunistically on aerial surveys included Greater White-fronted, Snow, and Canada geese, Northern Pintails, Greater Scaup, Oldsquaws, American Wigeons and Pacific and Red-throated loons. In 1995, we found nine Greater White-fronted Goose nests (1.5 nest/km^2) in the Facility Area, the only area that was intensively searched. On brood-rearing surveys of the delta, we counted 1,234–1,347 of these geese, most of which were on the Outer Delta. One Snow Goose nest was found in 1995, and 12 adults were seen during brood-rearing surveys. Canada Geese were seen on the delta only during fall-staging, when 848 were on the Outer Delta and 75 were in the Development Area. Two species of ducks were observed nesting in the Facility Area: four nests belonged to Oldsquaws and two nests belonged to Northern Pintails. On brood-rearing surveys of the delta for other waterfowl, we incidentally counted 115 Greater Scaup, 30 Oldsquaws, 161 Northern Pintails, and 85 American Wigeons. During fall-staging in 1995, we also saw large numbers of Northern Pintails (540) and Greater Scaup (600). Although both Pacific and Red-throated loons were probably undercounted on our surveys, which were designed to count the more obvious Yellow-billed Loon, both were abundant on the delta during the nesting and brood-rearing seasons. Pacific Loons also were abundant in the Transportation Corridor, whereas Red-throated Loons occurred in small numbers (<10). In 1995 in the Facility Area, we found one Pacific Loon nest and two Red-throated Loon nests. However, during brood-rearing, six broods of Pacific Loons and none of Red-throated Loons were counted in the Facility Area.

Caribou—During calving, the Colville Delta is used by small numbers of caribou, compared to the large numbers found east and south of the delta. During 1995, we estimated 0.03 caribou/km^2 were on the delta during calving, whereas 1.5 caribou/km^2 were estimated in the survey area east of the delta, which included the transportation corridor. South of the Kuparuk Oilfield, we estimated a density of 5.1 caribou/km^2, which was the highest density recorded in any survey area in our three years of surveys. On the mid-June calving survey, we estimated that 4,826 caribou or 27% of Central Arctic Herd were in the vicinity of the delta and Transportation Corridor. The distribution of caribou during calving was similar to that in 1993; the highest densities were found south and west of the Kuparuk Oilfield and east of the Colville River. Calf percentages were low in 1995; only 17% of the total caribou were calves compared to 28–42% of the total caribou from 1978 to 1990. Caribou use the delta annually for insect-relief habitat, especially during July. The onset of mosquito activity was earlier than normal in 1995, causing caribou to move toward the coast through the Transportation Corridor in late June; approximately 3,000 caribou

were observed in the western portion of the Kuparuk Oilfield, and these caribou probably traversed a portion of the corridor. Caribou moved southwesterly into the Transportation Corridor and Development Area from 18–23 July; over 1,000 caribou were recorded with approximately half occurring in the Development Area on some of these days. After 23 July, the number of caribou in the survey areas declined to insignificant numbers as the activity of insects diminished.

Foxes—Both arctic and red fox dens were examined for activity in 1995. Forty den sites were identified, of which 18 were on the delta, 10 were in the Transportation Corridor, and 12 were north or south of the corridor outside the study area. Four active dens, all on the delta, belonged to red foxes. Of 34 arctic fox dens examined, 9 (26%) were natal dens, 4 (12%) were secondary dens (used by families after birth), and 21 (62%) were inactive. Fifty percent of the arctic fox dens on the delta were active, 40% of the dens in the Transportation Corridor were active, and 25% of the dens outside the study area were active. The density of arctic fox dens (active and inactive) on the delta (1 den/39.4 km^2) was slightly lower than in the Transportation Corridor (1 den/34.3 km^2); both densities are nearly the same as densities in published accounts of the Colville area and between the higher density in developed areas and lower density in undeveloped areas of Prudhoe Bay. Foxes preferred elevated and well-drained microsites in Riverine or Upland Shrub and Moist Sedge-Shrub Meadow for denning habitat.

Polar Bears—Sporadic records of polar bear dens in the vicinity of the Colville Delta indicate that these bears den occasionally on land and on sea ice near the delta; the most recent den was located in the winter of 1991–1992. Polar bears that den in terrestrial areas select den sites where snow drifts accumulate, such as areas of vertical relief along rivers, streams, and lakes.

Grizzly Bears—In 1995, two sightings of grizzly bears occurred on the delta, eight in the Transportation Corridor, and six south or east of the corridor. Grizzly bears were seen five times in 1993 and once in 1992. ADFG estimates that at least 28 bears occupy the area (~17,400 km^2) between the Colville River in the west and the Shaviovik River in the east. Fourteen bear dens have been located by ADFG between the Colville River and the Kuparuk Oilfield, one of which was found in the Transportation Corridor.

Muskoxen—Muskoxen were introduced to the Arctic National Wildlife Refuge in 1969 after extirpation in the late 1800s, and that introduced population probably has spread to the low hills south of the Kuparuk Oilfield. The number of muskoxen sighted in the Colville–Kuparuk area has increased in recent years. On 5 June 1995, we counted 61 muskoxen, of which 7 were calves, in the uplands east of the Itkillik River. In July, we saw a group of 30 muskoxen with 9 calves. During summer, some groups of muskoxen move to the junction of the Itkillik and Colville rivers and occasionally further downstream. In winter, muskoxen use upland habitats near bluffs and ridges where the snow cover is thin and soft. Although we have not flown surveys during winter, we suspect that this muskox population seeks such areas in the uplands east of the Itkillik River.

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INTRODUCTION

The Colville River Delta (hereafter, Colville Delta or the delta) is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. The Colville Delta also has attracted two permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family homestead, both of which rely heavily on these fish and wildlife resources. Although oil exploration on the delta has been occurring periodically for several decades, only recently have plans to commercially develop the area proceeded beyond the exploration phase. ARCO Alaska, Inc. (hereafter, ARCO) and the Kuukpik Unit Owners currently are formulating plans for the Alpine Development Project on the central delta. As part of this planning process, and in recognition of the regional and local importance of the Colville Delta to a variety of interested parties, ARCO initiated a number of studies in 1992 to examine the biological, physical, and cultural resources of the delta. In this 1995 annual report, we present the results of our fourth year of study of the wildlife resources of the Colville Delta.

The Colville River drains a watershed of ~53,000 km^2, which encompasses ~29% of the Arctic Coastal Plain of Alaska (Walker 1976). The high-volume flow and heavy sediment load of the Colville River create a large (551 km^2), dynamic deltaic system in which geomorphological and biological processes have created a diversity of habitats, lakes, and wetlands that support a wide array of wildlife. The delta is known to be a regionally important nesting area for Yellow-billed Loons (*Gavia adamsii*), Tundra Swans (*Cygnus columbianus*), Brant (*Branta bernicla*), and Spectacled Eiders (*Somateria fischeri*) (Rothe et al. 1983, North et al. 1984, Meehan and Jennings 1988). The delta also provides breeding habitat for passerines, gulls, and predatory birds such as jaegers and owls. In spring, the delta provides some of the earliest open water and snow-free areas for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for staging. In addition to use by birds, the delta is used seasonally by caribou (*Rangifer tarandus*) for insect-relief habitat and by arctic (*Alopex lagopus*) and red (*Vulpes vulpes*) foxes for denning habitat. In recent times, the delta and adjacent areas have been visited increasingly by muskoxen (*Ovibos moschatus*) and brown bears (*Ursus arctos*), and the delta occasionally is used for denning by polar bears (*Ursus maritimus*).

Although the exact boundaries of study areas and the list of focal species examined by these studies varied over the four years (as better information on the location of oil reservoirs evolved), the primary goal of these studies has been to collect data on the distribution and abundance of selected species to be used as a baseline for conditions on the delta prior to oil development. During a meeting with the U.S. Fish and Wildlife Service (USFWS) in the spring of 1992, we agreed to focus our studies on particular species primarily based on the following criteria: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, and/or 3) special concern of regulatory agencies. Accordingly in 1992, Yellow-billed Loons, Tundra Swans, Brant, Spectacled Eiders, caribou, and arctic foxes were studied primarily in six study plots, of which three were on the delta and three were on the Kachemach and Miluveach rivers east of the Colville River (Smith et al. 1993). Species that were not the focus of surveys that year but were monitored opportunistically included Red-throated Loons (*Gavia stellata*), Pacific Loons (*G. pacifica*), Greater White-fronted Geese (*Anser albifrons*), King Eiders (*Somateria spectabilis*), muskoxen, and red foxes. In 1993, we studied the same focal species but surveyed the entire delta and that part of the coastal plain east of the Colville River to approximately Kalubik Creek (Smith et al. 1994). In 1994, the study was greatly reduced in scope, so we only surveyed the delta for eiders (Johnson 1995).

In spring 1995, ARCO developed preliminary plans for oil production facilities on the Colville Delta, so we expanded our studies to monitor the distribution, abundance, and habitat use of the same suite of species investigated in 1992 and 1993. The overall goal of the 1995 studies was to investigate the use of the Colville Delta and adjacent areas by selected birds and mammals between late spring (May) and early fall (September). Our specific objectives were to:

1. map and classify the important wildlife habitats in the study area;

2. monitor the distribution, abundance, and habitat use of selected waterbird species during the pre-nesting, nesting, brood-rearing, and fall-staging seasons;

3. monitor the distribution and abundance of caribou during the calving and post-calving seasons;

4. locate fox dens and describe their habitat associations; and

5. monitor the distribution of other large mammals in the study area.

STUDY AREA

The geographic extent of the wildlife investigations has varied among years due to changes in exploration plans and potential development scenarios. In 1992, ARCO identified several possible drill sites for oil exploration on and east of the Colville Delta. The boundaries of the wildlife study area in 1992 included these proposed drill sites and extended from Kalubik Creek on the east to the Nechelik (western) Channel of the Colville River on the west; thus, it included the entire delta and a large area of adjacent coastal plain (Smith et al. 1993). Intensive surveys for a variety of bird species were conducted that year on six plots ranging from 46 to 61 km^2. In 1993, the locations proposed for drilling were expanded to include additional areas not included in the 1992 study area. As a result, the study area boundaries were extended in 1993 to include a 1,120-km^2 block of the Kuparuk Uplands that adjoined the southeastern portion of the 1992 study area and a 210-km^2 area that included the mouth of the Itkillik River (Smith et al. 1994). In 1994, a 478-km^2 area consisting of just the delta was surveyed for eiders only (Johnson 1995). In 1995, ARCO proposed specific sites for potential facilities and infrastructure, so the wildlife study area was defined to include those proposed sites, while continuing to survey the entire delta for evaluating regional distributions of wildlife.

The 1995 study area comprised several contiguous areas that were used to describe the distribution of wildlife. As used in this report, the Colville Delta comprises 551 km^2 in area and refers to that zone between the westernmost and easternmost distributary channels of the Colville River (Figure 1). The potential development scenario initially evaluated by ARCO included a gravel airstrip and two gravel pads (one for a drill site and one for a drill site/processing facility) connected by a gravel road. A transportation pipeline to Kuparuk would connect this development to existing infrastructure. Although one development alternative included a road from Kuparuk to the delta (Figure 1), the road to the development is not the preferred option. The entire area within 1,000 m of the airstrip and the drill site/processing facility, and within 200 m of the drill site and the connecting road is called the Facility Area (14 km^2 total). Because ongoing exploration will refine the location of oil reserves and the feasibility of their extraction, and because social, environmental, and economic concerns will affect the location of surface development, the facility arrangement depicted in this report undoubtedly will be modified. The Alpine Development Area (hereafter, Development Area; 169 km^2) includes both the Facility Area and that part of the delta between the Nechelik and East (main) channels to ~2 km north of the proposed airstrip. The Outer Delta (352 km^2) is that portion of the delta north of the Development Area. Finally, the Western Delta (31 km^2) is the area west of the Nechelik Channel and bounded by a high-water distributary. Between the Colville River and the westernmost drill site in the Kuparuk Oilfield (DS-2M) lies the proposed Transportation Corridor (343 km^2), so called because it includes the proposed pipeline routes.

The Colville River has two main distributaries: the Nechelik Channel and the East Channel. These two channels together carry about 90% of the water passing through the delta during spring floods and 99% of the water after those floods subside (Walker 1983). Several smaller distributaries branch from the East Channel, including the Sakoonang, Tamayayak, and Elaktoveach channels. In addition to river channels, the delta is characterized by

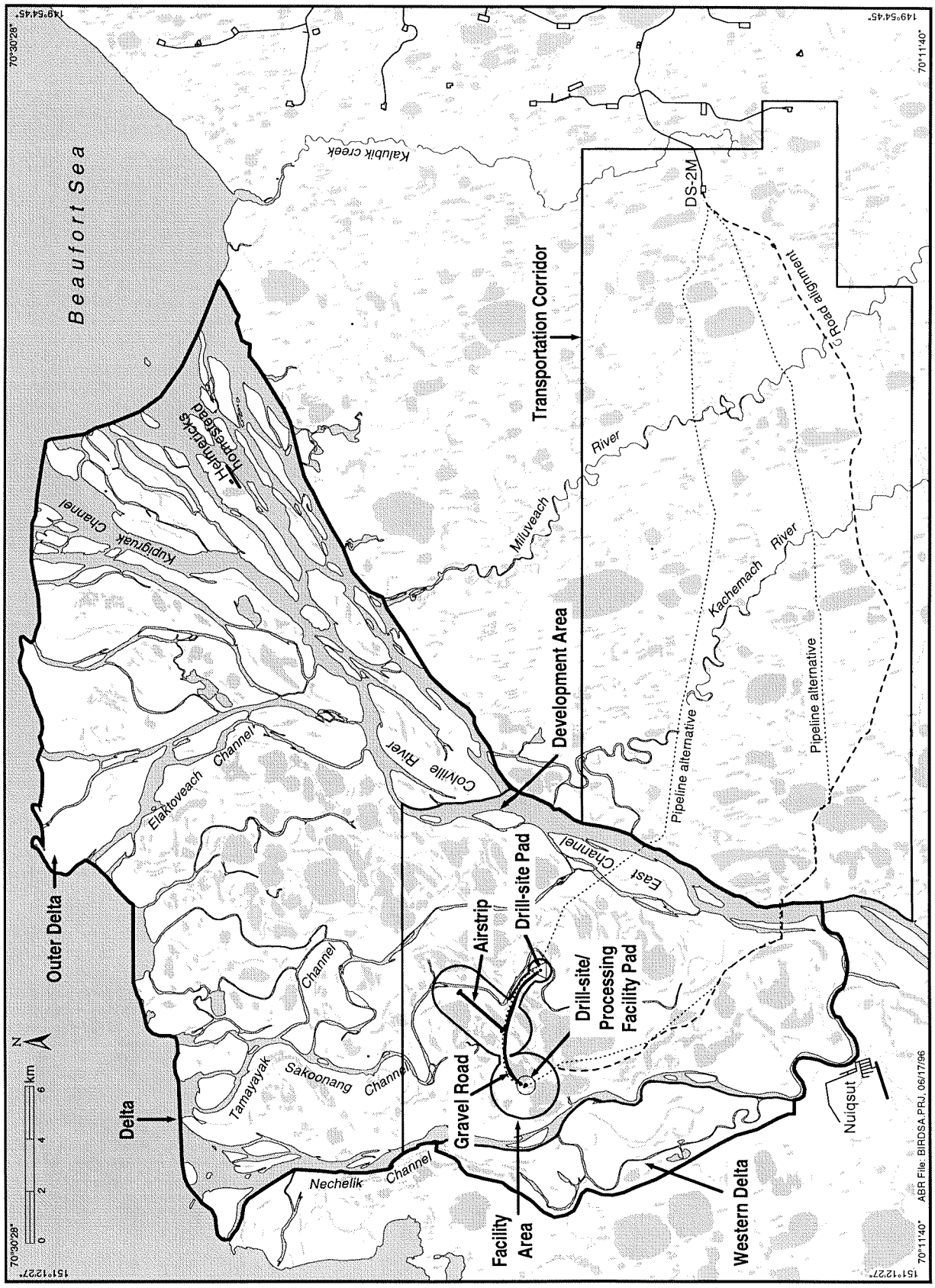


Figure 1. Study area boundaries for the wildlife studies on the Colville River Delta and proposed Transportation Corridor, Alaska, 1995.

numerous lakes and ponds, sandbars, mudflats, sand dunes, and low- and high-centered polygons (Walker 1983).

The East Channel is deep and flows under ice during winter, whereas the Nechelik and other channels are shallow and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta, with the depth of the river at freeze-up being the main factor determining the inland extent of this intrusion (Walker 1983). The Colville River flows through continuous permafrost for its entire length. This presence of continuous permafrost, combined with freezing of the upper layer of surface water in winter, influences the volume, timing, and character of river flow and erosion within the delta (Walker 1983).

Uplands reaching 50 m in elevation dominate the southeastern portions of the Transportation Corridor. These uplands gradually descend northward into flat, low-lying terrain typical of the Arctic Coastal Plain. The landforms and vegetation of this region have been described in detail by Walker et al. (1980).

The study area has an arctic maritime climate. Winters last about 8 months and are cold and windy. Summers are cool, with temperatures ranging from -10° C in mid-May to +15° C in July and August (North 1986). Summer weather is characterized by low precipitation, overcast skies, fog, and persistent winds, which come predominantly from the northeast. The rarer westerly winds usually bring storms that often are accompanied by high, wind-driven tides and rain (Walker and Morgan 1964).

Spring is brief, lasting only ~3 weeks in late May and early June, and is characterized by the flooding and breakup of the river. In late May, water from melting snow flows both over and under the river ice, resulting in flooding that peaks during late May or the first week of June (Walker 1983). Breakup of the river ice usually occurs when flood waters are at maximal levels. Water levels subsequently decrease in the delta throughout the summer, with the lowest water levels occurring in late summer and fall, just before freeze-up (Walker 1983).

Lakes and ponds are dominant physical features of the Colville Delta. Most of the waterbodies are shallow (e. g., polygon ponds ≤2 m deep), so they freeze to the bottom in winter but thaw by June. Deep ponds (>2 m deep) with steep, vertical sides are found on the delta but are uncommon elsewhere on the Arctic Coastal Plain. Lakes >5 ha in size are common and cover 16% of the delta's surface (Walker 1978). Some of these lakes are deep (to 10 m) and freeze only in the upper 2 m; ice remains on these lakes until the first half of July (Walker 1978). Several other types of lakes occur in the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes (Walker 1983).

Many of the lakes in the delta are "tapped" (Walker 1978), in that they are connected to the river by narrow channels. These channels are caused by thermokarst decay of ice wedges between the river and adjacent lakes and by the migration of river channels (Walker 1978). Water levels in these tapped lakes fluctuate more dramatically than those in untapped lakes. River sediments raise the bottom of these lakes near the channel, exposing previously submerged areas. Because tapped lakes and river channels are the first areas of the delta to become flooded in spring, they constitute important staging habitat for migrating waterfowl in that season (Rothe et al. 1983).

METHODS

In 1995, wildlife and habitat studies were conducted to assess the distribution, abundance, and habitat use of various species of wildlife on the Colville Delta and in the adjacent Transportation Corridor. Habitat studies included habitat classification and mapping of the Colville Delta and Transportation Corridor and analyses of habitat selection by a subset of wildlife species. The general methodology for the habitat-selection analyses are discussed in the following section; species-specific methods are discussed in subsections for each species.

HABITAT CLASSIFICATION AND MAPPING

The development of a wildlife habitat classification was a three-step process: 1) field

surveys of vegetation-soil-hydrology relationships were conducted, 2) an ecological land classification (ELC) was developed, delineating terrain units, surface-forms, and vegetation across the study area, and 3) a reduced set of wildlife habitat classes was derived by combining ELC types. The ELC and habitat classifications in 1995 built upon the land classification effort initiated in 1992 (Jorgenson et al. 1993).

FIELD METHODS

Two types of field surveys were conducted during 28 July to 16 August 1995: 1) 11 transects (~1 km long) were sampled to represent topographic sequences and 2) 20 point locations were sampled in ecosystems underrepresented in transects and to establish ground reference points for mapping purposes (Appendix Figure A1). Topographic relief was measured at frequent intervals along each transect and 6–9 sampling sites were placed systematically along each transect to represent bands of distinct plant communities, topographic sequences, or edaphic conditions. At each sampling site (both transect and spot checks), measurements or descriptions were recorded of the topography, soil stratigraphy, hydrology, and vegetation. Quantitative sampling of plant cover was conducted only on transect sampling sites; qualitative descriptions of plant cover were made at spot checks.

Changes in topography along transects were determined by periodic measurements of elevation. Elevations were obtained by differential leveling using an autolevel and stadia rod. Measurements were taken at all major breaks in slope (mesosite variation) and periodically at low and high microsites (e.g., polygon centers and rims; microsite variation). Surveys were referenced to a geodetic control network established for the hydrologic monitoring (Jorgenson et al. 1996) to provide elevations above mean sea level.

Near-surface soil stratigraphy was described from a soil core or soil pit at each sampling site (transects and spot checks). Most soil profiles were limited to the active (thawed) layer (~50–100 cm) and these samples were obtained from soil plugs dug with a shovel. Deeper soil cores (up to 2.5 m deep) were obtained from 19 sites using a 7.5-cm diameter SIPRE corer with a portable power head. Several additional profiles were described from cutbanks after unfrozen material was removed with a shovel to expose undisturbed frozen sediments. Descriptions for each profile included the texture of each horizon, the depth of organic matter, depth of thaw, and ice volume and structure. In the field, soil texture was classified according to the Soil Conservation Service system (Soil Survey Division Staff 1993). Cryogenic structure (forms, distribution, and volumes of ice) was classified in the field according to Russian (Katasonov 1969) and North American systems (Philanen and Johnston 1963), but were reclassified following Murton and French (1994) after review of field descriptions and examination of close-up photography.

Hydrologic measurements at each sampling site included water-surface elevation (transect plots only), depth of water relative to ground surface, pH, and electrical conductivity (EC). Water-surface elevations were obtained during differential leveling, described above. Water depths were measured with a ruler. Water pH and EC were measured with portable meters that were calibrated daily.

At each sampling site on transects, percent cover by plant species was determined using the point-intercept method (Mueller-Dombois and Ellenberg 1974). A 50-m long vegetation sampling transect was oriented approximately perpendicular to the elevation transect; the functional criteria for placement of the vegetation sampling transect was that it be entirely contained within a single terrain unit, surface form, and vegetation type. At 1-m intervals, the plant species (or other ground cover) present was determined by aligning the cross-hairs on a sighting tube or by sighting along a meter tape (n = 50 points per vegetation transect). If more than one layer of plants overlapped at a point, each occurrence was recorded, thereby generating a repetitive cover index that could exceed 100%. Bare soil was recorded only when litter was absent. Similarly, litter was recorded only when vegetation was absent and only the first occurrence of litter was recorded even if there were multiple layers of litter. At spot-check sampling sites, percent cover of dominant plant species was estimated visually. At all sampling locations (transect and spot checks) a summary list was compiled of all plant species observed (whether or not they were sampled by the point-intercept method). Taxonomic nomenclature

followed Hultén (1968) for vascular plants, Crum and Anderson (1981) for bryophytes, and Thomson (1984) for lichens. Identification of mosses and lichens during field sampling was limited to a few species, however, due to difficulty in consistent identification during point sampling. Voucher specimens were collected for all taxa identified and are archived at ABR.

Data from the transect and spot check sampling sites were tabulated to aid in classification of sites and to provide ground reference data for mapping. Quantitative analyses of ecological relationships between vegetation and pedologic and hydrologic characteristics are scheduled to be done after additional data are collected in 1996.

ECOLOGICAL LAND CLASSIFICATION AND MAPPING

The ELC classified ecosystems based on three components: terrain unit (surficial geology and waterbody type), microtopographic surface-form (related to ice content), and vegetation type, each using a standard classification system developed for Alaska (Appendix Table A1). Use of this three-component system provided terrain information for a variety of studies related to facility design and impact mitigation, such as flood distribution, engineering geology, permafrost, and fish and wildlife habitats. The terrain unit classification system (Appendix Tables A2 and A3) was developed by Kreig and Reger (1982) and has been adopted by the Alaska Division of Geological and Geophysical Surveys for their engineering-geology mapping scheme. This classification system was modified slightly to incorporate surficial geology units in the Transportation Corridor that have been identified by Rawlinson (1993) and our study, and to better differentiate deltaic sediments that are related to flooding regimes. The surface-form classification (Appendix Table A4) was based on the scheme developed by Washburn (1973), but was modified to include surface forms described by Everett (1980) and the National Wetlands Group (1988). Vegetation was classified using the Alaska Vegetation Classification system developed by Viereck et al. (1992) that includes information from Walker and Acevedo (1987) and was modified to include additional salt-affected classes (Appendix Table A5).

The classification, mapping, and mensuration involved the following steps. Ecological land classes were delineated on acetate overlays of 1:18,000-scale color-infrared (CIR) or true-color photographs (8 July 1992 and 5 July 1983, respectively). CIR coverage was not available for the entire study area. Photographs were obtained from AeroMap, Inc., Anchorage, AK. The minimal mapping size for polygons was 0.25 ha for waterbodies, 2.0 ha for wetland complexes, and 0.5 ha for other classes. A mirror stereoscope was used for photo-interpretation. Acetates then were digitized and encoded with Atlas GIS software (Strategic Mapping, Inc., Santa Clara, CA). To control accuracy, photos and acetates were registered to UTM coordinates of prominent features (control points, typically waterbody shorelines or shoreline features) identified on a controlled base map developed from SPOT imagery. The digitized map of each photo was geometrically rectified by performing a three-point transformation ("rubber-sheeting") to match control point UTMs and, thus, to compensate for distortion caused by camera tilt. After rectification, features on adjacent photos were joined to create a seamless map of the entire area. Area measurements for each polygon were obtained with the GIS.

DERIVATION OF WILDLIFE HABITATS

The habitat classification was based on landscape properties we considered most important to wildlife: shelter, security (or escape), and food. These factors may be directly related to the quantity and quality of vegetation, plant species composition, surface form, soils, hydrology, and/or microclimate. We emphasize here that wildlife habitats are not equivalent to vegetation types. In some cases, dissimilar vegetation types may be combined because selected wildlife species either do not distinguish between them or use them similarly. Conversely, wildlife may distinguish between habitats with similar vegetation on the basis of relief, soil characteristics, associated invertebrate fauna, or other factors not reflected in plant species-composition. We also emphasize that wildlife habitat classifications for the same region may differ, depending on the wildlife species or species-groups being considered. A comparison of habitat classifications previously used in this region

(Appendix Table A8) illustrates some of the differences among various systems. In our study, we concentrated on breeding waterbirds and their use of waterbody and wet and moist tundra types and on mammals and upland birds that use shrublands and dry tundra types.

We collapsed 195 ELC class combinations into an initial set of 49 wildlife habitat types from a hierarchical classification of wildlife habitats (Table 1) that has been used in several bird-habitat studies in the nearby Prudhoe and Kuparuk oilfields (Murphy et al. 1989, Johnson et al. 1990, Anderson et al. 1991, Murphy and Anderson 1993). Several new habitat types (e.g., Aquatic Sedge with Deep Polygons, Deep Open Water with Polygonized Margins, and various Tapped Lake classes) were added to the original system to recognize habitats unique to the Colville Delta region. The initial 49 wildlife habitat types were further reduced by eliminating types with very small areas (<0.5% of the area) that had low levels of wildlife use and by combining similar types with apparently similar levels of use. The combining of habitat types was subjective and incorporated information from previous wildlife investigations in the region (Bergman et al. 1977, Kessel 1979, Martin and Moitoret 1981, Seaman et al. 1981, Troy et al. 1983, Spindler et al. 1984, Meehan 1986, Nickles et al. 1987, Meehan and Jennings 1988, Murphy et al. 1989, Murphy and Anderson 1993) and our knowledge of factors important to the wildlife species under consideration.

HABITAT SELECTION

To assess the importance of various habitats to wildlife on the Colville Delta, habitat selection was evaluated in a detailed analysis conducted for selected wildlife species. Quantitative analyses of habitat selection by these species were based on the locations of nests and individual birds and on fox dens observed during aerial and ground surveys. Habitat use was calculated for applicable combinations of season (pre-nesting and brood-rearing for eiders; nesting and brood-rearing for Tundra Swans, Brant, and Yellow-billed Loons), year of survey (different combinations depending on the species), and area surveyed (Delta survey area or Transportation Corridor). For each combination, we calculated:

1. percent use of each habitat;
2. percent availability of each habitat;
3. numbers of adults, nests, young, or dens for each habitat;
4. selection index; and
5. rank order of selection.

Percent use was calculated as the percentage of the total number of groups of birds, nests, nest colony locations, broods, or dens, as appropriate to the species and season, that were observed in each habitat. For Brant colonies and fox dens, both of which are fairly static in location, the total accumulated number of locations was used in the analyses. For all other species, the parameters were calculated for each year surveyed. The percent availability of each habitat was the percentage of that habitat in the total area surveyed. Except where noted, all habitats were considered available within a survey area. The availability of habitats often differed among species and among years and seasons, because the survey areas differed. We used Ivlev's E ([% use – % availability] / [% use + % availability]; Ivlev 1961) for the selection index because it calculates a selection ratio bounded between -1 and 1, with 0 indicating that percent use equaled percent availability. We calculated the multi-year selection ratios by first pooling the data for each year under consideration, then recalculating Ivlev's E with those pooled data. Separate analyses were calculated for the Delta and Transportation Corridor areas for all species except Yellow-billed Loons and Brant, which did not have adequate sample sizes in the Transportation Corridor for analysis. In addition to calculating habitat use and selection, we measured the distance (on a digital map) from each location to the nearest waterbody habitat to assess each species' affinity for types of water.

WILDLIFE SURVEYS

For the 1995 wildlife studies, we used a combination of fixed-wing aircraft and helicopters to fly aerial surveys over the Colville Delta and the Transportation Corridor for selected avian and mammalian species. We also conducted a few ground-based surveys in the vicinity of the proposed Facility Area. As in 1992 and 1993, the 1995 avian studies focused on the distribution and abundance of

Table 1. Habitat classification system for the Arctic Coastal Plain of Alaska (modified from Jorgenson et al. 1989).

Class
MARINE WATERS
- Inshore Waters
- Offshore Waters
- Sea Ice

COASTAL ZONE
- Nearshorer Water (Estuarine)
  - Open Nearshorer Water
  - Brackish Ponds
    - Deep
      - without Islands
      - with Islands
      - with Polygonized Margins
    - Shallow
  - Tapped Lakes (Deltas only)
    - Deep
      - Low-water Connection
      - High-water Connection
    - Shallow
      - Low-water Connection
      - High-water Connection
- Coastal Wetland Complex
  - Salt Marsh
    - Halophytic Sedge
    - Halophytic Grass
    - Halophytic Herb
    - Halophytic Dwarf Willow Scrub
- Barren
  - Coastal Islands
  - Coastal Beaches
    - Cobble-gravel
    - Sand
  - Coastal Rocky Shores
    - Low
    - Cliffs
  - Tidal Flats
  - Salt-killed Tundra
  - Causeway

FRESH WATERS
- Open Water
  - Deep Open Lakes
    - Isolated
      - without Islands
      - with Islands
      - with Polygonized Margins
    - Connected
  - Shallow Open Water (Isolated or Connected)
    - without Islands
    - with Islands
    - with Polygonized Margins
- Rivers and Streams
  - Tidal
  - Lower Perennial
  - Upper Perennial
    - Deep pools
    - Shallow
    - Riffles
    - Falls
  - Intermittent
- Water with Emergents (shallow, isolated or connected)
  - Aquatic Sedge
    - without Islands
    - with Islands
    - Deep Polygon Centers
  - Aquatic Grass
    - without Islands
    - with Islands
  - Aquatic Herb
    - without Islands
    - with Islands
- Impoundment
  - Drainage Impoundment
  - Effluent Reservoir

BASIN WETLAND COMPLEXES
- Young (ice-poor)
- Old (ice-rich)

Class
MEADOWS
- Wet Meadows
  - Nonpatterned
    - Sedge (*Carex, Eriophorum*)
    - Sedge-Grass (*Carex, Dupontia*)
  - Low-relief
    - Sedge
  - High-relief (sedge-willow)
    - Sedge
- Moist Meadows
  - Low-relief
    - Sedge-Dwarf Shrub Tundra
    - Tussock Tundra
    - Herb
  - High-relief
    - Sedge-Dwarf Shrub Tundra
    - Tussock Tundra
- Dry Meadows
  - Grass
    - Herb

SHRUBLANDS
- Riverine Shrub
  - Riverine Low Shrub
    - Willow
    - Birch
    - Alder
  - Riverine Dwarf Shrub
    - Dryas
- Upland Shrub
  - Upland Low Shrub
    - Mixed Shrub Tundra
    - Willow
    - Alder
  - Upland Dwarf Shrub
    - Dryas
    - Ericaceous
- Shrubby Bogs
  - Low Shrub Bog
    - Mixed Shrub
  - Dwarf Shrub Bog
    - Ericaceous

PARTIALLY VEGETATED
- Riverine Barrens (including deltas)
  - Barren
  - Partially Vegetated
- Eolian Barrens
  - Barren
  - Partially Vegetated
- Upland Barrens (talus, ridges, etc.)
  - Barren
  - Partially Vegetated
- Lacustrine Barrens (shore bottoms, margins)
  - Barren
  - Partially Vegetated
- Alpine
- Cliffs (rocky)
- Bluffs (unconsolidated)
  - Barren (unstable)
  - Partially Vegetated (stable)
- Burned Areas (barren)

ARTIFICIAL
- Fill
  - Gravel
    - Barren or Partially Vegetated
    - Vegetated
  - Medium-grained
    - Barren or Partially Vegetated
    - Vegetated
  - Sod (organic-mineral)
    - Barren or Partially Vegetated
    - Vegetated
- Excavations
  - Gravel
    - Barren or Partially Vegetated
    - Vegetated
  - Structure and Debris

Spectacled Eiders, Tundra Swans, Yellow-billed Loons, and Brant during different phenological seasons (detailed in the methods for each species). During surveys, we collected additional information on other waterbirds, such as King Eiders, Greater White-fronted, Canada (*Branta canadensis*), and Snow (*Chen caerulescens*) geese, and Pacific and Red-throated loons. Surveys for mammals concentrated on caribou and arctic foxes (as in previous years), but information also was collected opportunistically on other species, such as brown bears and muskoxen. Specific details on surveys and their timing are presented in Table 2.

EIDERS

In 1995, we flew aerial surveys during the pre-nesting and brood-rearing periods and conducted ground-based surveys to search for nests and broods in both the delta and the Transportation Corridor (Table 2). For the pre-nesting survey, we used the same methods as we did in 1994 (Johnson 1995). We flew the pre-nesting survey with two observers (one on each side of the plane) and a pilot. The pilot navigated with a Global Positioning System (GPS) and flew east-west transect lines spaced 400 m apart. Each observer visually searched a 200-m-wide transect, thereby covering 100% of the study areas. When an eider or group of eiders was sighted on the ground, the plane circled the location, and we recorded its coordinates on the GPS. We recorded the locations of eiders on the ground and flying on 1:63,360-scale USGS maps. We used audio tapes to record numbers, species, and sex of eiders; tapes were transcribed after each flight. The locations of flying eiders were digitized manually, whereas the locations of non-flying eiders were transferred electronically from the GPS to a GIS database for mapping and analysis.

The ground-based nest searches were conducted with the same techniques used in 1994; however, the 1995 survey area was restricted to the proposed Development Area and the Transportation Corridor (Figure 1). The four researchers lived in a camp and used boats from Nuiqsut and a helicopter to access remote areas. We searched the Facility Area in its entirety, whereas our searches in the remainder of the Development Area and the Transportation Corridor were limited to locations with records of Spectacled Eider nests or broods from previous years or to locations where Spectacled Eiders had been observed during the 1995 pre-nesting survey. Although we primarily searched for Spectacled Eider nests, we also recorded locations of King Eider, Tundra Swan, goose, loon, or other waterbird nests when they were encountered. For each nest, we recorded the species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, number of eggs in the nest. All nest locations were mapped on copies of 1:18,000-scale color aerial photographs. We added the nest locations of eiders found in 1995 to an existing GIS database containing nest locations identified in 1992–1994.

The 1995 brood-rearing survey for eiders was conducted by two observers in a helicopter. We followed the same transect lines used for the pre-nesting surveys, except that coverage was reduced by 50% (i.e., transect lines now were separated by 800 m) in the Transportation Corridor and on the Outer Delta; the Development Area was surveyed at 100% coverage, however. We recorded the species, numbers of adults and young, and locations of broods on 1:63,360-scale USGS maps and later transferred these data to our GIS database. Two observers also conducted a ground search for eider broods in the vicinity of the Facility Area on 25 and 28 July.

From the data collected during the pre-nesting survey, we calculated the observed number of birds, the observed number of pairs, the indicated number of birds, the indicated number of pairs, and densities (number/km^2) for each study area. Following USFWS (1987b) protocol, the total indicated number of birds was calculated by first multiplying the number of males not in flocks by 2, then adding this product to the number of males in flocks. The indicated number of pairs was the number of males not in flocks. Density estimates were not adjusted with a visibility correction factor (VCF). The VCF developed for use on the Yukon-Kuskokwim Delta currently is under review and is not recommended for surveys conducted on the Arctic Coastal Plain (G. Balogh, USFWS, pers. comm.). Similarly, for the brood-rearing survey, no VCF was used to calculate densities of adults and young.

Habitat selection by Spectacled Eiders was analyzed for group locations during pre-nesting and brood-rearing in the Delta and Transportation

Table 2. Descriptions of wildlife surveys conducted on the Colville River Delta and in adjacent areas, Alaska, 1995.

Species	Survey Type	Season	Dates	Aircraft [a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Area Surveyed
BIRDS								
Eiders	Aerial	Pre-nesting	10, 12 June	C185	0.4	0.4	30–35	Delta
			13–14 June	C185	0.4	0.4	30–35	Transportation Corridor
	Ground	Nesting	21–26 June	-	-	-	-	Portions of Development Area and Transportation Corridor
	Aerial	Brood-rearing	24–26 July	206L	0.4	0.4	30–40	Development Area
			26–27 July	206L	0.4	0.8	30–40	Outer Delta and Transportation Corridor
	Ground	Brood-rearing	25, 28 July	n/a	n/a	n/a	n/a	Facility Area
Tundra Swan	Aerial	Nesting	24–26 June	C185	1.6	1.6	150	Delta and Transportation Corridor
		Brood-rearing	20–22 Aug.	C185	1.6	1.6	150	Delta and Transportation Corridor
		Fall staging	19 Sep.	C207	n/a	n/a	150	Delta and Transportation Corridor
Loons	Aerial	Nesting	27 June	C185	n/a	n/a	30–40	Delta and Transportation Corridor
		Brood-rearing	18–20 Aug.	206L	n/a	n/a	30–70	Delta and Transportation Corridor
	Ground	Brood-rearing	28 July, 20 Aug.	-	-	-	-	Facility Area
Brant	Aerial	Nesting	17 June	C185	n/a	n/a	100–150[b]	Portions of Outer Delta and Development Area
		Brood-rearing	4 Aug.	PA18	n/a	n/a	75	Portion of Outer Delta
		Fall staging	19 Aug.	C185	n/a	n/a	60	Portion of Outer Delta
MAMMALS								
Caribou	Aerial	Calving	3 June	C185	0.8	3.2	90	Colville Delta survey area
			4–5 June	C185	0.8	1.6	90	Colville East survey area
			12–13 June	C185	0.8	1.6	90	Colville East survey area (expanded)
			5 June	C185	0.8	3.2	90	Colville Inland survey area
			13 June	C185	0.8	1.6	90	Kuparuk Inland survey area
		Insect	28 June–27 July	PA18, 206L	1.6	1.6	150	Development Area and Transportation Corridor
Foxes	Aerial	Denning	18 May	PA18	0.8	0.8	90	Development Area
			1–6 July, 17–21 July	206L	n/a	n/a	30–150	Delta and Transportation Corridor

[a] C185 = Cessna 185 airplane; C207 = Cessna 207 airplane; PA18 = Piper "Super Cub" airplane; 206L = Bell "Long Ranger" helicopter.
[b] Colonies were inspected from lower altitudes.
n/a = not applicable.

Corridor survey areas. Locations from aerial surveys in 1993–1995 were used for analysis of selection during the pre-nesting season. The pre-nesting survey in 1993 and portions of the brood-rearing survey in 1995 were flown at 50% coverage; all others were flown at 100%. For the purposes of our analyses, we assumed that the surveys flown at 50% coverage were a representative sample of the available habitat and therefore, were equivalent (after doubling the number of groups and individuals) to surveys with complete coverage. Habitat selection by broods could be calculated only for 1995, which was the only year that aerial surveys were flown during brood-rearing. For all other seasons when surveys were inadequate to calculate habitat availability (e.g., nesting, when ground-based searches were done only in selected areas), we summarized the percent use of each habitat.

TUNDRA SWANS

We flew the 1995 aerial surveys of Tundra Swans on the Colville Delta and in the Transportation Corridor (Figure 1) in accordance with protocols established by the USFWS (USFWS 1987a, 1991). Single surveys were flown during the nesting, brood-rearing, and fall-staging seasons. Survey dates, aircraft types, and other survey information are presented in Table 2.

During the nesting and brood-rearing surveys, we flew east-west transects spaced at 1.6-km intervals. The two observers (one on each side of the plane) each visually searched 800-m-wide strips while the pilot navigated and scanned for swans ahead of the aircraft. Locations and counts of swans were marked on 1:63,360-scale USGS maps. Nest locations were recorded with a GPS system and photographed with a 35-mm camera for site verification.

The fall-staging survey departed from the standard USFWS protocol, because we flew roughly parallel flight lines spaced 2.4–3.5 km apart and oriented northeast-southwest. These flight lines roughly conformed to the orientation of the Colville River and extended from the East Channel to the Nechelik Channel. We diverged from these lines frequently to count swans observed in the distance; we also revisited locations where we had seen swans during previous surveys. In the Transportation Corridor, we flew a meandering lake-to-lake flight path, with the survey effort being directed primarily at the larger waterbodies.

We calculated total numbers of swans, nests, and broods and estimated densities (numbers/km^2) for each variable by survey area and season. On the Colville Delta, aerial surveys were flown in 1992, 1993, and 1995. Additional data on swan use of the Transportation Corridor were available for 1988–1993 from a subset of data collected in the Kuparuk River Unit (see Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993, 1994).

We based estimates of nesting success on the ratio of the number of broods to the number of nests counted during aerial surveys of the Colville Delta. The accuracy of these estimates can be affected by three factors. First, swan broods are less likely to be missed by observers during aerial surveys than are swan nests (see Stickney et al. 1992), which may inflate the calculations of nesting success. Second, some broods probably are lost to predation between hatch and the aerial survey. Third, because swan broods can move large distances and move into or out of the survey area prior to the survey, the estimate of nesting success can be biased low or high. Immigration and emigration of broods are less of a problem for estimating success in large well-defined study areas. Thus, our estimates of nesting success are calculated only for the delta and should be considered a relative index of annual nesting success.

LOONS

We used the same methods for aerial surveys of loons in 1995 as we did in 1992 and 1993 (Smith et al. 1993, 1994), except we used a helicopter during the 1995 brood-rearing survey (Table 2). During nesting and brood-rearing seasons, we flew lake-to-lake while searching lakes approximately 5 ha or larger in size. This 5-ha criterion was used to improve survey efficiency for Yellow-billed Loons, which typically nest on larger lakes. We also recorded locations of Pacific and Red-throated loons on these surveys. Our surveys for these two species were not thorough, however, because we did not search systematically lakes smaller than 5 ha, which often are used by these species for nesting and brood-rearing. In addition to the aerial surveys in 1995, we also conducted two ground-based searches

for broods in the vicinity of the proposed Facility Area.

We calculated the total number of adults, nests, broods, and young by season for all three species of loons in 1995, but estimated density only for Yellow-billed Loons because the aerial surveys were less systematic for the other two species. Multi-year comparisons were made for Yellow-billed Loons; these comparisons were not possible for the other two species because their detectability differed from that of Yellow-billed Loons and because survey intensity varied among years.

Because so few Yellow-billed Loons occurred in the Transportation Corridor, analyses of habitat selection were conducted only for the Colville Delta. We calculated selection indices for nests using data pooled from 1993 and 1995. Analyses of habitat selection by broods used data from 1995 only.

BRANT AND OTHER WATERFOWL

Aerial surveys for Brant were flown during nesting, brood-rearing, and fall staging in 1995 (Table 2). Methods were similar to those used from 1989 to 1994 for surveys of Brant between the Colville and Sagavanirktok rivers (Ritchie et al. 1990, Anderson et al. 1995). The survey area extended up to 15 km inland from the coast on the delta and up to 20 km inland in the Transportation Corridor. Our aerial survey to locate nesting Brant was flown lake-to-lake within a predetermined path that included known colony sites and lakes with numerous islands (i.e., potential colony sites). We recorded a nest where either a down-filled bowl or an adult in incubation posture was observed. Aerial counts of Brant and their nests should be considered conservative estimates, because incubating Brant are inconspicuous, unattended nests are difficult to see, and the number of passes flown over a colony purposely was limited to minimize disturbance.

The brood-rearing survey route followed as closely as possible the shorelines of bays, deltaic islands, and river channels and extended 10.5 km inland. We also revisited nesting areas that were identified as being active during the June aerial survey to investigate their possible use by broods. A similar survey route was flown to locate and count fall-staging Brant, and all areas on the delta used at the time of the brood-rearing survey were revisited.

We calculated 1995 estimates of the number of Brant observed during nesting and brood-rearing and compared those estimates to numbers observed in previous years. The nesting data did not include the Anachlik Colony complex, which is the largest colony on the Arctic Coastal Plain, comprising >900 nests (Bayha et al. 1992). Numbers of brood-rearing birds in the Outer Delta survey area were compared with USFWS estimates from 1988 and 1990–1991 (Bayha et al. 1992).

Because the aerial surveys for Brant covered a subset of the Outer Delta survey area, analyses of habitat availability and use were calculated only for the area surveyed. In addition, because Brant are traditional in their selection of nesting sites, habitat selection was calculated on the total accumulated number of nest colony locations observed in 1992, 1993, and 1995, rather than on locations from each year independently. The location of nest colonies was used in the analysis, regardless of the number of nests in each colony although the number of nests also is presented. For the brood-rearing analyses, we used the pooled data for the number of groups observed in 1993 and 1995.

We collected data on other geese and waterfowl secondarily to other survey objectives. During the brood-rearing and fall-staging aerial surveys for Brant, we recorded locations and estimated numbers of Greater White-fronted (both surveys) and Canada geese (fall-staging survey only). In addition, we opportunistically collected information on geese and various ducks during the brood-rearing surveys for eiders, swans, and loons. Data collected during the ground-based nest searches in the Facility Area also were tabulated and nest locations were mapped.

CARIBOU

During the calving season (late May–mid-June), we conducted two aerial surveys of the Colville Delta and the Transportation Corridor, as well as in other areas to the north and south of the Transportation Corridor. The objectives of these surveys were to delineate the distribution and quantify the relative abundance of caribou near the peak and end of the calving season.

We flew calving surveys during 3–5 and 12–13 June 1995 (Table 2). The first survey, which was scheduled to coincide with the expected peak of

calving activity, covered the same three areas surveyed in 1993 (Smith et al. 1994): Colville Delta, Colville East, and Colville Inland (these survey areas are depicted on calving distribution figures in Results and Discussion). The second survey was scheduled near the end of calving, to coincide with the timing of comparable surveys (e.g., by ADFG) in previous years. Based on the distribution of caribou during the first survey, we adjusted the areas for the second survey. The Colville Delta survey area was omitted because caribou had been recorded during the pre-nesting survey for eiders (10 and 12 June); that survey was conducted at a lower altitude and provided complete coverage (therefore constituting a census). The Colville East area was extended to the south another 9.7 km (6 mi) to latitude 70° N (into the northern portion of the Colville Inland survey area). The remainder of the Colville Inland area was dropped from the second survey, and the area south of the Kuparuk Oilfield and north of 70° N (designated as the Kuparuk Inland survey area) was added.

As in previous years (Smith et al. 1993, 1994), we flew aerial surveys of systematically spaced strip transects (Caughley 1977) during the calving season. A pilot and two observers in a fixed-wing aircraft surveyed north–south–oriented transect lines (Table 2). A GPS receiver was the principal means of navigation, supplemented by periodic checks of location and ground elevation on USGS topographic maps.

Transects were spaced at intervals of 1.6 km (1 mi) in the Colville East survey area and at 3.2 km in the Colville Delta and Colville Inland survey areas. Each observer viewed a 400-m-wide strip on his respective side of the aircraft, resulting in 50% coverage of the survey area at 1.6-km spacing of transects and 25% of the survey areas at 3.2-km spacing. The strip width was delimited visually by tape marks on the wing struts and windows of the aircraft (Pennycuick and Western 1972). To maximize the time spent searching, we did not map the exact locations of caribou groups. Instead, we tallied the number of caribou in 3.2-km-long segments of transect lines, delineated along section lines on the topographic maps. Caribou were classified as either "large" animals (adults or yearlings) or as calves.

As an index to survey conditions, snow coverage was estimated visually on portions of each transect. Spring snow melt occurs during the calving season, and the dissected pattern of snow cover greatly reduces an observer's ability to detect caribou (Lawhead and Cameron 1988). Patchy snow cover is the most important factor affecting the sightability ("the probability that an animal within the observer's field of search will be seen by that observer" [Caughley 1974: 923]) of caribou during the calving season. An effective way to adjust counts made during poor viewing conditions is to estimate sightability and calculate a sightability correction factor (SCF) (Gasaway et al. 1986) by conducting double counts using different survey methods. Smith et al. (1994) calculated an SCF by comparing fixed-wing and helicopter counts obtained during conditions of intermediate (20–70%) snow cover. Because our first survey (3–5 June) was conducted under similar conditions, we applied that SCF to our results. Only the counts of large caribou were adjusted, however, because Smith et al. (1994) were unsuccessful in developing an SCF for calves. The SCF was not applied to the counts for 12–13 June because snow cover had disappeared by the time of the second survey and sightability was much higher.

Population numbers for large, calf, and total caribou within the survey areas were estimated from our survey counts with formulas developed by Gasaway et al. (1986). The counts of total and calf caribou from a survey were expanded for the entire survey area to estimate the observable population (i.e., the population for the entire survey area, unadjusted for sightability). In text, the estimates are followed in parentheses by 80% confidence intervals (e.g., an observable population estimate of 70 (±30) means that the 80% confidence interval ranges from 40 to 100). The estimate of the observable population for the first survey was multiplied by the SCF to calculate the adjusted population estimate, which is an estimate of the number of caribou in the entire area surveyed, assuming 100% sightability (see Smith et al. 1994).

We conducted surveys during the insect season (the time of year when mosquitoes and oestrid flies harass caribou) to document the movements and abundance of caribou in the Development Area and Transportation Corridor. Distribution and movements were monitored by an observer stationed

at ARCO's Kuparuk facility from 29 June to 27 July; additional observations were provided by biologists working on other projects. Daily observations recorded weather conditions, levels of insect harassment, and the resulting movements by caribou, which were observed with both ground-based and aerial surveys. Observations from a truck were used to monitor the general movements of caribou in the vicinity of the Kuparuk and Milne Point road system; those observations then were used to optimize scheduling of aerial surveys (by fixed-wing aircraft or helicopter, as dictated by aircraft availability) during different levels of insect harassment.

Aerial surveys consisted of a combination of systematic strip-transect surveys specifically for caribou and opportunistic, nonsystematic reconnaissance observations during the course of other surveys (e.g., for fox dens and waterbird broods). On most of the systematic transect surveys, we used a Super Cub, carrying one observer and the pilot, but one transect survey and the reconnaissance observations were conducted using a helicopter (Table 2). We used 1.6-km-wide, east-west-oriented strip transects (viewing out to 0.8 km on each side of the airplane) to achieve complete coverage of the area. This broad strip was sufficient for detecting larger groups of caribou, but single animals and small groups (<5 animals) probably were undersampled. We recorded locations and numbers of caribou on USGS 1:63,360-scale maps. We also recorded group type (cow/calf-dominated, bull-dominated, mixed sex/age) and, when possible, we determined age and sex composition of groups (bull, cow, yearling, calf, and unknown).

FOXES

We evaluated the distribution and status of arctic and red fox dens on the Colville Delta and Transportation Corridor during both aerial and ground-based surveys. We conducted an aerial survey of the Colville Delta on 18 May 1995 to locate fox dens on the assumption that recently excavated soil would be easy to see against the snow (Smith et al. 1994). This survey followed east-west-oriented transect lines spaced 0.8 km apart (Table 2). The transect strip width was 400 m on each side of the airplane, resulting in complete coverage of the Development Area. During this survey, observations in the Transportation Corridor were limited to checking sites identified in 1992 and 1993 by Smith et al. (1993, 1994); a complete survey was not done. The pilot navigated with a GPS receiver, and the airplane deviated from the transect lines only to circle potential den sites not readily viewed from the survey line. We mapped suspected den sites on topographic maps and recorded the location with a GPS receiver, so that the sites could be relocated later for closer inspection on the ground. In addition to aerial surveys for dens, we recorded on color photocopies of aerial photographs all fox sightings and den locations identified during ground-based surveys for bird nests.

Additional aerial surveys on 1–6 and 17–21 July used a helicopter to search for additional dens along drainages, old lake banks, and mounds and pingos, and to check the status of sites found on the May survey or reported by Smith et al. (1994). The early July survey concentrated on searching for additional dens and rechecking the status of known dens from the air. The survey later in July was devoted to ground visits at as many sites as possible. Using the GPS coordinates recorded earlier, we landed at each den site to determine the status of the site. Ground-based inspections identified the species using the den and evaluated recent evidence of use by foxes. The presence or absence of adult and pup foxes, fresh droppings, fresh digging, tracks, trampled vegetation, shed fur, prey remains, and predator sign (e.g., pup remains) were used to determine den status (Garrott 1980). We classified dens into three categories (following Burgess et al. 1993):

1. natal dens (used to whelp young), which had abundant pup sign from the current year;

2. secondary dens, which contained pup sign from the current year, but in smaller quantities indicating shorter residency later in the season (secondary dens were not used for whelping, but were used by litters moved from natal dens); and

3. inactive dens, which lacked current pup sign but showed evidence of use in previous years (limited use by adults was possible at these sites).

It is not unusual for foxes to move pups from natal dens to secondary dens during the denning season, and repeated observations are needed to be able to classify den status with confidence. Long-term observation of specific sites throughout the denning season was not an objective of this study, however, so classification of den status on the basis of our brief visits is necessarily subjective. For the same reason, it was not possible to obtain counts of pups at all active dens.

Habitat selection analyses for foxes were calculated by using the total accumulated number of den locations (1992, 1993, and 1995) as the measure of habitat use of the area and the total area of all terrestrial (non-water) habitats as the measure of habitat availability; water habitats were omitted because they obviously could not be used for fox dens. No distinction was made between active, inactive, primary, or secondary dens in the selection analysis.

OTHER MAMMALS

Observations of other mammals were recorded opportunistically during aerial and ground surveys for waterbirds, caribou, and fox dens. Additional information on polar and grizzly bears was collected from the literature and from communications with resource agency researchers (S. Amstrup, NBS, Anchorage; R. Shideler, ADFG Habitat Division, Fairbanks) working on the Arctic Coastal Plain.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

The 195 classes (terrain unit, surface-form, vegetation combinations, see Appendix Tables A1–A5) identified by the ecological land classification were reduced to a set of 24 wildlife habitat types for the Delta survey area and Transportation Corridor (Table 3, Figure 2; Appendix Table A6). This aggregation resulted in 12 waterbody, 10 terrestrial, and 2 wetland-complex types. A list of plant taxa found within the habitats is provided in Appendix Table A7.

The large differences in availability of habitats between the Delta survey area and the Transportation Corridor reflected differences in salinity and riverine processes between the two areas (Figure 2, Table 4). In the Delta survey area, the most available habitats were Wet Sedge-Willow with Low-relief Polygons (18.5% of the area), River or Stream (14.8%), Barrens (14.3%), and Tidal Flats (10.1%). Other habitats that were less available but were unique to the Delta survey area included Brackish Waters (1.2%), Tapped Lakes with Low-water Connections (3.9%), Salt Marshes (3.0%), Salt-killed Tundra (4.6%), and Aquatic Sedge with Deep Polygons (2.5%). The most available habitats in the Transportation Corridor were Moist Tussock Tundra (27.6%), Moist Sedge-Shrub Meadow (24.7%), and Deep Open Water without Islands (9.0%).

Because of our interest in reducing the number of habitats to facilitate analysis and presentation, habitats may include some rather dissimilar ecological land classes. For example, the Riverine and Upland Shrub class combined tall willows on the floodplains with *Dryas* tundra on upland ridges, because the *Dryas* tundra covered a very small total area. Similarly, several ELC classes with differing surface-forms were combined into one (e.g., Wet Sedge-Willow with Low-relief Polygons). A cross-reference between our habitat classes and other wildlife habitat classifications that have been used on the Arctic Coastal Plain is presented in Appendix Table A8.

Basin Wetland Complexes were particularly important features of the Transportation Corridor, where they included a variety of moist, wet, and aquatic habitats. In our usage, Basin Wetland Complexes are portions of thaw-lake basins that delineate areas containing a complex mosaic of habitat patches, components of which were below the scale of mappable units (<0.25 ha for waterbody habitat and <0.5 ha for terrestrial habitat). Most habitats within thaw-lake basins, however, were large enough to map as distinct, rather homogenous types (e.g., emergent grass, shallow lakes). Therefore, Basin Wetland Complexes are not strictly equivalent to thaw-lake basins and the areas calculated for Basin Wetland Complexes are only a small portion of the total area covered by thaw-lake basins. Although the total area of thaw-lake basins could be calculated from the ELC terrain unit

Table 3. Descriptions of wildlife habitat types found in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska.

Habitat	Description
Open Nearshore Water (Estuarine Subtidal)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced by winds may raise sea level as much as 2–3 m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. This habitat is important for some species of waterfowl during molting and during spring and fall staging, and for loons while foraging.
Brackish Water	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake (or Pond) with Low-water Connection	Waterbodies that have been partially drained through erosion of banks by adjacent river channels, but which are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shorelines. Deeper lakes in this habitat do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes provide important overwintering habitat for fish.
Tapped Lake (or Pond) with High-water Connection	Similar to preceding type, except that the connecting channels are dry during low water and the lakes are connected only during flooding events. Water tends to be fresh. Small deltaic fans are common near the connecting channels due to deposition during seasonal flooding. These lakes provide important fish habitat.
Salt Marsh	On the Beaufort Sea coast, arctic Salt Marshes generally occur in small, widely dispersed patches, most frequently on fairly stable mudflats associated with river deltas. The surface is flooded irregularly by brackish or marine water during high tides, storm surges, and river-flooding events. Salt Marshes typically include a complex assemblage of small brackish ponds, halophytic sedge and grass wet meadows, halophytic dwarf-willow scrub, and small barren patches. Dominant plant species usually include *Carex subspathacea, C. ursina, Puccinellia phryganodes, Dupontia fisheri, P. andersonii, Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.* Salt Marsh is an important habitat for brood-rearing and molting waterfowl.
Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flats occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flats frequently are associated with lagoons and estuaries and may vary widely in salinity levels. Tidal Flats are considered separately from other barren habitats because of their importance to estuarine and marine invertebrates and shorebirds.
Salt-killed Tundra	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and which are being colonized by salt-tolerant plants. Colonizing plants include *Puccinellia andersonii, Dupontia fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, Stellaria humifusa, Cerastium beeringianum,* and *Salix ovalifolia* This habitat typically occurs either on low-lying areas that formerly supported Wet Sedge-Willow Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that formerly supported Moist Sedge-Shrub Meadows and Upland Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizing plants.
Deep Open Water (Lakes and Ponds) without Islands	Deep (≥1.5 m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes; most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. They do not freeze to the bottom during winter. Lakes usually are not connected to rivers. Sediments are fine-grained silt and clay. Deep Open Waters without Islands are differentiated from those with islands because of the importance of islands to nesting waterbirds.

Table 3. Continued

Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many species of waterbirds.
Shallow Open Water (Lakes and Ponds) without Islands	Ponds and small lakes <1.5 m deep with emergent vegetation covering <5% of the waterbody surface. Due to the shallow depth, water freezes to the bottom during winter and thaws by early to mid-June. Maximal summer temperatures are higher than those in deep water. Although these ponds generally are surrounded by wet and moist tundra, ponds located in barren areas also are included in this category. Sediments are fine-grained silt and clay.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex shorelines characterized by low-center polygons. Distinguished from Shallow Open Water without Islands because shoreline complexity appears to be an important feature of nesting habitat for many species of waterbirds.
River or Stream	Permanently flooded channels of the Colville River and its tributaries and smaller stream channels in the Transportation Corridor. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of the Colville River Delta are slightly saline, whereas streams in the Transportation Corridor are non-saline. During winter unfrozen water in deeper channels can become hypersaline.
Aquatic Sedge Marsh	Permanently flooded waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤0.3 m deep. Water and bottom sediments of this shallow habitat freeze completely during winter, but the ice melts in early June. The sediments generally consist of a peat layer (0.2–0.5 m deep) overlying fine-grained silt.
Aquatic Sedge with Deep Polygons	Primarily a coastal habitat in which thermokarst of ice-rich soil has produced deep (>1 m), permanently flooded polygon centers. Emergent vegetation, mostly *C. aquatilis,* usually is found around the margins of the polygon centers. Occasionally, centers will have the emergent grass *Arctophila fulva*. Polygon rims are moderately well drained and dominated by sedges and dwarf shrubs, including *Dryas integrifolia*, *Salix reticulata, S. phlebophylla,* and *S. ovalifolia.*
Aquatic Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva*. Due to shallow water depths (<1 m), the water freezes to the bottom in the winter, and thaws by early June. *Arctophila* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in the thaw lake cycle and is more productive than Aquatic Sedge Marshes. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (ice-poor)	Basin wetland complexes (both young and old) occur in drained lake basins and are characterized by a complex mosaic of open water, aquatic sedge and grass marshes, and wet and moist meadows in patches too small (<0.5 ha) to map individually. Deeper basins may be entirely inundated during spring breakup. Water levels gradually recede following breakup. Basins often have distinct upland rims marking the location of old shorelines, although boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw-lake stages. Soils generally are fine-grained, organic-rich, and ice-poor in the young type. The lack of ground ice results in poorly developed polygon rims in wetter areas and indistinct edges of waterbodies. Ecological communities within younger basins appear to be much more productive than are those in older basins, which is the reason for differentiating between the two types of basin wetland complexes.
Old Basin Wetland Complex (ice-rich)	Similar to preceding type, but characterized by well-developed low- and high-center polygons resulting from ice-wedge development and aggradation of segregated ice. The waterbodies in old complexes have smoother, more rectangular shorelines and are not as interconnected as in young complexes. The vegetation types generally include Wet Sedge Willow with Low-relief Polygons, Moist Sedge-Shrub Meadows, and Moist Tussock Tundra. Aquatic Sedge and Grass Marshes are absent. Soils generally have a moderately thick (0.2–0.5 m) organic layer overlying fine-grained silt or sandy silt.

Table 3. Continued

Habitat	Description
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strangmoor cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. The uninterrupted movement of water and dissolved nutrients in nonpatterned ground results in more robust growth of sedges than in polygonized habitats. *Carex aquatilis* and *Eriophorum angustifolium* usually dominate, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata, S. arctica,* and *S. planifolia*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying fine-grained silt.
Wet Sedge-Willow Meadow with Low-relief Polygons (High- or Low-density)	Occurs in lowland areas within drained lake basins, level floodplains, and swales on gentle slopes and terraces, associated with low-centered polygons and strangmoor (undulating raised sod ridges). Water depth varies through the season (<0.3 m maximum). Polygon rims and strangmoor interrupt surface and groundwater flow, so only interconnected polygon troughs receive downslope flow and dissolved nutrients; in contrast, the input of water to polygon centers is limited to precipitation. As a result, vegetation growth typically is more robust in polygon troughs than in centers. Vegetation is dominated by the sedges, *Carex aquatilis* and *Eriophorum angustifolium,* although other sedges may be present, including *C. rotundata, C. saxatilis, C. membranacea, C. chordorriza,* and *E. russeolum.* Willows (*Salix lanata, S. arctica,* and *S. planifolia)* usually are abundant.
Moist Sedge-Shrub Meadow (Low- or High-relief Polygons)	Occurs on better-drained uplands between thaw basins, riverbanks, old stabilized dunes, lower slopes of pingos, and foothill slopes, generally associated with nonpatterned ground, frost scars, and high-centered polygons with low relief. Vegetation is dominated by *C. aquatilis, C. bigelowii, E. angustifolium, S. planifolia,* and *Dryas integrifolia.* The ground is covered with a nearly continuous carpet of mosses. Soils generally have a thin layer (20–30 cm) of organic matter over silt loam.
Moist Tussock Tundra	Similar to preceding type, except that the vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum.* This type tends to occur on the upper portions of slopes and in better drained conditions than Moist Sedge-Shrub Tundra.
Riverine or Upland Shrub	Both open and closed stands of low (≤1.5 m high) and tall (>1.5 m high) willows along riverbanks and *Dryas* tundra on upland ridges and stabilized sand dunes. Tall willows occur mainly along larger streams and rivers, where the vegetation is dominated by *Salix alaxensis.* Low willow stands are widespread and typically have a canopy of *S. lanata* and *S. glauca.* Understory plants include the shrubs *Arctostaphylos rubra, S. reticulata,* and *D. integrifolia,* and the forbs *Astragalus* spp., *Lupinus arcticus*, and *Equisetum* spp. *Dryas* tundra is dominated by *D. integrifolia* but may include abundant dwarf willows such as *S. phlebophylla.* Common forbs include *Silene acaulis, Pedicularis lanata,* and *Astragalus umbellatus,* and *C. bigelowii* frequently is present. In Riverine Shrub, an organic horizon generally is absent or buried due to frequent sediment deposition. In Upland Shrub, soils generally have a thin (<5 cm) organic horizon.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas resulting from riverine, eolian, or thaw-lake processes. Riverine Barrens on river flats and bars are flooded seasonally and can have either silty or gravelly sediments. The margins frequently are colonized by *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum,* and *Equisetum arvense.* Eolian Barrens generally are located adjacent to river deltas and include active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical pioneer plants include *Salix alaxensis, Elymus arenarius,* and *Deschamspia caespitosa.* Lacustrine Barrens occur along margins of drained lakes and ponds. These areas may be flooded seasonally or can be well drained. On the delta, sediments usually are clay-rich, slightly saline, and are being colonized by salt-marsh plant species. Barrens may receive intensive use seasonally by caribou as insect-relief habitat.
Artificial (Water, Fill, Peat Road)	A variety of small disturbed areas, including impoundments, gravel fill, and a sewage lagoon at Nuiqsut. Gravel fill is present at Nuiqsut, and at the Helmericks residence near the mouth of the Colville River. A peat road runs roughly north-south within the Transportation Corridor. Two Kuparuk drill sites (2M and 2K) are included, as are several old exploratory drilling pads.

Table 4. Availability of wildlife habitat types in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1995.

	Delta		Transportation Corridor	
Habitat	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Open Nearshore Water (marine)	10.46	1.9	0	0
Brackish Water	6.50	1.2	0	0
Tapped Lake w/ Low-water Connection	21.42	3.9	0	0
Tapped Lake w/ High-water Connection	20.36	3.7	0.10	<0.1
Salt Marsh	16.73	3.0	0	0
Tidal Flat	55.90	10.1	0	0
Salt-killed Tundra	25.63	4.6	0	0
Deep Open Water w/o Islands	23.31	4.2	30.76	9.0
Deep Open Water w/ Islands or Polygonized Margins	5.13	0.9	6.52	1.9
Shallow Open Water w/o Islands	2.32	0.4	10.84	3.2
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0.1	7.36	2.1
River or Stream	81.76	14.8	2.30	0.7
Aquatic Sedge Marsh	0	0	0.97	0.3
Aquatic Sedge w/ Deep Polygons	13.58	2.5	0.03	<0.1
Aquatic Grass Marsh	1.37	0.2	0.65	0.2
Young Basin Wetland Complex	<0.01	<0.1	14.23	4.1
Old Basin Wetland Complex	0.01	<0.1	35.59	10.4
Nonpatterned Wet Meadow	41.98	7.6	24.47	7.1
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	18.5	19.87	5.8
Moist Sedge-Shrub Meadow	13.10	2.4	84.66	24.7
Moist Tussock Tundra	2.49	0.5	94.60	27.6
Riverine or Upland Shrub	27.40	5.0	7.74	2.3
Barrens (riverine, eolian, lacustrine)	79.01	14.3	1.93	0.6
Artificial (water, fill, peat road)	0.02	<0.1	0.47	0.1
Total	551.25		343.11	

classifications (old and young thaw basins plus the surface area of waterbodies within the basins), the larger thaw-basin concept was not used because it involves classifying ecosystems at a different scale and there are a wide variety of stages in thaw-basin evolution that could confound analysis of habitat use.

EIDERS

BACKGROUND

Spectacled Eiders are uncommon nesters (i.e., they occur regularly but are not found in all suitable habitats) on Alaska's Arctic Coastal Plain that tend to concentrate around large river deltas (Johnson and Herter 1989). Spectacled Eiders arrive on the Colville Delta in early June, and the first nests have been found from 8 to 24 June (Simpson et al. 1982, North et al. 1984, Nickles et al. 1987, Gerhardt et al. 1988). Male Spectacled Eiders leave their mates for molting areas when incubation begins (Gabrielson and Lincoln 1959). The latest record of Spectacled Eiders on the Colville Delta is 28 August (Gerhardt et al. 1988).

King Eiders nest in high densities in the Prudhoe Bay area, approximately 65 km east of the Colville River (Derksen et al. 1981, Troy 1988). On the Colville Delta, they are common visitors but uncommon or rare nesters (Simpson et al. 1982, North et al. 1984). King Eiders are seen frequently in flocks on open channels and waterbodies in early June, when Spectacled Eiders already have

dispersed to nesting habitats (Johnson 1995); thus, King Eiders possibly arrive on the delta slightly later and/or they use the delta as a resting area before moving to nesting areas farther east.

Common Eiders are rare on the Colville Delta (Simpson et al. 1982, Renken et al. 1983, North et al. 1984), and recent records of Steller's Eiders east of Point Barrow are scant (Johnson and Herter 1989). Five Steller's Eiders were seen on the delta on 10 June 1995, but they were not relocated on subsequent visits (J. Bart, Ohio State University, pers. comm.).

DISTRIBUTION AND ABUNDANCE

Pre-nesting

The distribution of both Spectacled and King eiders was similar to that recorded on surveys flown in 1993 and 1994, and to the sightings made on smaller study plots in 1992 (Smith et al. 1993; Figures 3 and 4). Spectacled Eiders were more numerous in the Delta survey area than in the Transportation Corridor, whereas King Eiders were more numerous in the Transportation Corridor. Only one pair of Common Eiders was observed in three years of aerial surveys; that pair was seen in 1992 on the coastline of the delta.

During pre-nesting surveys, we found higher percentages of single birds or pairs for Spectacled Eiders than King Eiders. On aerial surveys in 1995, we counted 115 groups of eiders. Thirty groups contained Spectacled Eiders, and 22 (73%) of these consisted of single birds or pairs. King Eiders comprised 76 groups, of which 41 (54%) were single birds or pairs.

Delta—Spectacled Eiders were strongly associated with the coast in all years (Figure 3). During pre-nesting in 1995, Spectacled Eiders were not found farther inland on the Colville Delta than 11.5 km south of the coast; the average distance was 4.8 km. From 1992 to 1994, the farthest inland pre-nesting Spectacled Eiders were seen was 14 km. King Eiders had a similar affinity for the coast; the maximal distance a group was found from the coast between 1992 and 1995 was 14 km, and the average was 4.9 km (Figure 4).

Spectacled Eiders were the dominant eider species (numerically) on the delta, where we counted 61 Spectacled Eiders (55%), 34 King Eiders (31%), and 15 (14%) eiders that were unidentified (Table 5). The relative species composition on the delta was similar in 1994, when Spectacled Eiders comprised 56% of the eiders observed (Johnson 1995). In 1993, however, they composed only 44% of all eiders (Smith et al. 1994).

Densities of Spectacled Eiders were similar among the three years in which surveys were conducted over the majority of the delta. In 1995, the uncorrected density (i.e., raw counts of birds that were uncorrected for sightability) of flying and non-flying Spectacled Eiders on the Delta survey area was 0.11 birds/km^2 (Table 5). Because of changes in study area boundaries over the years, that density is not strictly comparable to the densities reported for 1994 and 1993 (Johnson 1995 and Smith et al. 1994, respectively). Recalculating these densities to an area surveyed in 1994 (478 km^2) that was common to all three years of study resulted in estimated densities of 0.13–0.17 birds/km^2 (Table 6). In contrast, densities of King Eiders on that common survey area declined from 0.14 to 0.07 birds/km^2 from 1993 to 1995.

Neither the Development Area or Facility Area appears to be important to breeding eiders (Figures 3 and 4). During pre-nesting surveys in 1995, we saw one pair of Spectacled Eiders (Table 6) and one pair of unidentified eiders in the Development Area and no eiders in the Facility Area. In 1994, four Spectacled Eiders and one King Eider were counted in what is now the Development Area; only the King Eider, which was flying, occurred in what is now the Facility Area. During 1993, two pairs of Spectacled Eiders, five King Eiders, and one unidentified female eider were seen in the Development Area; of these, only one pair of Spectacled Eiders was located in the Facility Area.

Over the entire delta, the Outer Delta contained the highest density of Spectacled and King eiders (Table 6). In 1995, the density of Spectacled Eiders was slightly lower than that in 1994, but about the same as that in 1993. The density of King Eiders was lower than that of Spectacled Eiders in both 1995 and 1994, but in 1993, the densities of the two species were about the same.

Overall, the distribution, abundance, and relative species composition of eiders was consistent

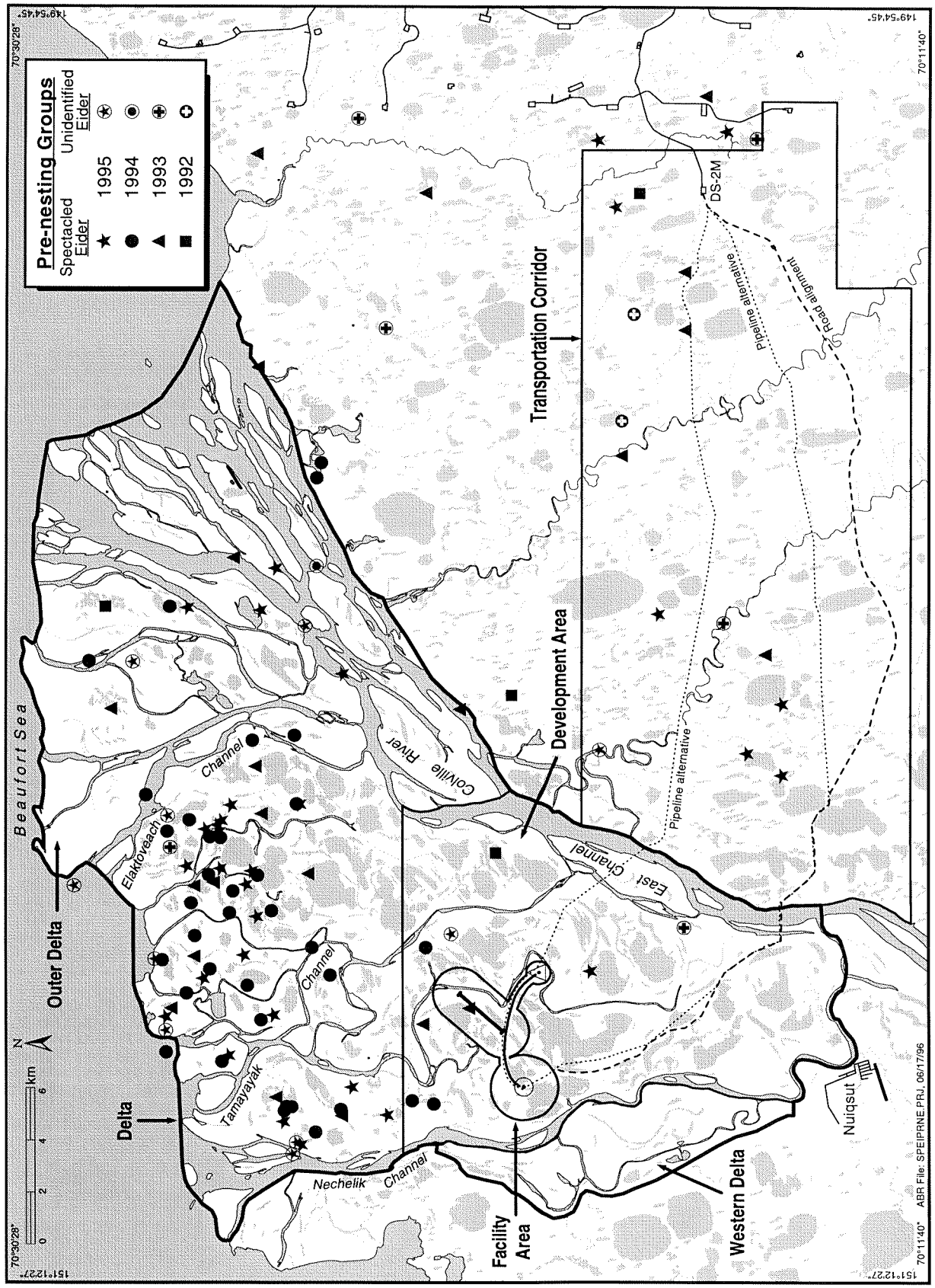


Figure 3. Distribution of Spectacled and unidentified eider groups observed during pre-nesting aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1993, and 1995. Locations from Smith et al. (1993, 1994), Johnson (1995), and this study.

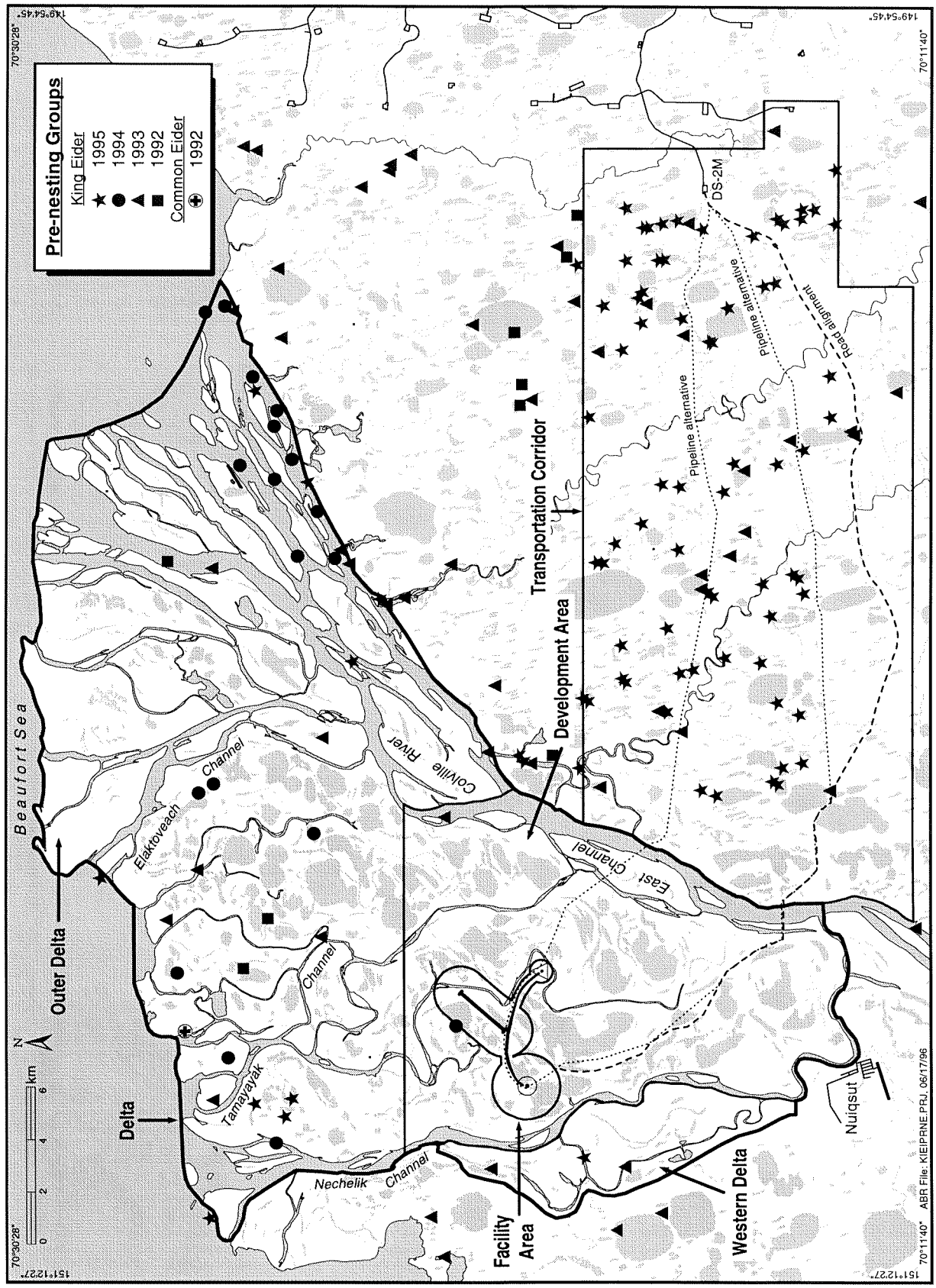


Figure 4. Distribution of King and Common eider groups observed during pre-nesting aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1993, and 1995. Locations from Smith et al. (1993, 1994). Johnson (1995), and this study.

Table 5. Counts and densities (uncorrected) of eiders seen during aerial surveys (100% coverage) of the Delta survey area (540 km^2), Colville River Delta, Alaska, 10–12 June 1995.

Species	Count						Density (birds or pairs/km^2)			
	Males	Females	Total Observed	Pairs Observed	Total Indicated[a]	Pairs Indicated[b]	Observed Birds	Observed Pairs	Indicated Birds	Indicated Pairs
NON-FLYING BIRDS										
Spectacled Eider	20	18	38	18	40	20	0.07	0.03	0.07	0.04
King Eider	12	10	22	10	24	12	0.04	0.02	0.04	0.02
Unidentified eider	4	4	8	4	8	4	0.01	0.01	0.01	0.01
FLYING BIRDS										
Spectacled Eider	13	10	23	9	26	13	0.04	0.02	0.05	0.02
King Eider	6	6	12	6	12	6	0.02	0.01	0.02	0.01
Unidentified eider	4	3	7	2	8	4	0.01	0.00	0.01	0.01
FLYING AND NON-FLYING BIRDS										
Spectacled Eider	33	28	61	27	66	33	0.11	0.05	0.12	0.06
King Eider	18	16	34	16	36	18	0.06	0.03	0.07	0.03
Unidentified eider	8	7	15	6	16	8	0.03	0.01	0.03	0.01

[a] Total indicated = (number of males not associated with a flock x 2) + number of males in flock (see USFWS 1987b).
[b] Pairs indicated = number of males not associated with a flock (see USFWS 1987b). Flock = group of >4 males.

Table 6. Densities of pre-nesting eiders counted in different portions of the Colville River Delta study area, Alaska. Counts were made from fixed-wing aircraft in early June 1993, 1994 (ABR, unpubl. data), and 1995 (this study).

		1995			1994			1993[a]		
Area	Species	No.	Birds /km^2	Area (km^2)	No.	Birds /km^2	Area (km^2)	No.	Birds /km^2	Area (km^2)
Delta[b]				478			478			239
	Spectacled Eider	61	0.13		79	0.17		31	0.13	
	King Eider	34	0.07		58	0.12		34	0.14	
Development Area				126			126			63
	Spectacled Eider	2	0.02		4	0.03		4	0.06	
	King Eider	0	0.00		1	0.01		5	0.08	
Facility Area				14			14			7
	Spectacled Eider	0	0.00		0	0.00		1	0.14	
	King Eider	0	0.00		1	0.07		0	0.00	
Outer Delta				352			352			176
	Spectacled Eider	59	0.17		75	0.21		27	0.15	
	King Eider	34	0.10		57	0.16		29	0.16	
Transportation Corridor				274			0			137
	Spectacled Eider	9	0.03		-	-		8	0.06	
	King Eider	240	0.88		-	-		31	0.23	

[a]Survey coverage in 1993 was 50% of that in 1994 and 1995.
[b]Although the delta is 551 km^2 in total area, only 478 km^2 were surveyed in all 3 years.

among years on the delta. With the exception of King Eiders, changes in densities among years were minor, and Spectacled Eiders outnumbered King Eiders in all years but 1993. The Outer Delta consistently attracted higher densities of both species than other areas on the delta.

Transportation Corridor—In 1995, we counted only 9 Spectacled Eiders (4%) and 4 unidentified eiders (2%) compared to 240 King Eiders (95%) (Table 7). Similarly in 1993, Spectacled Eiders made up a low percentage of the total eiders (19%) on the Transportation Corridor.

Spectacled Eiders in the Transportation Corridor occurred in low densities, were widely distributed, and were found farther inland than on the Delta survey area (Figure 3). In 1995, all Spectacled Eiders were within 24 km of the coast, and in 1993 all were within 23 km of the coast. The density of Spectacled Eiders in the Transportation Corridor was slightly lower in 1995 than in 1993; we tallied 0.03 birds/km^2 in 1995, which was down from 0.06 birds/km^2 in 1993 (Table 6).

King Eiders also were widely distributed throughout the Transportation Corridor, but unlike Spectacled Eiders, they occurred at remarkable densities (Figure 4, Table 6). Densities increased almost four-fold from 1993 to 1995. Especially large numbers of groups were seen in the eastern portion of the Transportation Corridor (Figure 4).

Table 7. Counts and densities (uncorrected) of eiders seen during aerial surveys (100% coverage) of the Transportation Corridor survey area (274 km^2), Colville River Delta, Alaska, 13–14 June 1995.

	Count						Density (birds or pairs/km^2)			
Species	Males	Females	Total Observed	Pairs Observed	Total Indicated[a]	Pairs Indicated[b]	Observed Birds	Observed Pairs	Indicated Birds	Indicated Pairs
NON-FLYING BIRDS										
Spectacled Eider	5	3	8	3	10	5	0.03	0.01	0.04	0.02
King Eider	104	85	189	84	208	104	0.69	0.31	0.76	0.38
Unidentified eider	2	2	4	2	4	2	0.01	0.01	0.01	0.01
FLYING BIRDS										
Spectacled Eider	1	0	1	0	2	1	0.00	0.00	0.01	0.00
King Eider	30	21	51	20	60	30	0.19	0.07	0.22	0.11
Unidentified eider	0	0	0	0	0	0	0.00	0.00	0.00	0.00
FLYING AND NON-FLYING BIRDS										
Spectacled Eider	6	3	9	3	12	6	0.03	0.01	0.04	0.02
King Eider	134	106	240	104	268	134	0.88	0.38	0.98	0.49
Unidentified eider	2	2	4	2	4	2	0.01	0.01	0.01	0.01

[a] Total indicated = (number of males not associated with a flock x 2) + number of males in flock (see USFWS 1987b).
[b] Pairs indicated = number of males not associated with a flock (see USFWS 1987b). Flock = group of >4 males.

Nesting

Delta—The northern portion of the delta where eiders tend to concentrate during pre-nesting (Figures 3 and 4) also is where eiders nest most commonly. In 1995, when nest-searching was restricted to the Facility and Development areas and the Transportation Corridor (Figure 5), no Spectacled or King eider nests were found in either area. During 1994, however, Johnson (1995) concentrated his search in areas of historic locations of nests and sightings from a pre-nesting aerial survey and found 17 Spectacled Eider nests, 2 King Eider nests, and 1 probable King Eider nest (identification based on color patterns of contour feathers in the nest; Anderson and Cooper 1994). Smith et al. (1994) used a similar technique in 1993 and found two Spectacled Eider nests, five probable Spectacled Eider nests, and 1 unidentified eider nest. In 1992, the nest searches were restricted to two 10-ha study plots, one on the Outer Delta and one in the Development Area. Only one nest was found, and that belonged to a Spectacled Eider on the Outer Delta (Smith et al. 1993). Eleven Spectacled Eider nests were recorded on the Colville Delta during bird studies conducted from 1981 to 1987 (Renken et al. 1983, Rothe et al. 1983, North et al. 1984, Nickles et al. 1987, Gerhardt et al. 1988).

The Spectacled Eider nests that we found during four years of nest searches have been an average of 1.2 m (range = 0.1–10 m, n = 20) from permanent water (ABR unpubl. data, Smith et al. 1994, Johnson 1995, this study). Another five nests that were identified as probable Spectacled Eider nests were 0.5 m from water (Smith et al. 1994).

Possibly because the nest searches were focused on Spectacled Eiders, few nests of other eider species have been found. The one Common Eider nest, one unidentified eider nest, and one probable King Eider nest all were 0.5 m from water. Nests of King Eiders (including three in the Transportation Corridor) tended to be farther from water on average ($\bar{x}$ = 17 m, n = 5) and the distance was more variable (range = 0.5–80 m) than for nests of Spectacled Eiders.

Transportation Corridor—During searches for Spectacled Eider nests in 1995, we found three King Eider nests in the Transportation Corridor, where nest searches were conducted for the first time (Figure 5). On average, these nests were 1 m away from permanent water. Many more King Eiders undoubtedly nest in this area, however, because 240 were seen on pre-nesting surveys. Also, our nest searching was conducted in only a small portion of the Transportation Corridor, which was not in the area of greatest concentration of King Eiders during pre-nesting (Figure 4).

Brood-rearing

Delta—Only one Spectacled Eider brood and one King Eider brood were observed during a helicopter survey of the delta in 1995. The distribution of broods in 1995 and during previous studies (Figure 6) was similar to the distribution of eiders during pre-nesting surveys (Figures 3 and 4). No eider broods were seen in the Development Area in 1995, where the survey coverage was 100%. Coverage was 50% for the remainder of the survey areas. The estimated density of Spectacled and King eider broods was 0.004 broods/km^2 each on the Delta survey area and 0.006 broods/km^2 on the Outer Delta. The number of broods undoubtedly was undercounted because of the cryptic coloration of female eiders and their young. No brood survey was conducted in 1992 (Smith et al. 1993) or 1994 (Johnson 1995); however, when brood searches were conducted on the ground in 1993 (Smith et al. 1994), researchers found 11 Spectacled Eider broods with 42 young (density on the Delta survey area = 0.023 broods/km^2). Densities reported from helicopter surveys in the Prudhoe Bay area ranged from 0.008 to 0.05 broods/km^2 for 1991–1993 (TERA 1995).

Transportation Corridor—During helicopter surveys at 50% coverage, 1 Spectacled Eider brood with 1 young and 51 King Eider broods with 156 young were observed (Figure 6). Brood surveys were not conducted in this area in previous years. The density of Spectacled Eiders was 0.007 broods/km^2 and the density of King Eiders was 0.186 broods/km^2. King Eider broods were dispersed throughout the Transportation Corridor. Three large creches of King Eiders were observed with 23, 32, and 42 young; average brood size for King Eiders in the corridor was 3.1 young (n = 51). The contrast in the number of broods of Spectacled and King eiders in the Transportation Corridor was

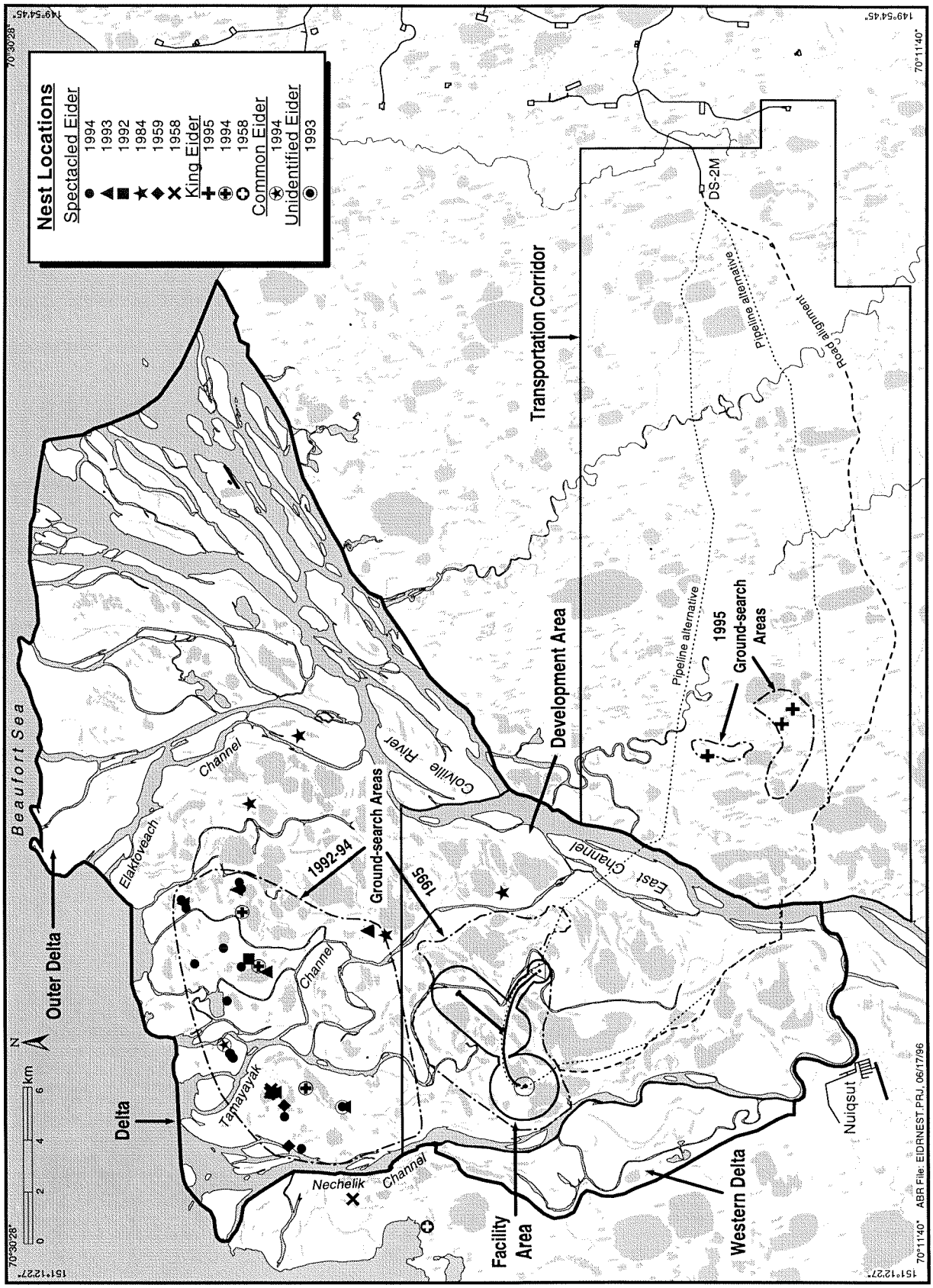


Figure 5. Distribution of eider nests located during ground searches in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1958–1959, 1984, 1992–1995. Locations are from T. Myers (1958–1959, unpubl. data), M. North (1984, unpubl. data), Smith et al. (1993, 1994), Johnson (1995), and this study.

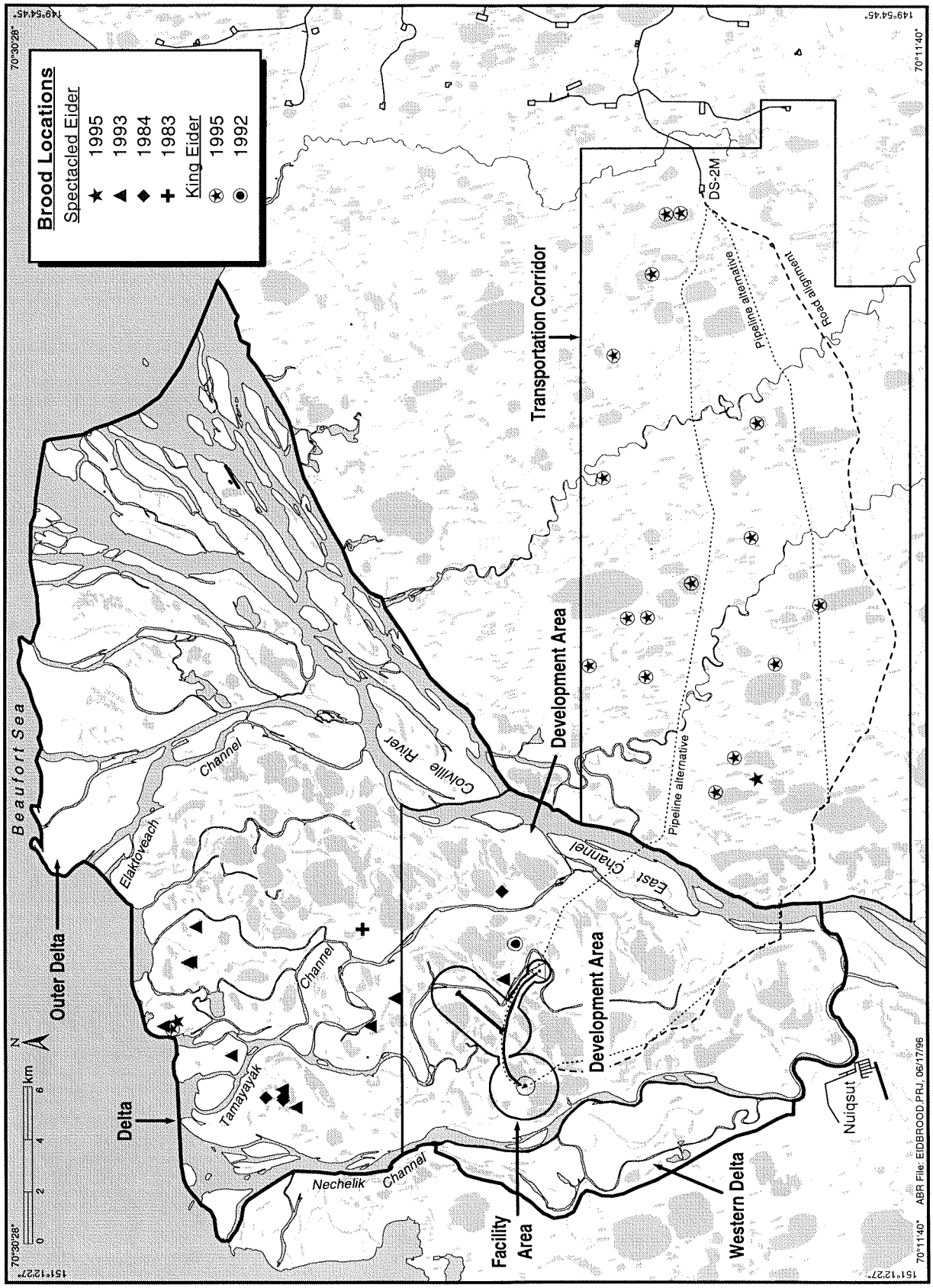


Figure 6. Distribution of Spectacled and King eider broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1983–1984, 1992–1993, and 1995. Locations are from M. North (1983, 1984, unpubl. data), Smith et al. (1993, 1994), and this study.

similar to the contrast in abundance of these two species during pre-nesting.

HABITAT SELECTION

Both Spectacled and King eiders showed strong preferences for waterbodies during all portions of the breeding season, but habitat preferences differed between the two major survey areas. Aquatic Sedge with Deep Polygons, a habitat more typical of the Delta survey area than the Transportation Corridor, was used more often on the delta than any other habitat during pre-nesting and nesting. Young Basin Wetland Complexes were nearly absent from the Delta survey area, but were highly preferred in the Transportation Corridor during pre-nesting and brood-rearing.

Pre-nesting

Delta—Based on three years of aerial surveys on the delta, Spectacled Eiders preferred (i.e., use was disproportionately greater than availability) eight habitats, and King Eiders preferred four habitats (Tables 8 and 9). Annual measures of habitat selection are reported in Appendix Tables B1–B3 for Spectacled Eiders and in Appendix Tables B6–B8 for King Eiders. We defined habitat preference

Table 8. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1993–1995 (ABR, unpubl. data and this study). Numbers of adults and groups from 1993 were doubled to account for 50% survey coverage. See Appendix Tables B1–B3 for individual years.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	0	0	2.0	-1.00	16
Brackish Water	14	4	6.5	1.2	0.68	4
Tapped Lake w/ Low-water Connection	14	7	11.3	4.1	0.47	7
Tapped Lake w/ High-water Connection	6	4	6.5	3.7	0.28	8
Salt Marsh	6	3	4.8	3.2	0.20	9
Tidal Flat	4	2	3.2	10.7	-0.54	14
Salt-killed Tundra	23	10	16.1	4.9	0.53	6
Deep Open Water w/o Islands	6	4	6.5	4.1	0.20	10
Deep Open Water w/ Islands or Polygonized Margins	0	0	0	1.0	-1.00	16
Shallow Open Water w/o Islands	2	1	1.6	0.4	0.58	5
Shallow Open Water w/ Islands or Polygonized Margins	2	1	1.6	0.1	0.89	1
River or Stream	8	2	3.2	15.1	-0.65	15
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	21	11	17.7	2.5	0.75	3
Aquatic Grass Marsh	1	1	1.6	0.2	0.75	2
Young Basin Wetland Complex	0	0	0	<0.1	-1.00	16
Old Basin Wetland Complex	0	0	0	<0.1	-1.00	16
Nonpatterned Wet Meadow	14	5	8.1	7.6	0.03	11
Wet Sedge-Willow Meadow w/ Low-relief Polygons	20	6	9.7	17.6	-0.29	13
Moist Sedge-Shrub Meadow	4	1	1.6	2.2	-0.16	12
Moist Tussock Tundra	0	0	0	0.4	-1.00	16
Riverine or Upland Shrub	0	0	0	4.5	-1.00	16
Barrens (riverine, eolian, lacustrine)	0	0	0	14.5	-1.00	16
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	16
Total	145	62	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability); calculated for groups only.
[b] Order is increasing from high preference to high avoidance.

Table 9. Habitat selection (pooled among years) for King Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1993–1995 (ABR, unpubl. data and this study). Numbers of adults and groups from 1993 were doubled to account for 50% survey coverage. See Appendix Tables B6—B8 for individual years.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	9	1	3.0	2.0	0.20	3
Brackish Water	0	0	0	1.2	-1.00	10
Tapped Lake w/ Low-water Connection	2	1	3.0	4.1	-0.15	5
Tapped Lake w/ High-water Connection	0	0	0	3.7	-1.00	10
Salt Marsh	0	0	0	3.2	-1.00	10
Tidal Flat	4	2	6.1	10.7	-0.28	8
Salt-killed Tundra	2	1	3.0	4.9	-0.24	7
Deep Open Water w/o Islands	0	0	0	4.1	-1.00	10
Deep Open Water w/ Islands or Polygonized Margins	0	0	0	1.0	-1.00	10
Shallow Open Water w/o Islands	0	0	0	0.4	-1.00	10
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0	0.1	-1.00	10
River or Stream	57	14	42.4	15.1	0.48	1
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	2	1	3.0	2.5	0.09	4
Aquatic Grass Marsh	0	0	0	0.2	-1.00	10
Young Basin Wetland Complex	0	0	0	<0.1	-1.00	10
Old Basin Wetland Complex	0	0	0	<0.1	-1.00	10
Nonpatterned Wet Meadow	1	1	3.0	7.6	-0.43	9
Wet Sedge-Willow Meadow w/ Low-relief Polygons	8	4	12.1	17.6	-0.18	6
Moist Sedge-Shrub Meadow	0	0	0	2.2	-1.00	10
Moist Tussock Tundra	0	0	0	0.4	-1.00	10
Riverine or Upland Shrub	0	0	0	4.5	-1.00	10
Barrens (riverine, eolian, lacustrine)	27	8	24.2	14.5	0.25	2
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	10
Total	112	33	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability); calculated for groups only.
[b] Order is increasing from high preference to high avoidance.

to occur when the selection index (Ivlev's E) ranged from 0.2 to 1.0, habitat use to be proportional to availability when the index ranged from –0.19 to 0.19, and habitat avoidance to occur when the index ranged from –0.2 to –1.0. On the delta, Spectacled Eiders preferred, in decreasing order of preference, Shallow Open Water with Islands or Polygonized Margins, Aquatic Grass Marsh, Aquatic Sedge with Deep Polygons, Brackish Water, Shallow Open Water without Islands, Salt-killed Tundra, Tapped Lake with Low-water Connections, Tapped Lake with High-water Connections, and Salt Marsh. Several habitats—Shallow Open Water with Islands or Polygonized Margins, Shallow Open Water without Islands, and Aquatic Grass Marsh—had high indices of selection, despite having only one Spectacled Eider group within their boundaries. The high indices reflected the low availability of these habitats, rather than high use; these habitats each encompassed less than 0.5% of the Delta survey area. The greatest use (in terms of number of groups) during pre-nesting was of Aquatic Sedge with Deep Polygons (11 groups) and Salt-Killed Tundra (10 groups),

which were ranked third and sixth in order of selection, respectively (Table 8). Two habitats were used in proportion to their availability: Nonpatterned Wet Meadow and Moist Sedge-Shrub Meadow. Tidal Flat, River or Stream, and Wet Sedge-Willow Meadow with Low-relief Polygons were used by Spectacled Eiders but were avoided as a result of their high availability (each occupied >10% of the delta).

King Eiders preferred open water habitats during pre-nesting, which indicated that they had not yet dispersed to breeding areas (Table 9). The most preferred habitat was River or Stream, followed by Barrens (in this case, riverine) and Open Nearshore Water. Tapped Lake with Low-water Connections, Aquatic Sedge with Deep Polygons, and Wet Sedge-Willow Meadow with Low-relief Polygons, were used in proportion to their availability. Only three habitats were used but used proportionately less than their availability: Nonpatterned Wet Meadow, Salt-Killed Tundra, and Tidal Flat.

Transportation Corridor—Only 14 Spectacled Eiders were seen in two years of pre-nesting surveys in the Transportation Corridor, suggesting that it is not as important an area for breeding as is the delta. Three habitats in the Transportation Corridor were preferred by Spectacled Eiders, and all were different from those preferred in the Delta survey area. Young Basin Wetland Complex was the most preferred, followed by Wet Sedge-Willow Meadow with Low-relief Polygons and Nonpatterned Wet Meadow (Table 10; Appendix Tables B4 and B5).

Table 10. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 and 1995 (ABR, unpubl. data and this study). Numbers of adults and groups in 1993 were doubled to account for 50% survey coverage. See Appendix Tables B4 and B5 for individual years.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	-	-	-	0	-	-
Brackish Water	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0	0	0	<0.1	-1.00	6
Salt Marsh	-	-	-	0	-	-
Tidal Flat	-	-	-	0	-	-
Salt-killed Tundra	-	-	-	0	-	-
Deep Open Water w/o Islands	2	1	12.5	9.3	0.15	4
Deep Open Water w/ Islands or Polygonized Margins	0	0	0	1.6	-1.00	6
Shallow Open Water w/o Islands	0	0	0	3.4	-1.00	6
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0	2.5	-1.00	6
River or Stream	0	0	0	0.7	-1.00	6
Aquatic Sedge Marsh	0	0	0	0.3	-1.00	6
Aquatic Sedge w/ Deep Polygons	0	0	0	<0.1	-1.00	6
Aquatic Grass Marsh	0	0	0	0.2	-1.00	6
Young Basin Wetland Complex	4	3	37.5	4.8	0.77	1
Old Basin Wetland Complex	0	0	0	11.1	-1.00	6
Nonpatterned Wet Meadow	2	1	12.5	7.6	0.24	3
Wet Sedge-Willow Meadow w/ Low-relief Polygons	2	1	12.5	5.8	0.36	2
Moist Sedge-Shrub Meadow	4	2	25.0	23.6	0.03	5
Moist Tussock Tundra	0	0	0	25.9	-1.00	6
Riverine or Upland Shrub	0	0	0	2.4	-1.00	6
Barrens (riverine, eolian, lacustrine)	0	0	0	0.6	-1.00	6
Artificial (water, fill, peat road)	0	0	0	0.2	-1.00	6
Total	14	8	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability); calculated for groups only.
[b] Order is increasing from high preference to high avoidance.

summarized data for habitat associations. Seven of the 25 (28%) (total includes 5 identified by contour feathers) Spectacled Eider nests were found in Aquatic Sedge with Deep Polygons on the delta between 1992 and 1994 (Table 12). No nests were found in 1995, when the search was conducted in the vicinity of the Facility Area. Other important nesting habitats were Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra, which together accounted for 52% of all nests. We did not find eiders nesting on water, but those that nested on islands or shorelines could be classified as nesting in a waterbody habitat at the scale of our digital mapping. Spectacled Eider nests were strongly associated with waterbodies in all habitats in which they occurred. The mean distance of nests to waterbodies was 0.02 km (n = 25), based on measurements of a digitized map. Brackish Water was the nearest waterbody class to 44% of the nests, and Deep Open Water without Islands was the nearest to 20% of the nests.

Only three King Eider nests (one was identified by contour feathers) have been found during four years of ground searches on the delta. Two of these nests were in Aquatic Sedge with Deep Polygons and the third was in Salt-killed Tundra (Table 13). The mean distance from waterbodies was 0.08 km, and the nearest waterbodies were both types of tapped lakes and Deep Open Water without Islands.

Transportation Corridor—No Spectacled Eider nests were found in the Transportation Corridor in 1995, the only year it was searched for nests. Three nests of King Eiders were found in areas where pre-nesting surveys indicated Spectacled Eiders might be nesting. These nests were found in Young Basin Wetland Complex, Nonpatterned Wet Meadow, and Moist Tussock Tundra (Table 13). These nests were an average of 0.02 km from two types of waterbodies; two nests were nearest to Young Basin Wetland Complex and one nest was nearest to Shallow Open Water without Islands.

Table 12. Habitat use by Spectacled Eiders and distance to nearest waterbody during nesting in the Delta survey area, Colville River Delta, Alaska, 1992–1995 (ABR, unpubl. data and this study). Nests were found during ground searches of selected portions of the study area. Distance to waterbody was measured from a digital map and may not be as accurate as measurement on ground.

Habitat	No. of Nests	Use (%)	Mean Distance to Waterbody (km)
HABITAT USED			
Brackish Water	5	20.0	
Tapped Lake w/ High-water Connection	1	4.0	
Salt Marsh	1	4.0	
Salt-killed Tundra	3	12.0	
Shallow Open Water w/o Islands	1	4.0	
Aquatic Sedge w/ Deep Polygons	7	28.0	
Nonpatterned Wet Meadow	5	20.0	
Wet Sedge-Willow Meadow w/ Low-relief Polygons	2	8.0	
Total	25	100.0	
NEAREST WATERBODY HABITAT			
Brackish Water	11	44.0	0.02
Tapped Lake w/ High-water Connection	4	16.0	0.04
Deep Open Water w/o Islands	5	20.0	0.02
Deep Open Water w/ Islands or Polygonized Margins	2	8.0	0.02
Shallow Open Water w/o Islands	1	4.0	0.00
Shallow Open Water w/ Islands or Polygonized Margins	2	8.0	0.01
Total	25	100.0	0.02

Unlike Spectacled Eiders, large numbers of King Eiders (223 adults) were seen on the ground in the Transportation Corridor. King Eiders preferred Aquatic Sedge Marsh more than any other habitat, although Deep Open Water without Islands was used by more eiders (22%) than any other habitat (Table 11; Appendix Tables B9 and B10). Other preferred habitats were Barrens, Shallow Open Water without Islands, Shallow Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, and Young Basin Wetland Complex.

Nesting

Delta—Nesting surveys have to be conducted on the ground because of the difficulty in finding eider nests from the air. Consequently, complete surveys of large portions of habitat in remote areas such as the Colville Delta are time-consuming and logistically difficult. We chose to search areas that either maximized our chances of finding nests (1992, 1993, and 1994) or that included important development sites (1995). Thus, we did not search a representative sample of habitats from which selection could be calculated, but instead we

Table 11. Habitat selection (pooled among years) by King Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 and 1995 (ABR, unpubl. data and this study). Numbers of adults and groups in 1993 were doubled to account for 50% survey coverage. See Appendix Tables B9 and B10 for individual years.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	-	-	-	0	-	-
Brackish Water	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0	0	0	<0.1	-1.00	11
Salt Marsh	-	-	-	0	-	-
Tidal Flat	-	-	-	0	-	-
Salt-killed Tundra	-	-	-	0	-	-
Deep Open Water w/o Islands	48	15	21.7	9.3	0.40	5
Deep Open Water w/ Islands or Polygonized Margins	10	4	5.8	1.6	-1.00	11
Shallow Open Water w/o Islands	26	6	8.7	3.4	0.44	3
Shallow Open Water w/ Islands or Polygonized Margins	13	4	5.8	2.5	0.41	4
River or Stream	0	0	0	0.7	-1.00	11
Aquatic Sedge Marsh	4	2	2.9	0.3	0.80	1
Aquatic Sedge w/ Deep Polygons	0	0	0	<0.1	-1.00	11
Aquatic Grass Marsh	0	0	0	0.2	-1.00	11
Young Basin Wetland Complex	30	7	10.1	4.8	0.36	6
Old Basin Wetland Complex	19	7	10.1	11.1	-0.04	8
Nonpatterned Wet Meadow	19	7	10.1	7.6	0.14	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	0	0	0	5.8	-1.00	11
Moist Sedge-Shrub Meadow	26	7	10.1	23.6	-0.40	10
Moist Tussock Tundra	26	8	11.6	25.9	-0.38	9
Riverine or Upland Shrub	0	0	0	2.4	-1.00	11
Barrens (riverine, eolian, lacustrine)	2	2	2.9	0.6	0.65	2
Artificial (water, fill, peat road)	0	0	0	0.2	-1.00	11
Total	223	69	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability); calculated for groups only.
[b] Order is increasing from high preference to high avoidance.

Table 13. Habitat use by King Eiders and distance to nearest waterbody during nesting in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1995 (ABR, unpubl. data and this study). Nests were found during ground searches of selected portions of the study area. Distance to waterbody was measured from a digital map and may not be as accurate as measurement on ground.

Survey Area / Habitat	No. of Nests	Use (%)	Mean Distance to Waterbody (km)
DELTA			
HABITAT USED			
Salt-killed Tundra	1	33.3	
Aquatic Sedge w/ Deep Polygons	2	66.7	
Total	3	100.0	
NEAREST WATERBODY HABITAT			
Tapped Lake w/ Low-water Connection	1	33.3	0.11
Tapped Lake w/ High-water Connection	1	33.3	0.06
Deep Open Water w/o Islands	1	33.3	0.07
Total	3	100.0	0.08
TRANSPORTATION CORRIDOR			
HABITAT USED			
Young Basin Wetland Complex	1	33.3	
Nonpatterned Wet Meadow	1	33.3	
Moist Tussock Tundra	1	33.3	
Total	3	100.0	
NEAREST WATERBODY HABITAT			
Shallow Open Water w/o Islands	1	33.3	0.00
Young Basin Wetland Complex	2	66.7	0.03
Total	3	100.0	0.02

Brood-rearing

Delta—Only one Spectacled Eider brood was found in 1995 during the only systematic aerial survey conducted on the delta during brood-rearing. This brood was seen in Shallow Open Water with Islands or Polygonized Margins (Appendix Table B11). However, 10 other brood groups (one group contained 2 adults with young) had been located during ground-based searches in 1993 (Table 14), and they were associated most often with Salt-killed Tundra (36% of all locations) and Brackish Water (27%), suggesting a strong attraction to coastal habitats. This same attraction was shown by broods to coastal lakes; most broods (64%) were nearest to Brackish Water ($\bar{x}$ = 0.03 km).

One King Eider brood was seen on the delta during the systematic aerial survey in 1995. This brood was in Aquatic Sedge with Deep Polygons approximately 0.02 km from Brackish Water (Appendix Table B12). One other King Eider brood was found during ground searches in 1992 in Wet Sedge-Willow Meadow with Low-relief Polygons 0.07 km from Deep Open Water without Islands.

Transportation Corridor—One Spectacled Eider brood was found in 1995 during an aerial survey of the Transportation Corridor. That brood occurred in

Table 14. Habitat use by Spectacled Eiders and distance to nearest waterbody during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1993 and 1995 (ABR, unpubl. data and this study). Broods were located during both aerial and ground surveys. Distance to waterbody was measured from a digital map and may not be as accurate as measurement on ground.

Habitat	No. of Brood Groups	No. of Young	Use[a] (%)	Mean Distance to Waterbody (km)
HABITAT USED				
Brackish Water	3	11	27.3	
Salt-killed Tundra	4	22	36.4	
Shallow Open Water w/o Islands	1	3	9.1	
Aquatic Grass Marsh	1	4	9.1	
Wet Sedge-Willow Meadow w/ Low-relief Polygons	2	7	18.2	
Total	11	47	100.0	
NEAREST WATERBODY HABITAT				
Brackish Water	7	33	63.6	0.03
Tapped Lake w/ High-water Connection	1	3	9.1	0.08
Deep Open Water w/o Islands	1	4	9.1	0.24
Shallow Open Water w/o Islands	1	3	9.1	0.00
Aquatic Grass Marsh	1	4	9.1	0.00
Total	11	47	100.0	0.05

[a] Use is calculated from number of brood groups only.

Shallow Open Water with Islands or Polygonized Margins (Appendix Table B13). Sixteen King Eider brood groups were found on the same aerial survey in six habitats, all of which were preferred and all but one of which was a waterbody (Table 15; Appendix Table B14). The most preferred habitat, which contained one brood group, was Aquatic Sedge Marsh, a rare habitat comprising 0.3% of the survey area. More important in terms of numbers of brood groups were Deep Open Water without Islands and Shallow Open Water without Islands, which were used by nine groups (56% of the total). Not surprisingly, these waterbody types also were found to be the nearest to King Eider broods; five groups were found in or near Deep Open Water without Islands and four were found in or near Shallow Open Water without Islands (Table 16).

TUNDRA SWANS

BACKGROUND

Tundra Swans arrive on the Colville Delta in mid- to late May (Simpson et al. 1982, Hawkins 1983). The occupation of breeding territories and nest initiation both begin soon after arrival, although poor weather can delay the process (Lensink 1973, McLaren and McLaren 1984). Tundra Swans are traditional in their selection of nesting sites, in that they often use the same nest mounds in successive years (Palmer 1976, Monda 1991). Incubation begins after egg-laying is completed, and hatching occurs 30–35 days later (Palmer 1976). Families then stay on or near their breeding territories until the young are fledged, after 8–10 weeks of brood-rearing (Bellrose 1978, Rothe et al. 1983, Monda

Table 15. Habitat selection by King Eiders during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1995.

Habitat	No. of Young	No. of Groups	Area (km^2)	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	-	-	0	-	0	-	-
Brackish Water	-	-	0	-	0	-	-
Tapped Lake w/ Low-water Connection	-	-	0	-	0	-	-
Tapped Lake w/ High-water Connection	0	0	0.10	0	0.04	-1.00	7
Salt Marsh	-	-	0	-	0	-	-
Tidal Flat	-	-	0	-	0	-	-
Salt-killed Tundra	-	-	0	-	0	-	-
Deep Open Water w/o Islands	76	5	25.59	31.3	9.3	0.54	5
Deep Open Water w/ Islands or Polygonized Margins	6	1	4.30	6.3	1.6	0.60	4
Shallow Open Water w/o Islands	23	4	9.32	25.0	3.4	0.76	3
Shallow Open Water w/ Islands or Polygonized Margins	41	3	6.73	18.8	2.5	0.77	2
River or Stream	0	0	1.97	0	0.7	-1.00	7
Aquatic Sedge Marsh	4	1	0.90	6.3	0.3	0.90	1
Aquatic Sedge w/ Deep Polygons	0	0	0.02	0	0.0	-1.00	7
Aquatic Grass Marsh	0	0	0.63	0	0.2	-1.00	7
Young Basin Wetland Complex	6	2	13.21	12.5	4.8	0.44	6
Old Basin Wetland Complex	0	0	30.40	0	11.1	-1.00	7
Nonpatterned Wet Meadow	0	0	20.85	0	7.6	-1.00	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	0	0	15.98	0	5.8	-1.00	7
Moist Sedge-Shrub Meadow	0	0	64.76	0	23.6	-1.00	7
Moist Tussock Tundra	0	0	71.03	0	25.9	-1.00	7
Riverine or Upland Shrub	0	0	6.49	0	2.4	-1.00	7
Barrens (riverine, eolian, lacustrine)	0	0	1.67	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0	0	0.42	0	0.2	-1.00	7
Total	156	16	274.38	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability); calculated for groups only.
[b] Order is increasing from high preference to high avoidance.

Table 16. Distance to nearest waterbody of King Eiders during brood-rearing in Transportation Corridor survey area, Colville River Delta, Alaska, 1995. Broods were located on aerial surveys. Distance to waterbody was measured from a digital map and may not be as accurate as measurement on ground.

Habitat	No. of Brood Groups	No. of Young	Use[a] (%)	Mean Distance to Waterbody (km)
Deep Open Water w/o Islands	5	76	31.3	0.01
Deep Open Water w/ Islands or Polygonized Margins	1	6	6.3	0.00
Shallow Open Water w/o Islands	4	23	25.0	0.00
Shallow Open Water w/ Islands or Polygonized Margins	3	41	18.8	0.00
Aquatic Sedge Marsh	1	4	6.3	0.00
Young Basin Wetland Complex	2	6	12.5	0.00
Total	16	156	100.0	0.01

[a] Use is calculated for brood groups only.

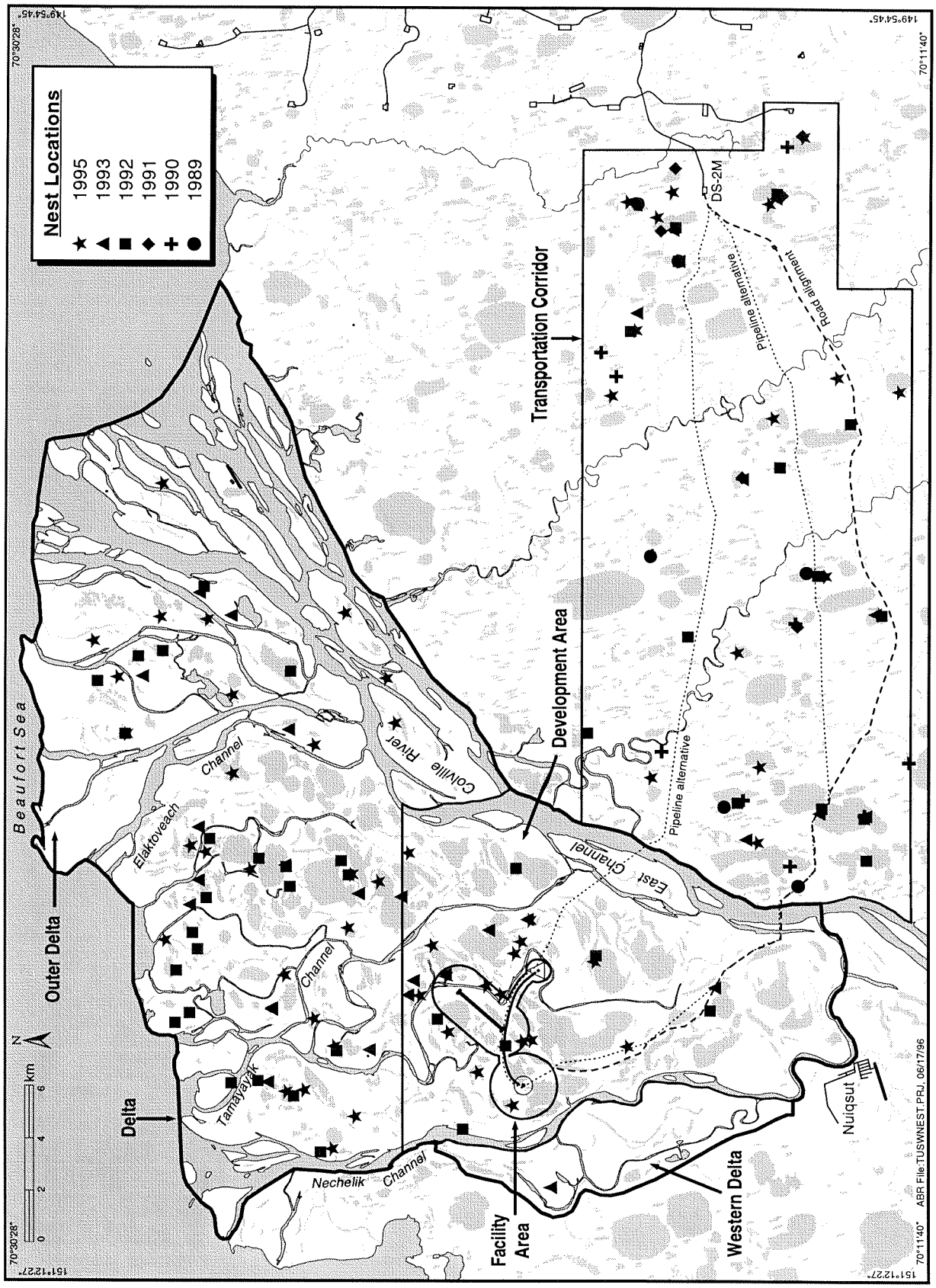


Figure 7. Distribution of Tundra Swan nests observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993, 1995. Locations are from ABR (1989–1991, unpubl. data), Smith et al. (1993, 1994), and this study.

and Ratti 1990). Tundra Swans leave northern Alaska by late September or early October on an easterly migration route for wintering grounds in eastern North America (Johnson and Herter 1989). Poor weather in early autumn may hasten their departure and may result in the mortality of young swans (Lensink 1973, Monda and Ratti 1990).

ABUNDANCE AND DISTRIBUTION

Nesting

Delta—During aerial surveys of the delta in 1995, we located 38 Tundra Swan nests (Figure 7, Table 17). This count represents a 90% increase from the 1993 count and a 170% increase from the 1992 count. During those same years, the number of nests also increased markedly (64%–71%) across that part of the Arctic Coastal Plain between the Kuparuk and Colville rivers (ABR, unpubl. data). Higher numbers of nests have been found on the delta during intensive ground-based searches. In 1982, 48 nests were found in the northern 80% of the delta (Simpson et al. 1982). In 1981, Rothe et al. (1983) found 32 swan nests on approximately 80% of the delta.

Estimated nest densities on the delta ranged from 0.03 to 0.07 nests/km^2 during 1992, 1993, and 1995. Nest densities measured from aerial surveys

Table 17. Counts (and densities) of Tundra Swan nests and broods from aerial surveys on the Colville River Delta, Alaska, 1989–1995. Counts in 1989–1993 were summarized from ABR (unpubl. data).

Survey Area	Year	Nests No.	Nests (No./km^2)	Broods No.	Broods (No./km^2)	Mean Brood Size
Delta (521 km^2)						
	1995	38	0.07	25	0.05	3.7
	1993	20	0.04	14	0.03	2.6
	1992	14	0.03	17	0.03	2.4
Development Area (169 km^2)						
	1995	12	0.07	6	0.04	3.7
	1993	7	0.04	3	0.02	2.0
	1992	5	0.03	7	0.04	1.9
Facility Area (14 km^2)						
	1995	5	0.37	2	0.15	3.5
	1993	1	0.07	0	0	0
	1992	2	0.15	3	0.22	1.3
Outer Delta (352 km^2)						
	1995	26	0.07	17	0.05	3.8
	1993	13	0.04	10	0.03	2.7
	1992	9	0.03	9	0.03	2.4
Transportation Corridor (343 km^2)						
	1995	18	0.05	10	0.03	2.7
	1993	10	0.03	10	0.03	2.3
	1992	12	0.03	17	0.05	2.1
	1991	7	0.02	6	0.02	2.8
	1990	11	0.03	14	0.05	3.2
	1989	6	0.02	2	0.01	3.0

of other areas on the coastal plain have been in the same range of values that we have measured: 0.04–0.06 nests/km^2 on the eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km^2 in the Kuparuk Oilfield and adjacent areas (Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1995, 1996).

In 1995 on the delta, 12 of the 38 nests (Figure 7, Table 17) located by aerial surveys occurred in the Development Area. Another five nests were found by ground-based observers, resulting in a combined count of 17 nests (0.10 nests/km^2) for the Development Area. Nesting densities from aerial surveys in 1995 were 2–3 times those in 1993 or 1992, and densities within the Development Area were similar to those estimated for the entire Delta survey area.

Of the 12 nests found during aerial surveys and the 5 found on ground-based surveys within the Development Area in 1995, the Facility Area (Figure 7) contained 6 of these nests. The delta-wide increase in nesting effort for 1995 over that of 1993 and 1992 was reflected in the number of nests found in the Facility Area (Table 17).

The remaining 26 swan nests found on the delta in 1995 were located on the Outer Delta (Figure 7, Table 17). Densities of nests in this portion of the delta have been similar to those for the Development Area for all three years.

We counted 208 adult swans on the Colville Delta in June 1995; 31% of these were associated with nests (Table 18). Although fewer total swans were counted in 1995 than in 1993 and 1992, the proportion of adults that were breeding was markedly greater in 1995 than in previous years (Table 18).

Transportation Corridor—In 1995, we located 18 swan nests (0.05 nests/km^2) in the Transportation Corridor (Figure 7, Table 17). During the previous seven years, numbers of nests located in the Transportation Corridor ranged from 6 to 12 (Table 17). The 1995 nest count thus represents a 75% increase over the previous high count.

Similar to the increase in swan nests in 1995, the total number of swans in the Transportation Corridor also increased (Table 18). However, the proportion of swans associated with nests has varied over the previous seven years and does not exhibit a discernible trend.

Table 18. Counts of Tundra Swans from aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1995. Counts for 1989–1993 summarized from ABR (unpubl. data).

		Nesting		Brood-rearing				Fall Staging
Survey Area	Year	Total Swans	Swans with Nests (%)	Total Swans (adults+young)		Adults with Broods (%)	Young (%)	Total Swans
Delta								
	1995	208	31	261	(169+92)	29	35	64[a]
	1993	240	12	237	(200+37)	13	17	295
	1992	249	7	299	(259+40)	13	13	0
Transportation Corridor								
	1995	87	40	93	(66+27)	30	29	5
	1993	50	32	83	(60+23)	33	28	No data
	1992	52	42	116	(80+36)	43	31	No data
	1991	40	25	84	(67+17)	18	20	No data
	1990	33	52	101	(56+45)	50	45	No data
	1989	38	24	71	(65+6)	6	8	No data

[a] Western Delta (31 km^2) was not surveyed.

Brood-rearing

Delta—Tundra Swan broods were evenly distributed throughout the survey areas (Figure 8). Brood counts on the Colville Delta on 20–22 August 1995 indicated that approximately 66% of the 38 nests were successful in 1995 (Table 17). Mean brood size was 3.7 young/brood (range = 1–8), and the density was 0.05 broods/km^2. Mean brood size was larger and brood density was higher in 1995 than in 1993 and 1992. The actual number of young swans that we counted in 1995 was more than twice as many as we recorded in either 1993 or 1992 (Table 18). Rothe et al. (1983) reported a nesting success rate of 90.6% ($n = 32$ nests) and a mean brood size of 2.1 young/brood for the Colville Delta in late July 1981. In 1982, nesting success was 70.8% ($n = 48$ nests), and mean brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). However, the results for both those earlier studies were based on intensive ground-based surveys.

Productivity (as indicated by nesting success and mean brood size) on the delta during the three years in which we conducted aerial surveys was within the range of values reported in other studies of swans on the Arctic Coastal Plain. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995) recorded mean brood sizes of 2.1–2.8 young/brood and densities of 0.02–0.04 broods/km^2 (Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1996). Platte and Brackney (1987) estimated 0.04 broods/km^2 on portions of the Arctic Coastal Plain during 1982–1985. Mean brood size averaged over those 4 years was 2.5 young/brood and nesting success during 1983-1985 ranged from 63% to 85%.

The large number of nests found in 1995, in combination with the large mean brood size of successful nests, resulted in young swans representing 35% of all swans present in August (Table 18). This percentage represents a sharp increase over those for 1993 and 1992. The proportion of all swans on the delta in mid-August of 1982 was 26% (Simpson et al. 1982). In the adjacent Kuparuk Oilfield, the proportion of young swans ranged from 21 to 31% during 1988–1993 and 1995 (Anderson et al. 1996).

In the Development Area, six broods were found during the aerial survey in 1995 (Table 17). In the Facility Area, two broods were observed.

On the Outer Delta, we observed 17 broods in 1995 (Table 17). Both 1993 and 1992 had fewer and smaller broods than did 1995.

Transportation Corridor—In 1995, we found 10 broods in the Transportation Corridor (Table 17). An additional brood was located by ground-based observers. The 1995 counts were about average for numbers and sizes of broods.

We counted 66 adult and 27 young swans in the Transportation Corridor in August 1995 (Table 18); 30% of the adult swans were with broods. Of the 93 swans present, 29% were young. Overall, the swan population using the Transportation Corridor exhibited considerable annual variability in nesting effort, nesting success, and mean brood size (Ritchie et al. 1989, 1990, 1991; Stickney, et al. 1992, 1993; Anderson et al. 1995, 1996). In 1995, numbers of nests and young swans in a large area that includes the Transportation Corridor were the highest recorded for that area since surveys began (Anderson et al. 1996).

Fall Staging

Delta—During fall staging, Tundra Swans were found most often on the Outer Delta in the river channels (Figure 9). Our aerial survey on 19 September 1995 was too late in the season to locate large groups of staging swans or to determine when most swans departed the delta. A small number (64) of swans remained in the area, and most of them were single family groups (Table 18). That count represented a substantial decline from the brood-rearing survey in mid-August, when we counted 261 swans. The weather on the Arctic Coastal Plain was much milder than usual in September (NOAA, unpublished weather data), indicating that factors other than temperatures at this time of year may affect the timing of the departure of swans from this area.

Similarly timed surveys in previous years have recorded highly variable use of the delta. For example, the staging survey of 15 September 1993 recorded 295 swans in the same area that we surveyed in 1995 (Table 18); weather during this survey also was exceptionally mild. In contrast, in 1992, 299 swans were counted on the brood-rearing survey, but an early freeze before the fall-staging survey (17 September) resulted in an early departure

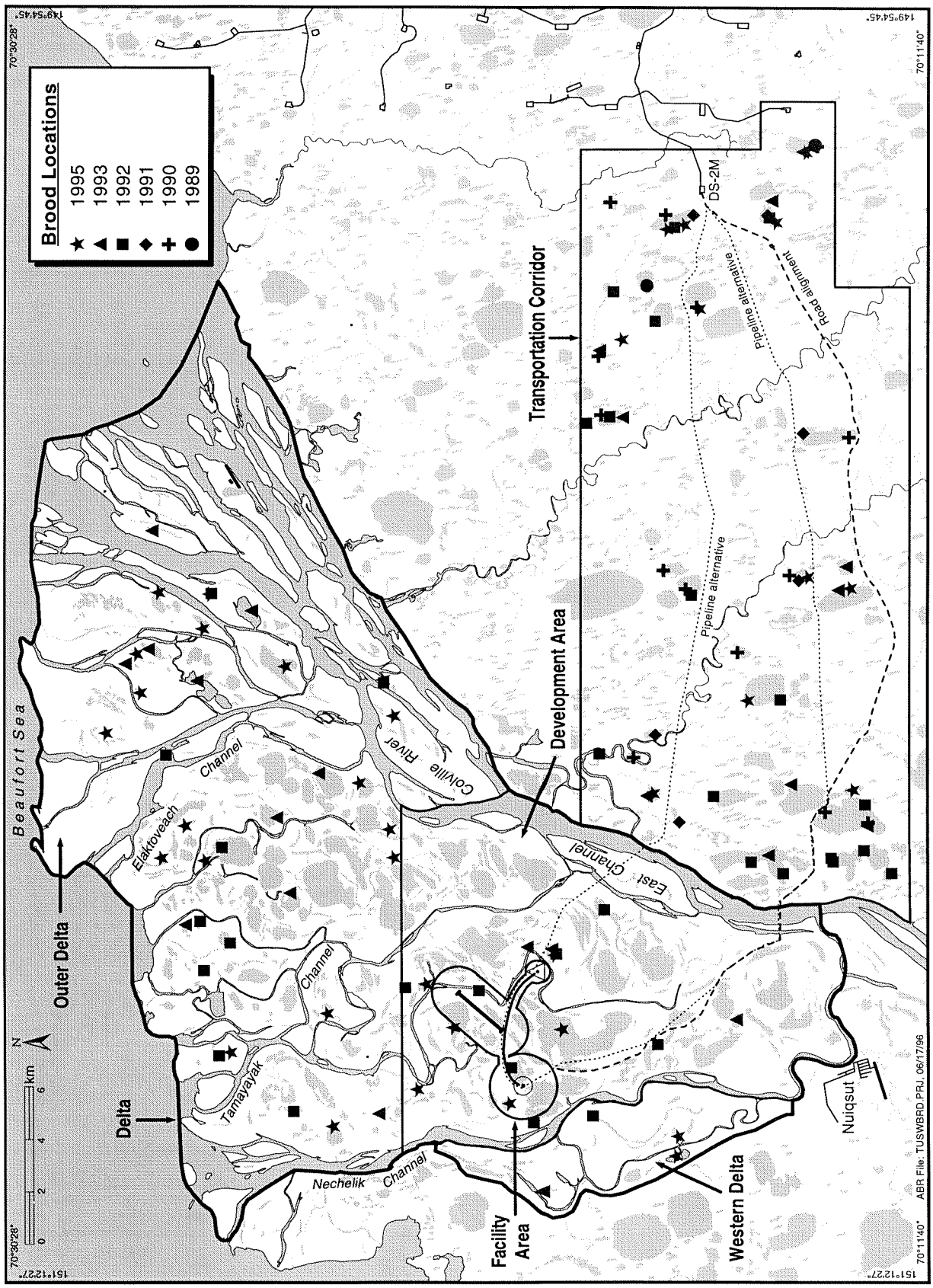


Figure 8. Distribution of Tundra Swan broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995. Locations are from ABR (1989–1991, unpubl. data), Smith et al. (1993, 1994), and this study.

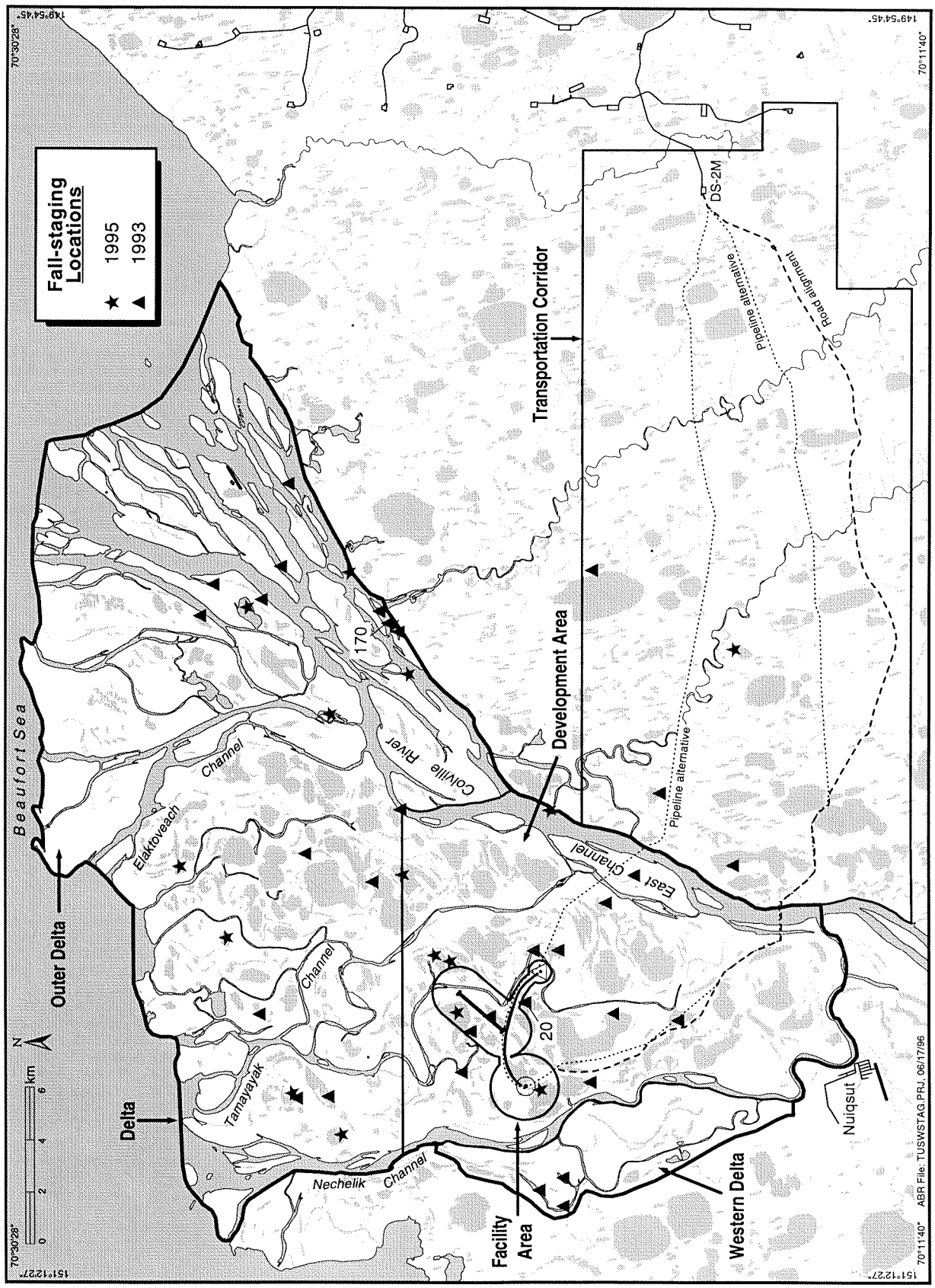


Figure 9. Distribution of Tundra Swan fall-staging groups observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1993 and 1995. Numbers indicate size of groups greater than 10. Locations are from Smith et al. (1993) and this study.

from the delta (Smith et al. 1993). Thus, as in 1995, swans had vacated the delta prior to the fall-staging survey, although under distinctly different weather conditions. These observations suggest that the majority of swans depart the delta over a short period and that their departure may be triggered by factors other than fall weather conditions. Although surveys in only one of the three years under consideration here documented staging by large numbers of swans prior to migrating, Campbell et al. (1988) reported large numbers of swans on the Colville Delta in fall.

The few swans present on the delta during our fall-staging survey were widely distributed. In the Facility Area, we saw 19 swans, including 2 broods; none were seen in the rest of the Development Area. However, in 1993, we counted 51 swans (17% of all swans) throughout the Development Area; 29 of those occurred in the Facility Area.

On the Outer Delta, the 45 swans found in 1995 were widely distributed as single family groups or as pairs. In 1993, the majority (~75%) of swans also occurred on the Outer Delta.

Transportation Corridor—During the 1995 aerial surveys, a single group (2 adults with 3 young) was recorded. Because our survey took place after most of the swans had departed and because staging surveys in the corridor have not been flown in previous years, we have limited information on the relative importance of this area to swans during fall staging.

HABITAT SELECTION

Nesting

Delta—During three years of surveys on the delta, swan nests were located in 14 of 23 habitats that were available (Table 19). Annual habitat selection measurements are presented in Appendix Tables B15–B17. Eight habitat types were preferred and 13 were avoided. Sixty-one nests (85% of the total)

Table 19. Habitat selection (pooled among years) by Tundra Swans during nesting on the Delta survey area, Colville River Delta, Alaska, 1992, 1993 (ABR, unpubl. data), and 1995. See Appendix Tables B15–B17 for individual years.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	15
Brackish Water	6.50	0	0	1.2	-1.00	15
Tapped Lake w/ Low-water Connection	21.42	3	4.2	3.9	0.03	9
Tapped Lake w/ High-water Connection	20.36	1	1.4	3.7	-0.45	11
Salt Marsh	16.73	6	8.3	3.0	0.47	2
Tidal Flat	55.90	1	1.4	10.1	-0.76	14
Salt-killed Tundra	25.63	8	11.1	4.6	0.41	3
Deep Open Water w/o Islands	23.31	3	4.2	4.2	-0.01	10
Deep Open Water w/ Islands or Polygonized Margins	5.13	1	1.4	0.9	0.20	8
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	15
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	15
River or Stream	81.76	0	0	14.8	-1.00	15
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	3	4.2	2.5	0.26	6
Aquatic Grass Marsh	1.37	1	1.4	0.2	0.70	1
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	15
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	15
Nonpatterned Wet Meadow	41.98	9	12.5	7.6	0.24	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	30	41.7	18.5	0.38	4
Moist Sedge-Shrub Meadow	13.10	3	4.2	2.4	0.27	5
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	15
Riverine or Upland Shrub	27.40	1	1.4	5.0	-0.56	12
Barrens (riverine, eolian, lacustrine)	79.01	2	2.8	14.3	-0.68	13
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	15
Total	551.25	72	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

were in preferred habitats and these habitats together composed 39.7% of the total Delta survey area.

Aquatic Grass Marsh was the most preferred of any habitat type for nesting swans on the delta (Table 19). However, only one nest on the delta was located in this habitat; the high selection index was attributable to the low availability (0.2% of total available habitats), rather than to a high use of this habitat. Other preferred habitats for nesting swans on the Delta survey area were Salt Marsh (6 nests), Salt-killed Tundra (8 nests), Moist Sedge-Shrub Meadow (3 nests), Aquatic Sedge with Deep Polygons (3 nests), and Deep Open Water with Islands or Polygonized Margins (3 nests).

Thirty nests (42% of the total) were located in Wet Sedge-Willow Meadow in the Delta survey area (Table 19). No other habitat type in the Delta survey area had more than nine nests. Wet Sedge-Willow Meadow with Low-relief Polygons as the most widely available habitat (18.5% of the area) and was ranked fourth in preference. The second-highest number of nests (9) occurred in Nonpatterned Wet Meadow, which ranked seventh in preference. Nonpatterned Wet Meadow was selected only slightly out of proportion to its occurrence on the delta.

The mean distance of swan nests to the nearest waterbody was 0.13 km (Table 20), indicating that proximity to waterbodies is important to nest-site selection. In decreasing order of use, the three waterbody types most commonly found in proximity to swan nests on the delta were Deep Open Water without Islands, Tapped Lake with Low-water Connections, and Brackish Water.

Transportation Corridor—Swan nests were found in 12 of 18 habitats available in the Transportation Corridor (Table 21; Appendix Tables B18–23). Six habitats were preferred and nine appeared to be avoided. Three of the six preferred habitats in the Transportation Corridor also were preferred in the delta (Deep Open Water with Islands or Polygonized Margins, Aquatic Grass Marsh, and Nonpatterned Wet Meadow), and the other three preferred habitats in the Transportation Corridor were either very rare or did not occur in the delta. Thirty-five nests (55% of the total) were in these six preferred habitats.

The mean distance of nests to the nearest waterbody was 0.06 km in the Transportation Corridor (Table 20). Thirty-seven nests (58% of the total) were located near the four most common waterbody types: Deep Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, Shallow Open Water with Islands or Polygonized Margins, and Shallow Open Water without Islands. Another twenty-one nests (38% of the total) were located in or near a Young or Old Basin Wetland Complex.

Table 20. Distance of Tundra Swan nests to nearest waterbody habitat on the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 (ABR, unpubl. data) and 1995.

	Delta		Transportation Corridor	
Nearest Waterbody Habitat	Number of Nests	Mean Distance (km)	Number of Nests	Mean Distance (km)
Brackish Water	15	0.17	0	-
Tapped Lake w/ Low-water Connection	16	0.10	0	-
Tapped Lake w/ High-water Connection	5	0.08	0	-
Deep Open Water w/o Islands	21	0.12	16	0.05
Deep Open Water w/ Islands	4	0.14	10	0.15
Shallow Open Water w/o Islands	7	0.17	4	0.08
Shallow Open Water w/ Islands	0	-	7	0.06
Aquatic Sedge Marsh	0	-	2	0.02
Aquatic Grass Marsh	4	0.13	4	0.09
Young Basin Wetland Complex	0	-	11	0.02
Old Basin Wetland Complex	0	-	10	0.03
Grand Total	72	0.13	64	0.06

Table 21. Habitat selection (pooled among years) by Tundra Swans during nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989–1993 (ABR, unpubl. data) and 1995. See Appendix Tables B18—B23 for individual years.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	14
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	2	3.1	9.0	-0.48	13
Deep Open Water w/ Islands or Polygonized Margins	6.52	11	17.2	1.9	0.80	2
Shallow Open Water w/o Islands	10.84	2	3.1	3.2	-0.01	8
Shallow Open Water w/ Islands or Polygonized Margins	7.36	4	6.3	2.1	0.49	5
River or Stream	2.30	0	0	0.7	-1.00	14
Aquatic Sedge Marsh	0.97	2	3.1	0.3	0.83	1
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	14
Aquatic Grass Marsh	0.65	1	1.6	0.2	0.78	3
Young Basin Wetland Complex	14.23	10	15.6	4.1	0.58	4
Old Basin Wetland Complex	35.59	7	10.9	10.4	0.03	7
Nonpatterned Wet Meadow	24.47	7	10.9	7.1	0.21	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	2	3.1	5.8	-0.30	10
Moist Sedge-Shrub Meadow	84.66	6	9.4	24.7	-0.45	12
Moist Tussock Tundra	94.60	9	14.1	27.6	-0.32	11
Riverine or Upland Shrub	7.74	1	1.6	2.3	-0.18	9
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	14
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	14
Total	343.11	64	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Brood-rearing

Delta—Swan broods were located in 12 of 23 habitats available on the delta. Five habitats were preferred and 12 were avoided (Table 22; Appendix Tables B15–B17). Twenty-six broods were located in preferred habitats, 25 were in habitats used in proportion to their availability, and only five broods were located in avoided habitats (all were in Barrens). Three of five preferred habitats on the delta were coastally influenced (Brackish Water, Tapped Lake with Low-water Connections, and Salt Marsh). All of the preferred habitats were lakes or were closely associated with lakes.

The most preferred habitat for swan broods was Brackish Water, which composed 1.2% of the Delta survey area; six broods (10.7% of the total) were located in this habitat (Table 22). The strong preference for coastally influenced habitats by brood-rearing swans suggests a seasonal change in habitat preference and distribution (36% of all swan broods on the Delta survey area were located in coastally influenced habitats, compared with only 19% of all nests). Although locations were not examined for evidence of northward dispersal of broods, the habitat use suggests that such a dispersal occurred.

All swan broods were located very close to (often swimming in) waterbodies (Table 23). The mean distance of broods to a waterbody was 0.06 km. Most broods were located near Brackish Water, and most of the remaining brood sightings were near one of the three most common waterbody types: Deep Open Water without Islands, Tapped Lake with Low-water Connections, and Tapped Lake with High-water Connections.

Transportation Corridor—Swan broods were located in 12 of 18 total habitats available in the

Table 22. Habitat selection (pooled among years) by Tundra Swans during brood-rearing on the Delta survey area, Colville River Delta, Alaska, 1992, 1993 (ABR, unpubl. data), and 1995. See Appendix Tables B15–B17 for individual years.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	13
Brackish Water	6.50	6	10.7	1.2	0.80	1
Tapped Lake w/ Low-water Connection	21.42	9	16.1	3.9	0.61	2
Tapped Lake w/ High-water Connection	20.36	3	5.4	3.7	0.18	6
Salt Marsh	16.73	5	8.9	3.0	0.49	4
Tidal Flat	55.90	5	8.9	10.1	-0.06	9
Salt-killed Tundra	25.63	0	0	4.6	-1.00	13
Deep Open Water w/o Islands	23.31	4	7.1	4.2	0.26	5
Deep Open Water w/ Islands or Polygonized Margins	5.13	2	3.6	0.9	0.59	3
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	13
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	13
River or Stream	81.76	0	0	14.8	-1.00	13
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	1	1.8	2.5	-0.16	10
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	13
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	13
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	13
Nonpatterned Wet Meadow	41.98	4	7.1	7.6	-0.03	8
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	10	17.9	18.5	-0.02	7
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	13
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	13
Riverine or Upland Shrub	27.40	2	3.6	5.0	-0.16	11
Barrens (riverine, eolian, lacustrine)	79.01	5	8.9	14.3	-0.23	12
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	13
Total	551.25	56	100.00	100.00		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table 23. Distance of Tundra Swan broods to nearest waterbody habitat on the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 (ABR, unpubl. data) and 1995.

	Delta		Transportation Corridor	
Nearest Waterbody Type	Number of Broods	Mean Distance (km)	Number of Broods	Mean Distance (km)
Brackish Water	15	0.04	0	-
Tapped Lake w/ Low-water Connection	11	0.05	0	-
Tapped Lake w/ High-water Connection	9	0.10	0	-
Deep Open Water w/o Islands	13	0.05	33	0.07
Deep Open Water w/ Islands	3	0.01	8	0.07
Shallow Open Water w/o Islands	3	0.21	3	0.08
Shallow Open Water w/ Islands	2	0.00	0	-
Aquatic Sedge Marsh	0	-	3	0.01
Aquatic Grass Marsh	0	-	6	0.05
Young Basin Wetland Complex	0	-	3	0.03
Old Basin Wetland Complex	0	-	3	0.08
Grand Total and Mean	56	0.06	59	0.06

Transportation Corridor (Table 24; Appendix Tables B18–B23). Five habitats were preferred, and 10 were avoided. Preferred habitats included four waterbody types (Aquatic Grass Marsh, Aquatic Sedge Marsh, Deep Open Water with Islands or Polygonized Margins, and Deep Open Water without Islands) and Riverine or Upland Shrub.

Thirty-nine brood sightings (66% of the total) were located in Deep Open Waters (30 in Deep Open Water without Islands and 9 in Deep Open Water with Islands). No other preferred habitat had more than two sightings of broods. Aquatic Grass Marsh and Aquatic Sedge Marsh were the two most highly preferred habitats, but their high preference, in part, reflected their low availability.

The mean distance of broods to the nearest waterbody was 0.06 km in the Transportation Corridor. For 41 broods (69% of the total) Deep Open Waters (with or without Islands) were the nearest waterbody types. Nine broods were located near marshes (six in Aquatic Grass Marsh and three in Aquatic Sedge Marsh), six were near Basin Wetland Complex (Young or Old), and three were near Shallow Open Water without Islands.

Table 24. Habitat selection (pooled among years) by Tundra Swans during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989–1993 (ABR, unpubl. data) and 1995. See Appendix Tables B18—B23 for individual years.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0.00	-	-	0	-	-
Brackish Water	0.00	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0.00	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0.0	<0.1	-1.00	13
Salt Marsh	0.00	-	-	0	-	-
Tidal Flat	0.00	-	-	0	-	-
Salt-killed Tundra	0.00	-	-	0	-	-
Deep Open Water w/o Islands	30.76	30	50.8	9.0	0.70	4
Deep Open Water w/ Islands or Polygonized Margins	6.52	9	15.3	1.9	0.78	3
Shallow Open Water w/o Islands	10.84	2	3.4	3.2	0.04	6
Shallow Open Water w/ Islands or Polygonized Margins	7.36	1	1.7	2.1	-0.12	8
River or Stream	2.30	0	0	0.7	-1.00	13
Aquatic Sedge Marsh	0.97	2	3.4	0.3	0.85	2
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	13
Aquatic Grass Marsh	0.65	2	3.4	0.2	0.89	1
Young Basin Wetland Complex	14.23	2	3.4	4.1	-0.10	7
Old Basin Wetland Complex	35.59	0	0.0	10.4	-1.00	13
Nonpatterned Wet Meadow	24.47	2	3.4	7.1	-0.36	9
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	1	1.7	5.8	-0.55	10
Moist Sedge-Shrub Meadow	84.66	4	6.8	24.7	-0.57	11
Moist Tussock Tundra	94.60	2	3.4	27.6	-0.78	12
Riverine or Upland Shrub	7.74	2	3.4	2.3	0.20	5
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	13
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	13
Total	343.11	59	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

LOONS

BACKGROUND

On the Arctic Coastal Plain of Alaska, Yellow-billed Loons nest between the Colville and Meade rivers, with the highest densities found south of Smith Bay (Brackney and King 1992). The Colville Delta is an important breeding area for Yellow-billed Loons and is one of two known areas in arctic Alaska where nesting is concentrated (North and Ryan 1988). Yellow-billed Loons arrive on the delta just after the first spring meltwater accumulates on the river channels, usually during the last week of May (Rothe et al. 1983), and use openings on rivers, tapped lakes, and in the sea ice before nest lakes are available in early June (North and Ryan 1988). Nest initiation begins the second week of June, hatching occurs in mid-July, and broods usually are raised in the nest lake (Rothe et al. 1983), although broods have been observed to move to different lakes (North 1986). North (1986) found most nests on the delta in what he described as deep open lakes and deep lakes with emergent grass.

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—During aerial surveys in 1995, we counted 40 Yellow-billed Loons, of which 15 were

Table 25. Numbers and densities of loons and their nests counted on aerial surveys in late June 1992, 1993 (ABR, unpubl. data), and 1995, on the Colville River Delta, Alaska.

		Yellow-billed Loons				Pacific Loons[a]		Red-throated Loons[a]	
Area	Year	No. of birds	No. of nests	Density of birds (birds/km^2)	Density of nests (nests/km^2)	No. of birds	No. of nests	No. of birds	No. of nests
Delta (323 km^2)									
	1995	40	12	0.12	0.04	62	10	11	0
	1993	50	11	0.15	0.03	151	34	47	1
	1992[b]	12	2	0.10	0.02	5	3	2	0
Development Area (169 km^2)									
	1995	24	5	0.14	0.03	33	4	8	0
	1993	28	7	0.17	0.04	81	17	12	0
	1992[b]	4	1	0.15	0.04	0	0	0	0
Facility Area (14 km^2)									
	1995	3	1	0.22	0.07	3	0	0	0
	1993	3	1	0.22	0.07	16	4	0	0
	1992[b]	-	-	-	-	-	-	-	-
Outer Delta (155 km^2)									
	1995	16	7	0.05	0.02	29	6	3	0
	1993	22	4	0.06	0.01	70	17	35	1
	1992[b]	8	1	0.09	0.01	5	3	2	0
Transportation Corridor (274 km^2)									
	1995	4	0	0.01	0.00	88	7	0	0
	1993	0	0	0.00	0.00	140	10	7	0
	1992[b]	-	-	-	-	-	-	-	-

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and survey intensity varied among years.

[b] In 1992, three plots were sampled; 119 km^2 were surveyed on the delta, 93 km^2 were surveyed on the northern delta, and the transportation corridor and the facility area were not surveyed.

associated with 12 nests (Table 25). The distribution of Yellow-billed Loons and their nests was concentrated in the Outer Delta and the Development Area between the Elaktoveach and Sakoonang channels (Figure 10). Densities were higher in the Development Area than in the Outer Delta (Table 25). The overall density actually was highest in the smaller Facility Area, where we found three Yellow-billed Loons and one nest.

Numbers of Yellow-billed Loons and their nests were fairly stable over the last two years of study (1995 and 1993). Nearly the same number of nests were recorded in the Delta survey area during these two years (12 in 1995 and 11 in 1993; Table 25). In 1992, the delta was sampled with three plots (Smith et al. 1993); on the portion of the these plots that was within the current Delta survey area (119 km^2), nine loons with three nests were recorded (ABR, unpubl. data). The actual (1995 and 1993) and estimated (1992) nest densities for the Delta survey area were relatively low ($\leq$0.04 nests/km^2) in all three years, but numbers of breeders appeared to be fairly stable. Densities of birds were somewhat more variable and reflected higher numbers of non-breeders in 1993. Over the same years, the densities of Yellow-billed Loons and their nests in the Development Area did not differ substantially (Table 25). Likewise, in the Facility Area, numbers of loons and nests were identical in 1993 and 1995. On the Outer Delta, the density of loons declined somewhat from 1992 to 1995, but the density of nests remained about the same.

Our surveys were designed to count Yellow-billed Loons, which tend to nest on large lakes; consequently, the survey route flown did not completely sample smaller waterbodies, which are favored by Pacific and Red-throated loons. Counts of Pacific and Red-throated loons reflect their general distribution among areas (Figure 11) but are not indicative of the relative abundance of these species (due to biases in species detectability) or annual changes in abundance (resulting from annual variation in survey intensity for smaller waterbodies). Therefore, we have not calculated densities for these two species. Relative to Yellow-billed Loons, Red-throated Loons and, to a lesser extent, Pacific Loons were undercounted because of their smaller size and use of smaller lakes with emergent vegetation; both factors decrease their detectability from aircraft. We believe the actual numbers of Pacific and Red-throated loons in the study area to be several times higher than our counts. In 1995, counts of Pacific Loons and their nests were similar between the Development Area and the Outer Delta (Table 25). The low numbers of Red-throated Loons reflects the limitations of our sampling and prevents us from evaluating their distribution. On ground-based searches of the Facility Area in 1995, we found three Pacific Loons and one nest and two Red-throated Loons and two nests.

In 1993, the lake-to-lake survey pattern was flown at a higher intensity (i.e., smaller lakes were surveyed) than in 1995. This difference in survey intensity is reflected in the higher counts of Pacific and Red-throated loons in 1993 and resulted in what probably is a more accurate representation of the distribution of these two species. Pacific Loons were about as abundant in the Outer Delta as in the Development Area in 1993, whereas Red-throated Loons were more abundant in the Outer Delta than in the Development Area (Table 25). On aerial surveys in the Facility Area (no ground-based survey was conducted in this area) in 1993, 16 Pacific Loons and 4 nests were found, whereas no Red-throated Loons were seen. In 1992, few loons were found on the plots surveyed, so distributional comparisons are not warranted.

Transportation Corridor—Yellow-billed Loons did not nest in the Transportation Corridor during the two years we surveyed that area (1995 and 1993; Table 25). In 1995, only four Yellow-billed Loons and no nests were observed there. None were sighted there in 1993, although two nests were found north of there (Smith et al. 1994).

Pacific Loons were abundant both in the Transportation Corridor and in the Delta survey area, whereas Red-throated Loons appeared to be more common in the Delta survey area than in the Transportation Corridor (Figure 11, Table 25). However, because the lake habitat differs between the Delta survey area and the Transportation Corridor (e.g., fewer large lakes in the Transportation Corridor), our search effort, which focused on Yellow-billed Loons, may have biased our counts of Pacific and Red-throated loons between these two distinctly different areas. Therefore, any comparison of the distributions of these two species between and the Delta survey area

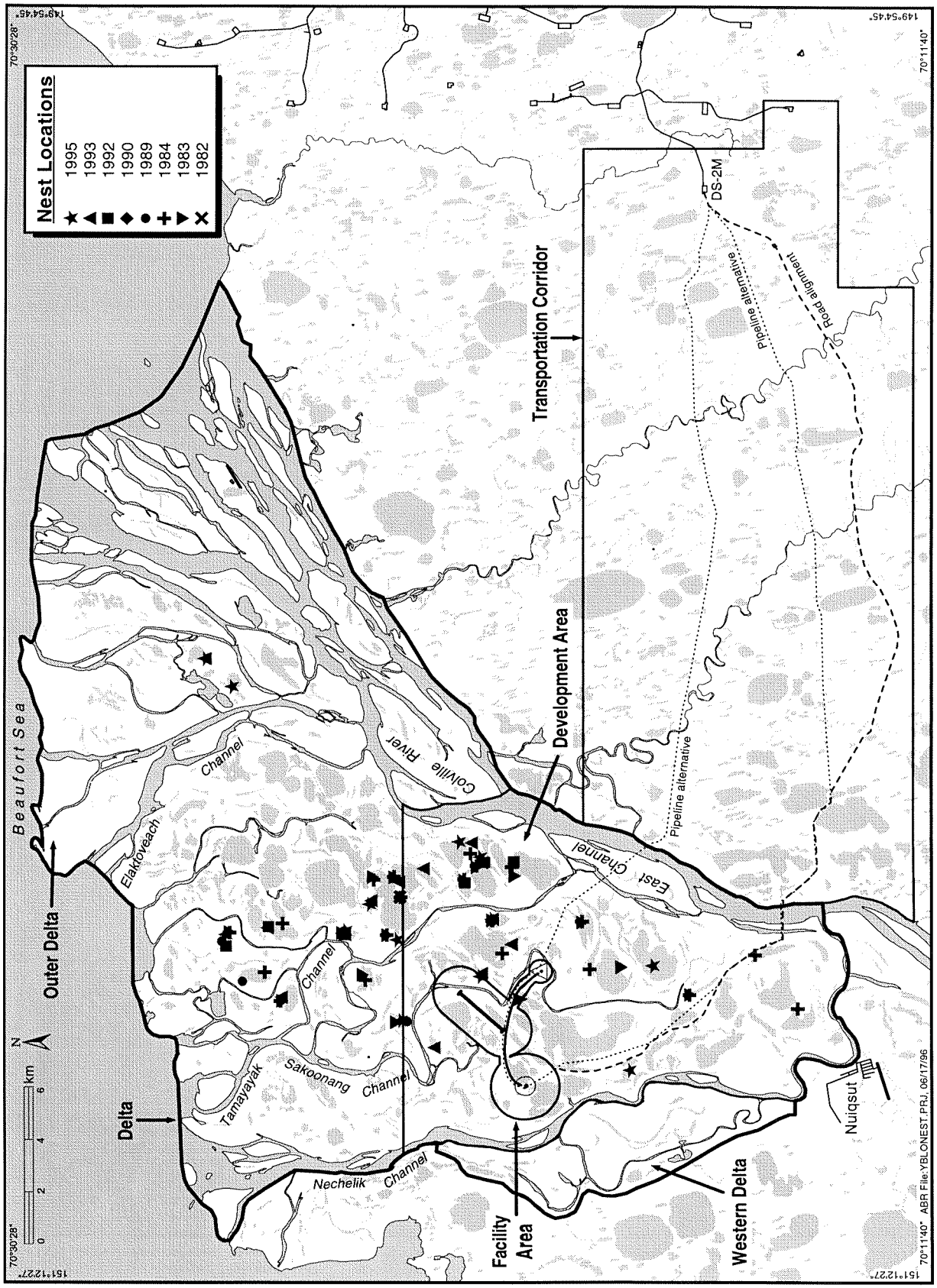


Figure 10. Distribution of Yellow-billed Loon nests observed during aerial and ground surveys in the Delta survey area, Colville River Delta, Alaska, 1982–1984, 1989-1990, 1992-1993, and 1995. Locations are from M. North (1982–1984, 1989–1990, unpubl. data), Smith et al. (1993, 1994), and this study.

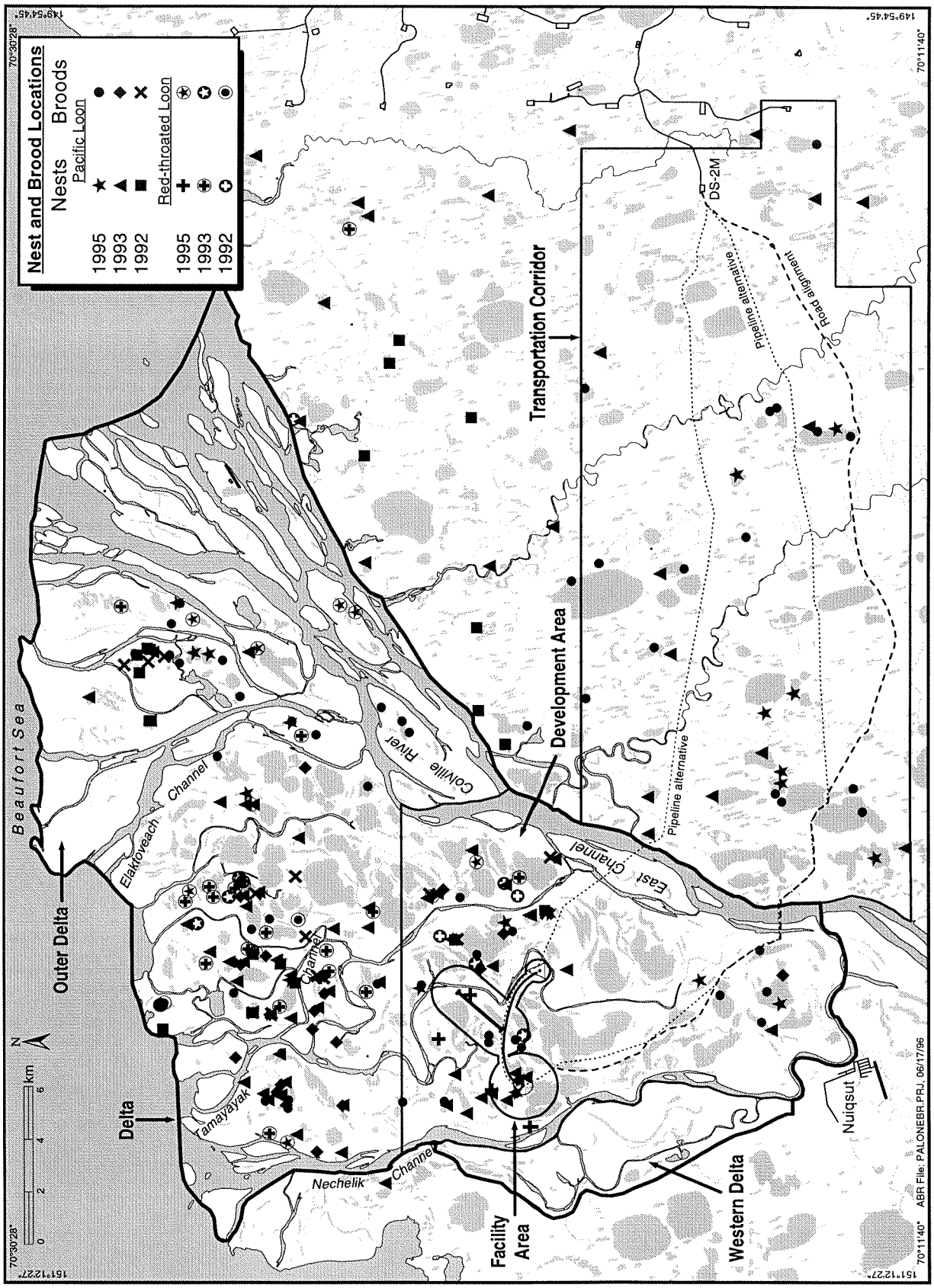


Figure 11. Distribution of Pacific and Red-Throated loon nests and broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1993, and 1995. Locations are from Smith et al. (1993, 1994) and this study.

and the Transportation Corridor should be made cautiously.

Brood-rearing

Delta—During aerial surveys for loon broods in the Delta survey area in 1995, we found more adult Yellow-billed Loons (53) than we did on the nesting survey (40) and one fewer brood (11) than the number of nests (Tables 25 and 26, Figure 12). The increase in adults probably was the result of a more intensive search effort during the brood-rearing season, when we used a helicopter as the survey platform rather than the fixed-wing aircraft that was used during nesting. Although the density of adults was higher in the Development Area than on the Outer Delta, densities of broods were similar between these two areas (Table 26). No Yellow-billed Loons were seen in the Facility Area during aerial surveys, although four adults were seen using lakes that intersected the Facility Area boundary.

Although the comparison among years is confounded by differing survey aircraft and study areas (Table 2), it appears that the density of Yellow-billed Loon broods in the Delta survey area was fairly stable during the three years of surveys (Table 26). The number of broods found on aerial surveys increased to 11 in 1995 (the only year a helicopter was used) from 8 in 1993 (ABR unpubl. data). The density recorded in 1992 was the lowest

Table 26. Numbers of loons and their broods counted on aerial surveys on the Colville River Delta, Alaska, late August 1992, 1993 (ABR, unpubl. data), and 1995.

	Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
Area Year	No. of Adults	No. of Broods	No. of Young	Birds/km^2	Broods/km^2	No. of Adults	No. of Broods	No. of Young	No. of Adults	No. of Broods	No. of Young
Delta (521 km^2)											
1995	53	11	15	0.10	0.02	213	38	46	55	9	11
1993	29	8	8	0.06	0.02	38	2	2	0	0	0
1992[b]	11	1	1	0.09	0.01	21	6	6	21	0	0
Development Area (169 km^2)											
1995	25	4	6	0.15	0.02	90	12	14	5	1	1
1993	15	3	3	0.09	0.02	17	1	1	0	0	0
1992[b]	8	0	0	0.30	0.00	10	1	1	7	0	0
Facility Area (14 km^2)											
1995	0	0	0	0.00	0.00	6	2	3	0	0	0
1993	1	0	0	0.07	0.00	0	0	0	0	0	0
1992[b]	-	-	-	-	-	-	-	-	-	-	-
Outer Delta (352 km^2)											
1995	28	7	9	0.08	0.02	123	26	32	50	8	10
1993	14	5	5	0.04	0.01	21	1	1	0	0	0
1992[b]	3	1	1	0.03	0.01	11	5	5	14	0	0
Transportation Corridor (274 km^2)											
1995	7	0	0	0.03	0.00	185	15	18	9	0	0
1993	0	0	0	0.00	0.00	0	0	0	0	0	0
1992[b]	-	-	-	-	-	-	-	-	-	-	-

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and survey intensity varied among years.

[b] In 1992, three plots were sampled; 119 km^2 were surveyed on the Delta, 93 km^2 were surveyed on the Outer Delta, and the Transportation Corridor and the Facility Area were not surveyed.

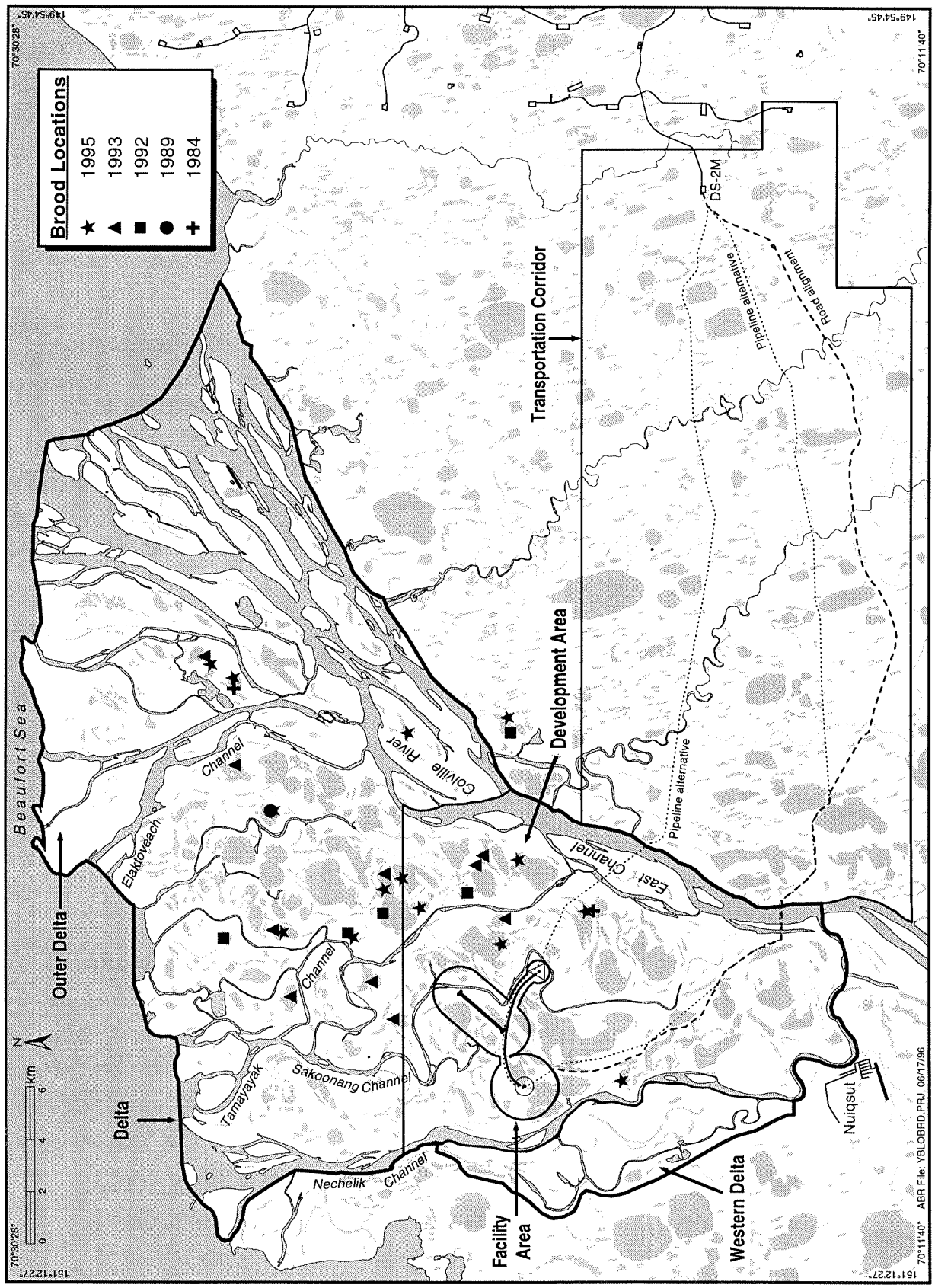


Figure 12. Distribution of Yellow-billed Loon broods observed during aerial and ground surveys in the Delta survey area, Colville River Delta, Alaska, 1984, 1989, 1992-1993, and 1995. Locations are from M. North (1984, 1989, unpubl. data), Smith et al. (1993, 1994), and this study.

among the three years, with only one brood observed on the three plots surveyed (ABR, unpubl. data). These three plots, however, covered only 119 km^2 and may not have been representative of the entire Delta survey area. The distribution of Yellow-billed Loons was similar each year, in that a higher density of adults was observed in the Development Area than in the Outer Delta, but the density of broods was nearly the same between the two areas. No broods were observed in the Facility Area in the two years that surveys were conducted there.

Both Pacific and Red-throated loons were abundant on the Delta survey area during helicopter surveys in 1995 (Figure 11, Table 26). More broods and adults of both species were seen on the Outer Delta than in the Development Area. In the Facility Area, we saw two broods of Pacific Loons and none of Red-throated Loons. Four additional broods of Pacific Loons and a pair of Red-throated Loons were seen during the course of other field activities in the Facility Area.

In 1993 and 1992, counts of Pacific and Red-throated loon adults and broods were the same or slightly higher on the Outer Delta than in the Development Area (Table 26). However, the low number of adults and broods seen in these two years suggests that the survey intensity was not sufficient to detect any differences.

Transportation Corridor—As during the nesting season, the Transportation Corridor was unimportant to Yellow-billed Loons during the brood-rearing season. In 1995, no broods and only four adults were seen during our intensive helicopter survey (Table 26). Likewise, no broods were seen there during a fixed-wing survey in 1993.

Pacific Loons and their broods were abundant (171 adults and 12 broods) in the Transportation Corridor in 1995, but the larger Delta survey area yielded slightly higher numbers (213 adults and 38 broods). More Red-throated Loons also were recorded in the Delta survey area than in the Transportation Corridor (Table 26); only seven Red-throated Loons and no broods were seen in the Transportation Corridor in 1995. In 1993, only a cursory search of the Transportation Corridor was done, and no Pacific Loons were recorded. In 1992, the Transportation Corridor was not surveyed.

HABITAT SELECTION

Nesting

On the delta in 1993 and 1995, 23 Yellow-billed Loon nests were recorded in 6 of 20 available habitats, of which 4 were preferred (Table 27). Annual measures of habitat selection are reported in Appendix Tables B24–B25. The most preferred habitats were the two Deep Open Water types (without Islands and with Islands or Polygonized Margins), which accounted for 9 (39%) of the 23 nests. Tapped Lake with High-water Connections, and Aquatic Sedge with Deep Polygons were the next most preferred habitats. Deep Open Lake without Islands and Wet Sedge-Willow Meadow with Low-relief Polygons were the two most frequently used habitats for nesting; each contained six nests, but the latter habitat, because of its abundance (20% of the area), actually was used in proportion to its availability. A larger sample of nests (located on aerial and ground-based surveys) confirmed the importance of Wet Sedge-Willow Meadow with Low-relief Polygons (28% of all nests) and Deep Open Water without Islands (22% of all nests; Table 28). However, nesting Yellow-billed Loons probably were attracted more to waterbodies than to a particular terrestrial habitat, because the mean distance to the nearest waterbody was 0.01 km and the waterbodies most commonly near nests were Deep Open Water without Islands (47% of all nests) and Tapped Lake with High-water Connections (31% of all nests).

No analysis of habitat selection was conducted for Yellow-billed Loons in the Transportation Corridor. Although aerial surveys during nesting and brood-rearing seasons were flown during 1993 and 1995, we found no nests or broods in this area.

Brood-rearing

During brood-rearing in 1995, we found 11 Yellow-billed Loon broods in only three habitats (Deep Open Lakes with and without Islands and Tapped Lake with High-water Connections), all of which were preferred (Table 29). These same habitats also were preferred during nesting. The most preferred and frequently used habitat for broods (73% of all broods) was Deep Open Water without Islands, which also was the most frequently

Table 27. Habitat selection (pooled among years) by Yellow-billed Loons during nesting on the Delta survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data), and 1995. See Appendix Tables B24–B25 for individual years.

Habitat	No of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	0	1.2	-1.00	7
Brackish Water	0	0	0.9	-1.00	7
Tapped Lake w/ Low-water Connection	0	0	4.8	-1.00	7
Tapped Lake w/ High-water Connection	4	17.4	4.7	0.57	3
Salt Marsh	0	0	2.6	-1.00	7
Tidal Flat	0	0	6.6	-1.00	7
Salt-killed Tundra	0	0	3.9	-1.00	7
Deep Open Water w/o Islands	6	26.1	5.1	0.67	2
Deep Open Water w/ Islands or Polygonized Margins	3	13.0	1.0	0.86	1
Shallow Open Water w/o Islands	0	0	0.5	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0.1	-1.00	7
River or Stream	0	0	14.1	-1.00	7
Aquatic Sedge Marsh	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	2	8.7	2.7	0.52	4
Aquatic Grass Marsh	0	0	0.3	-1.00	7
Young Basin Wetland Complex	-		0	-	-
Old Basin Wetland Complex	-	-	0	-	-
Nonpatterned Wet Meadow	2	8.7	8.1	0.00	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	6	26.1	20.1	0.13	5
Moist Sedge-Shrub Meadow	0	0	2.4	-1.00	7
Moist Tussock Tundra	0	0	0.2	-1.00	7
Riverine or Upland Shrub	0	0	5.4	-1.00	7
Barrens (riverine, eolian, lacustrine)	0	0	15.2	-1.00	7
Artificial (water, fill, peat road)	-	-	0	-	-
Total	23	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

used habitat for nesting loons. The concurrence of habitats selected in both seasons confirms the importance of large deep waterbodies to breeding Yellow-billed Loons.

BRANT

BACKGROUND

The Colville Delta is an important staging area for migrating Brant in early spring (Simpson et al. 1982, Renken et al. 1983) and supports the largest concentration of nesting Brant along the entire coastal plain of Alaska (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983, Bayha et al. 1992). Brant arrive on the Colville Delta during late May and early June, and nest initiation begins as soon as suitable nesting habitat is available (Kiera 1979, Rothe et al. 1983). Most Brant nests (>900; Philip Martin, USFWS, Fairbanks, unpubl. data) on the delta are located within a colony-complex consisting of at least ten islands centered around Anachlik Island (hereafter, the Anachlik Colony-complex) at the mouth of the East Channel (Simpson et al. 1982, Renken et al. 1983, Bayha et al. 1992). Additional traditional nesting locations for Brant are scattered across the northern half of the delta (Smith et al. 1993, 1994).

Table 28. Habitat use by Yellow-billed Loons and distance to nearest waterbody during nesting from aerial and ground surveys in the Delta survey area, Colville River Delta, Alaska, 1992–1993 (ABR, unpubl. data), and 1995. Nests were found during ground searches of selected portions of the study area. Distance to waterbody was measured from a digital map and may not be as accurate as measurement on ground.

Habitat	No. of Nests	Use (%)	Mean Distance to Waterbody (km)
HABITAT USED			
Tapped Lake w/ High-water Connection	4	12.5	
Deep Open Water w/o Islands	7	21.9	
Deep Open Water w/ Islands or Polygonized Margins	4	12.5	
Aquatic Sedge w/ Deep Polygons	4	12.5	
Nonpatterned Wet Meadow	3	9.4	
Wet Sedge-Willow Meadow w/ Low-relief Polygons	9	28.1	
Moist Sedge-Shrub Meadow	1	3.1	
Total	32	100.0	
NEAREST WATERBODY HABITAT			
Tapped Lake w/ Low-water Connection	1	3.1	0.08
Tapped Lake w/ High-water Connection	10	31.3	0.00
Deep Open Water w/o Islands	15	46.9	0.01
Deep Open Water w/ Islands or Polygonized Margins	5	15.6	0.00
Shallow Open Water w/o Islands	1	3.1	0.00
Total	32	100.0	0.01

After eggs hatch in early July, most brood-rearing groups move from nesting areas to halophytic sedge-grass meadows along the coast. A large, but unknown percentage of the Brant from the Anachlik Colony-complex migrates northeast towards Oliktok and Beechey points (Stickney et al. 1994, Anderson et al. 1996), but many remain on Anachlik Island, and another segment migrates northwest of the East Channel (J. Helmericks, pers. comm.). Brant from the smaller colonies most likely use halophytic meadows from the Elaktoveach Channel to as far west as the mouth of the Tingmeachsiovik River (Smith et al. 1994), outside of our study area.

The fall migration of Brant along the arctic coast of Alaska usually begins in mid-late August (Johnson and Herter 1989). Major river deltas, such as the Colville Delta, provide important resting and feeding areas for migrating Brant (Johnson and Richardson 1981). These Brant tend to stage along the coast in areas similar to, but not limited to, those used by brood-rearing groups (Smith et al. 1994).

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—During aerial and ground-based surveys in 1995, we recorded 37 Brant nests at 12 locations outside of the Anachlik Colony-complex (Figure 13). More than 123 Brant were seen on the delta, 97 of which were counted during the aerial survey. Our counts of nests and adults recorded during the aerial survey were only 38% and 44%, respectively, of those recorded in 1993 (Smith et al. 1994). However, Brant in 1995 occupied 8 of 10 locations used in 1993 for nesting and another

Table 29. Habitat selection by Yellow-billed Loons during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	2.0	-1.00	4
Brackish Water	6.50	0	0	1.3	-1.00	4
Tapped Lake w/ Low-water Connection	21.14	0	0	4.1	-1.00	4
Tapped Lake w/ High-water Connection	20.22	2	18.2	3.9	0.65	3
Salt Marsh	16.68	0	0	3.2	-1.00	4
Tidal Flat	55.90	0	0	10.7	-1.00	4
Salt-killed Tundra	25.63	0	0	4.9	-1.00	4
Deep Open Water w/o Islands	21.88	8	72.7	4.2	0.89	1
Deep Open Water w/ Islands or Polygonized Margins	4.83	1	9.1	0.9	0.81	2
Shallow Open Water w/o Islands	2.27	0	0	0.4	-1.00	4
Shallow Open Water w/ Islands or Polygonized Margins	0.52	0	0	0.1	-1.00	4
River or Stream	80.75	0	0	15.5	-1.00	4
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.01	0	0	2.5	-1.00	4
Aquatic Grass Marsh	1.37	0	0	0.3	-1.00	4
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	38.41	0	0	7.4	-1.00	4
Wet Sedge-Willow Meadow w/ Low-relief Polygons	88.55	0	0	17.0	-1.00	4
Moist Sedge-Shrub Meadow	10.72	0	0	2.1	-1.00	4
Moist Tussock Tundra	1.69	0	0	0.3	-1.00	4
Riverine or Upland Shrub	23.25	0	0	4.5	-1.00	4
Barrens (riverine, eolian, lacustrine)	76.82	0	0	14.8	-1.00	4
Artificial (water, fill, peat road)	0.02	0	0	0.0	-1.00	4
Total	520.61	11	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

location that was used in 1992. Although different observers were employed in 1995 than previous years and that may partially explain the lower count in 1995, the increase in nests from 1992 to 1993 and decrease in 1995 probably represents annual variation in nesting activity by Brant.

Most Brant nesting locations in 1995 occurred in the Outer Delta survey area (Figure 13). We located Brant at seven locations in this area in 1995, at nine locations in 1993, and at three locations in 1992. Our ground-based surveys indicated that some Brant were nesting farther inland than we regularly fly our aerial surveys; however, another study between the Colville and Kuparuk rivers has indicated that most (75%) Brant nesting locations occur within 5 km of the coast (Stickney et al. 1994). The distributional patterns that we have observed in all three years on the delta are consistent with these other longer-term studies.

We recorded four Brant nesting locations within the Development Area during combined aerial and ground-based surveys in 1995; we found one location in 1993 and two locations in 1992. The one location recorded in 1993 was used by Brant during all three years of surveys and had ≥3 nests in 1995 and ≥10 nests in 1993. Within the Facility Area, we found two Brant nesting locations in 1995. Because this area was not covered in previous years either by

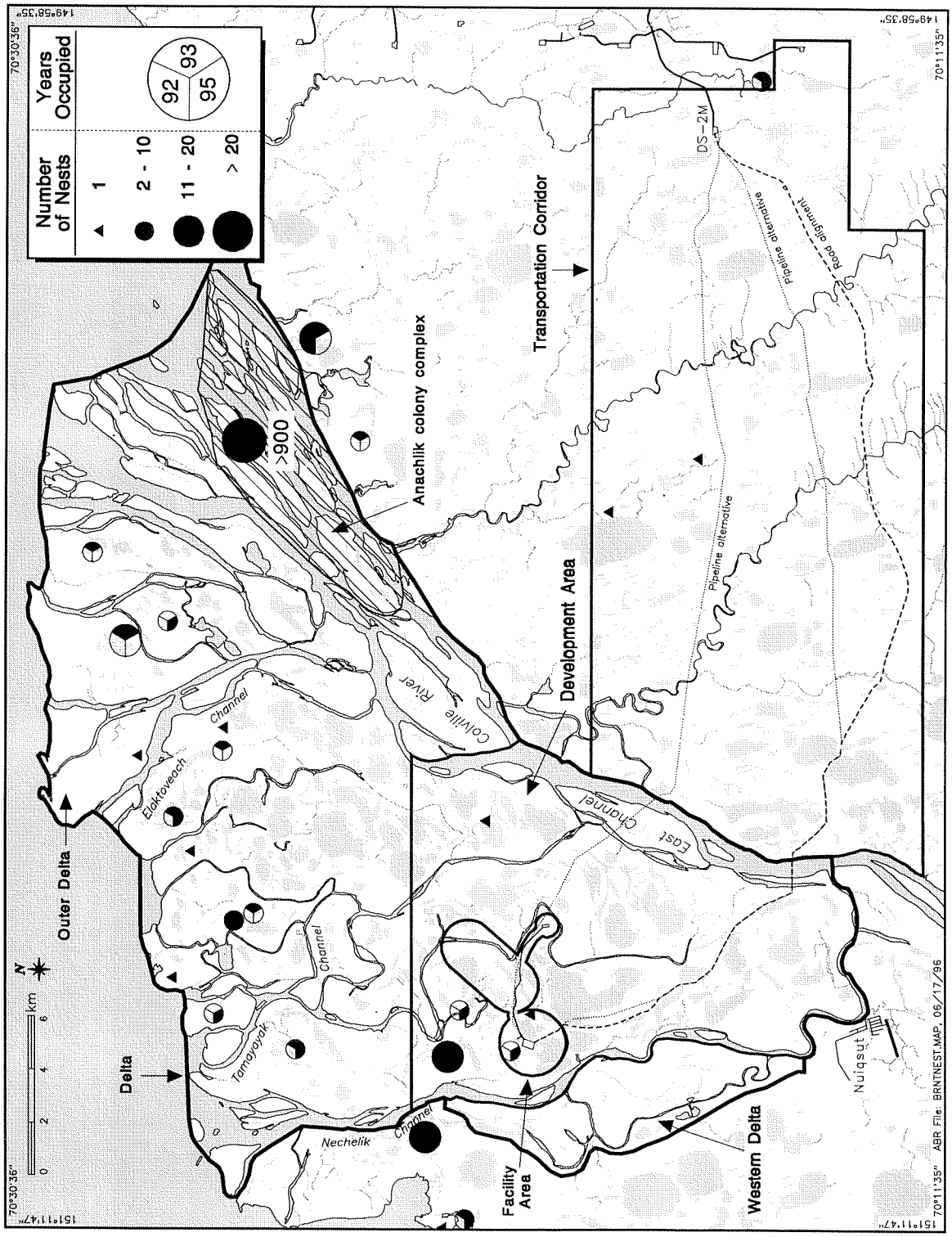


Figure 13. Distribution and nest counts of Brant colonies located during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, 1992–1993 and 1995.

ground surveys or aerial surveys searching for Brant, there are no data available on prior use of these locations by Brant. One location consisted of a solitary nest; the other location was a colony of ≥10 nests that probably was a traditional site.

Transportation Corridor—The number of Brant nesting in the Transportation Corridor was limited in all three years (Figure 13). In 1995, we counted a total of six Brant and found two Brant nests at two locations in the Transportation Corridor. Only 2–3 nesting locations are known to be used traditionally (Smith et al. 1993, 1994; Stickney et al. 1994), and these usually have <5 nests.

Brood-rearing

Delta—In 1995, a banding study indicated that brood-rearing groups of Brant from the Colville Delta dispersed as far east as Beechey Point (Anderson et al., 1996); whether they dispersed as far west as the Tingmeachsiovik River (as in 1993) was unknown. Within the delta, 1,480 Brant (768 adults and subadults and 712 goslings) were recorded at six locations along the coast (Figure 14). Size of brood-rearing groups ranged from 30 to 647 birds, and the percentage of goslings ranged from 45 to 60% ($\bar{x}$ = 48%).

The number of Brant in brood-rearing groups on the delta in 1995 was higher than in 1993 ($\bar{x}$ = 634 birds); both years were higher than 1992 (62 birds), when a bear destroyed much of the Anachlik Colony-complex (Jim Helmericks, pers. comm.; Figure 14, Table 30). The number of Brant observed in 1995 was the largest ever counted since surveys were started by USFWS in 1988 (Bayha et al. 1992, Smith et al. 1993, 1994) and reflect both the steady growth of the Anachlik Colony-complex and overall high productivity in 1995.

The mean percentage of goslings in 1995 (48%) was similar in 1993 (53%), but both were much higher than in 1992 (13%). The number of Brant in brood-rearing groups on the delta in 1995 was similar to the number in the adjacent region between the Kuparuk River and Kalubik Creek (1,569 birds), another destination for brood-rearing groups from the large Colville colonies. Furthermore, the mean percentage of goslings in groups on the delta was similar in the Kuparuk River to Kalubik Creek region (46%).

No brood-rearing groups of Brant were seen in either the Development Area or the proposed Facility Area during the aerial survey on 4 August 1995; none were seen in 1992 or 1993 as well. Although it is possible that small, inland groups may have been missed by the survey, data from Brant studies between the Sagavanirktok and Colville rivers indicate that most (>99%) Brant rear their broods along the coast (Stickney and Ritchie 1996).

The distribution of brood-rearing birds along the Outer Delta showed similar patterns in each year surveyed since 1988; Table 30). In all years except 1988 and 1992, most Brant occurred in that region of the delta between the East Channel and the Elaktoveach Channel. Why there was a different pattern in 1988 is unknown, but in 1992, the major nest losses sustained by the largest Colville colonies may have resulted in the lack of brood-rearing birds in the region northwest of this colony.

Transportation Corridor—No brood-rearing groups of Brant were seen in the Transportation Corridor in any year. Birds that nest in this area may migrate to the halophytic meadows between Kalubik Creek and the Miluveach River.

Fall Staging

Delta—During the fall-staging survey in late August 1995, 739 Brant were seen at 10 locations on the Colville Delta (Figure 15). Group sizes ranged from 10 to 250 birds ($\bar{x}$ = 73.9 birds). The number of Brant counted on the delta during staging in 1995 was higher than in either 1993 (686 birds) or 1992 (385 birds). The distribution of groups along the coast was not identical either among years or between brood-rearing and staging, although there were some similarities. In 1995, 8 of 10 groups were observed west of the Elaktoveach Channel. In contrast, most groups seen in 1993 (10 of 22) occurred east of the Elaktoveach Channel, a pattern also observed in 1989 by Bayha et al. (1992). This variability in staging locations may be due to a greater mobility of Brant during this period and/or greater ability to use a wider range of foods.

Although most fall-staging birds were seen near the coast, one group of 150 birds was seen in a large Tapped Lake with Low-water Connection in the Development Area, just outside of the boundary of the Facility Area (Figure 15). The area surrounding

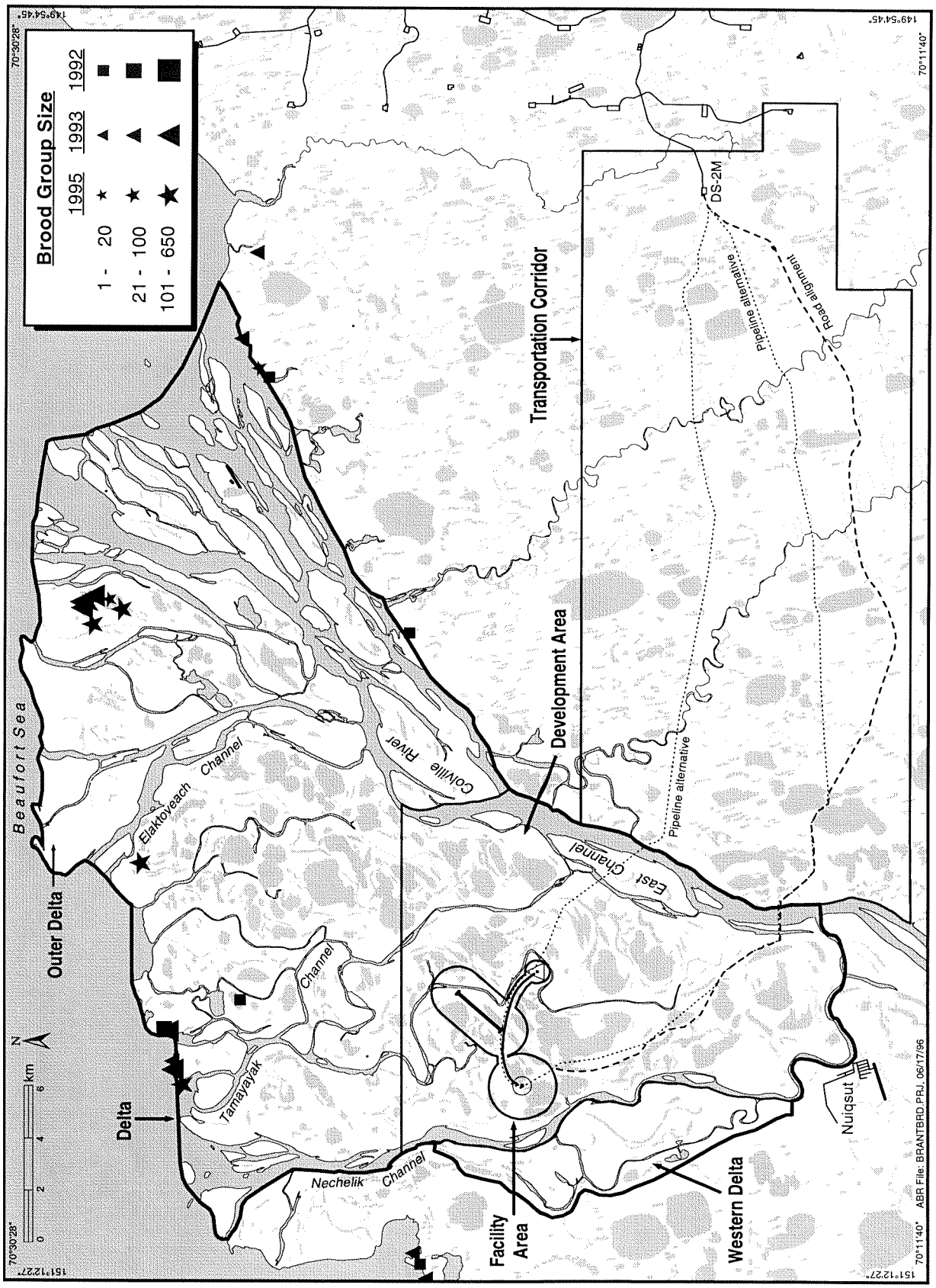


Figure 14. Distribution and size of Brant brood-rearing groups observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, 1992–1993 and 1995. Locations are from Smith et al. (1993, 1994) and this study.

Table 30. Abundance and distribution of Brant in brood-rearing groups during late July-early August on the Colville Delta, Alaska. Data for years prior to 1992 are from Bayha et al. (1992). Data for other years are from ABR (unpubl. data) and this study. Except where noted, all numbers are an average from two surveys.

Year	East Channel to Elaktoveach Channel	Elaktoveach Channel to Nechelik Channel	Total
1995[a]	1,175	305	1,480
1993	470	164	634
1992[a]	0	62	62
1991	410	100[a]	510
1990	433	195	628
1988	70	103	173

[a] Data are from one survey only.

this lake was not surveyed in previous years, so no information is available for prior use by Brant. There also is no record of use of the Transportation Corridor by Brant during fall staging, suggesting that suitable habitat is limited in the corridor during this period, as also is the case during brood-rearing.

HABITAT SELECTION

Brant associated closely with coastal areas during nesting, brood-rearing, and fall staging (Figures 13–15). Although we have found small nesting colonies or single nests in the Development Area and Transportation Corridor, surveys of these areas have been intermittent and sample sizes were inadequate for an analysis of habitat selection (small sample sizes in these areas may be due to a lack of suitable habitat). Therefore, we restricted our analysis to those portions of the Outer Delta that were surveyed completely in 1992, 1993, and 1995 during nesting and in 1993 and 1995 during brood-rearing.

Nesting

A total of 14 colonies (excluding the Anachlik Colony-complex) have been used by Brant for nesting in the Outer Delta survey area in 1992, 1993, and 1995 (Table 31). Five habitats were preferred, including Brackish Water, Aquatic Sedge with Deep Polygons, Salt Marsh, Salt-killed Tundra, and Nonpatterned Wet Meadow. Brackish Water was the most preferred habitat, with two colonies (14% of the total), whereas Salt-killed Tundra, which contained more colonies than any other habitat (4; 29% of the total), was fourth in preference because of its greater availability (9.3% of the total area). Basin Wetland Complexes, which typically are preferred by Brant elsewhere on the Arctic Coastal Plain, were not available in the Outer Delta survey area. Most colonies were within 60 m of a major waterbody (Table 32), primarily Brackish Water and secondarily Deep Open Lakes (both with and without Islands).

Brood-rearing

During brood-rearing in 1993 and 1995, 23 groups were observed in nine different habitats (Table 33). Annual measures of habitat selection are reported in Appendix Tables B26–27. Two habitats were preferred: nine groups were observed in Brackish Water, and two were observed in Salt Marsh. When disturbed by our survey aircraft, however, brood-rearing groups usually moved into nearby water, so this preference for waterbodies may be biased. Five other habitats were selected in proportion to their availability: Aquatic Sedge with Deep Polygons, Wet Sedge-Willow with Low-relief Polygons, Open Nearshore Water (another escape habitat), Salt-killed Tundra, and Tidal Flat. The average distance of brood-rearing groups from the nearest major waterbody was 290 m (Table 32); 20 of 23 groups were closest to Brackish Water,

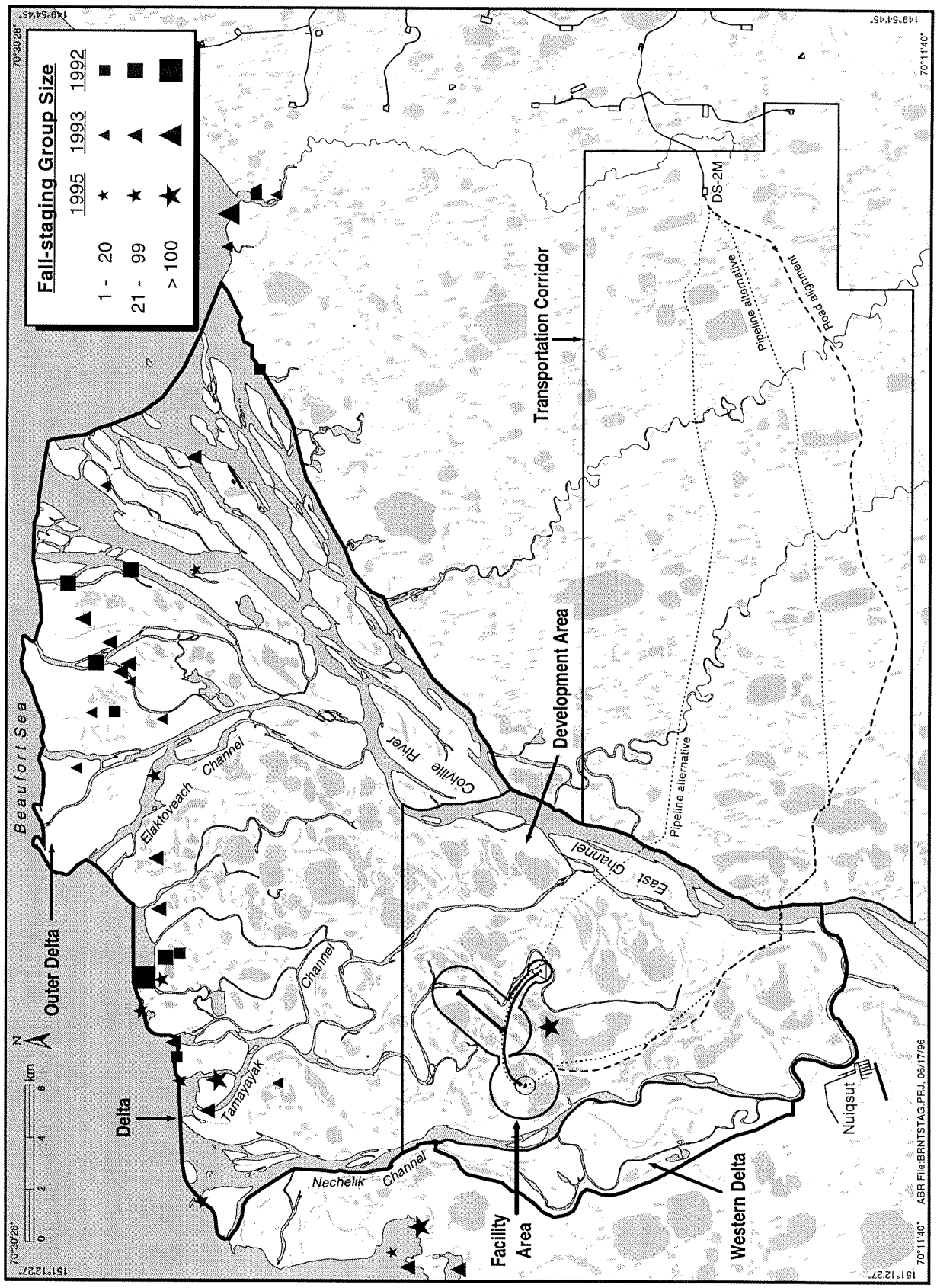


Figure 15. Distribution and size of Brant fall-staging groups observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, 1992–1993 and 1995. Locations are from Smith et al. (1993, 1994) and this study.

Table 31. Habitat selection by Brant during nesting (based on the cumulative locations of colonies) on the Outer Delta survey area, Colville River Delta, Alaska, 1992–1993 (ABR, unpubl. data) and 1995. Locations do not include the Anachlik colony complex.

Habitat	Area (km^2)	Maximal Estimate of Nests	No. of Nesting Locations	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	-	-	4.2	-	-
Brackish Water	6.41	2	2	14.3	2.6	0.70	1
Tapped Lake w/ Low-water Connection	5.54	0	0	0	2.2	-1.00	7
Tapped Lake w/ High-water Connection	2.20	0	0	0	0.9	-1.00	7
Salt Marsh	13.11	22	3	21.4	5.2	0.61	3
Tidal Flat	55.89	0	0	0.0	22.3	-1.00	7
Salt-killed Tundra	23.25	8	4	28.6	9.3	0.51	4
Deep Open Water w/o Islands	2.07	0	0	0	0.8	-1.00	7
Deep Open Water w/ Islands or Polygonized Margins	2.64	0	0	0	1.1	-1.00	7
Shallow Open Water w/o Islands	0.70	0	0	0	0.3	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0.26	0	0	0	0.1	-1.00	7
River or Stream	49.41	0	0	0	19.7	-1.00	7
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	7.62	15	2	14.3	3.1	0.65	2
Aquatic Grass Marsh	0.37	0	0	0	0.2	-1.00	7
Young Basin Wetland Complex	0	-	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	-	0	-	-
Nonpatterned Wet Meadow	15.33	30	2	14.3	6.1	0.40	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	16.55	3	1	7.1	6.6	0.04	6
Moist Sedge-Shrub Meadow	2.49	0	0	0	0.1	-1.00	7
Moist Tussock Tundra	1.68	0	0	0	0.7	-1.00	7
Riverine or Upland Shrub	1.25	0	0	0	0.5	-1.00	7
Barrens (riverine, eolian, lacustrine)	32.99	0	0	0	13.2	-1.00	7
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	7
Total	250.25	80	14	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability); calculated for nesting locations only.
[b] Order is increasing from high preference to high avoidance.

Table 32. Distance to nearest waterbody of Brant nesting colonies and brood-rearing groups from aerial and ground surveys in the Delta survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data), and 1995. Distance to waterbody was measured from a digital map and may not be as accurate as measurement on ground.

	Nesting[a]			Brood-rearing			
Nearest Waterbody Habitat	No. of Colonies	Use (%)	Mean Distance to Waterbody (km)	No. of Groups	Use (%)	Total Birds	Mean Distance to Waterbody (km)
Open Nearshore Water	-	-	-	1	4.3	196	0.00
Brackish Pond	10	71.5	0.08	18	78.3	2,809	0.12
Deep Open Water w/o Islands	1	7.1	0.04	-	-	-	-
Deep Open Water w/ Islands or Polygonized Margins	1	7.1	<0.01	2	8.7	64	0.28
River or Stream	-	-	-	2	8.7	50	0.0
Aquatic Grass	2	14.3	0.01	-	-	-	-
Total	14	100.0	0.06	23	100.0	3,119	0.12

[a] Excludes Anachlik Colony-complex.

Table 33. Habitat selection (pooled among years) by Brant during brood-rearing on the Outer Delta survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data) and 1995. See Appendix Tables B26–B27 for individual years.

Habitat	Area (km^2)	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	1	4.4	4.8	-0.05	5
Brackish Water	6.29	9	39.1	2.9	0.86	1
Tapped Lake w/ Low-water Connection	5.17	0	0	2.4	-1.00	10
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1 00	10
Salt Marsh	12.61	2	8.7	5.8	0.20	2
Tidal Flat	55.89	4	17.4	25.5	-0.19	7
Salt-killed Tundra	22.22	2	8.7	10.2	-0.08	6
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	10
Deep Open Water w/ Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	10
Shallow Open Water w/o Islands	0.53	0	0	0.2	-1.00	10
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	10
River or Stream	43.15	2	8.7	19.7	-0.39	8
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.41	1	4.4	2.9	0.20	3
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	10
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	10
Wet Sedge-Willow Meadow w/ Low-relief Polygons	9.33	1	4.4	4.3	0.01	4
Moist Sedge-Shrub Meadow	1.73	0	0	0.8	-1.00	10
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	10
Riverine or Upland Shrub	0.80	0	0	0.4	-1.00	10
Barrens (riverine, eolian, lacustrine)	28.08	1	4.4	12.8	-0.49	9
Artificial (water, fill, peat road)	0.02	0	0	0.0	-1.00	10
Total	219.06	23	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

2 groups were closest to Deep Open Lake with Islands, and one group was seen in the Colville River (River or Stream).

GREATER WHITE-FRONTED GEESE

The Colville Delta is a regionally important nesting area for Greater White-fronted Geese. In the early 1980s, the USFWS recorded mean densities during June of 6.28 birds/km^2, and nest densities of 1.8 nests/km^2, which are among the highest densities recorded for these geese on the Arctic Coastal Plain of Alaska (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983).

NESTING

We did not conduct intensive searches specifically for the nests of Greater White-fronted Geese in 1995, although we located 40 of their nests during the ground-based searches for Spectacled Eider nests in selected areas within the Development Area and Transportation Corridor. Nine Greater White-fronted Goose nests (1.5 nests/km^2) were found within the Facility Area in 1995 (see Figure 18 under "Other Waterbirds"), over 80% of which were located on polygon ridges, similar to the preferred nesting habitat reported by Simpson and Pogson (1982). The distance of nests to nearest waterbody ranged from <1–150 m. The mean clutch size in 1995 was 4.1 eggs (n = 14 nests), similar to the range reported by other studies on the Colville Delta (Simpson and Pogson 1982; Simpson 1983; Smith et al. 1993, 1994).

BROOD-REARING

The distribution and group sizes of brood-rearing and molting Greater White-fronted Geese were collected as secondary information during two aerial surveys conducted for eiders, loons, and Brant in late July 1995. Because locations and numbers

were recorded over multiple surveys on an opportunistic basis, the data are most valuable in describing the relative distribution of these groups; however, counts were not collected systematically to estimate abundance and should be interpreted cautiously. We also did not systematically count goslings, so some groups may have contained only molting birds without young. Therefore, numbers in groups represent counts of total birds. Although we did not conduct systematic searches for Greater White-fronted Geese, we saw 1,235–1,347 birds on surveys in 1995 (Figure 16). Group size of these brood-rearing and/or molting flocks ranged from 7 to 450. In 1992 we saw a total of 908 Greater White-fronted Geese on one survey; in 1993 we did not collect any information on these geese during brood-rearing.

In 1995, the Outer Delta was more important to Greater White-fronted Goose groups than were other portions of the study area (Figure 16). On the Outer Delta, 1,184 and 910 geese were found during two surveys; 81 were seen in the Development Area, but none were seen in the Facility Area. A similar distribution was found in 1992: 783 geese in the Outer Delta survey area and 125 in the Development Area. The Transportation Corridor appears to be used by fewer Greater White-fronted Geese during brood-rearing. In 1995, we saw 82–200 on two brood-rearing surveys.

FALL STAGING

During fall staging, Greater White-fronted Geese concentrated more towards the coast than they did during brood-rearing (Figure 17). On 18–21 August 1995, 647 birds were seen in 22 groups on the delta, including groups that were east and just outside of the study area. In 1993, no Greater White-fronted Geese were recorded during the single staging survey in August. In 1992, 1,900–2,300 geese were seen on the delta in three different surveys, and 555 were seen on the delta in 1991 (ABR, unpubl. data). Our data are insufficient to indicate whether this annual variation in numbers is due to differences in survey timing and intensity or due to actual changes in abundance.

In 1995, three groups (25, 30, and 100 birds) of Greater White-fronted Geese were seen within the Development Area; the group of 25 occurred in the Facility Area. In 1992, only 20 birds were observed on one survey in the Development Area, and none were in the Facility Area. In 1991, 194 birds were seen in the Development Area, of which 35 were in the Facility Area (ABR, unpubl. data).

During fall staging in 1995, we observed one group of 30 Greater White-fronted in the Transportation Corridor. On aerial surveys in 1988 and 1990–1991, we counted 18–354 of these geese in the Transportation Corridor (ABR, unpubl. data).

SNOW GEESE

Lesser Snow Geese may have nested commonly along portions of the Arctic Coastal Plain early in this century (Anderson 1913, Bailey 1948, Gabrielson and Lincoln 1959). In the past few decades, only small numbers have nested sporadically along the Beaufort Sea coast, generally west of the Sagavanirktok River Delta (Derksen et al. 1981, Simpson et al. 1982, R. J. King, USFWS, pers. comm.). Three small but notable colonies (26-≤400 nests) are known from the Sagavanirktok, Ikpikpuk, and Kukpowruk river deltas (Ritchie and Burgess 1993). In addition, small numbers of Snow Geese (indicating possible nesting) and nests have been observed from the Kuparuk Oilfield to Kasegaluk Lagoon (King 1970, Ritchie and Burgess 1993, ABR, unpubl. data). In the past, molting and brood-rearing areas for Snow Geese may have been more widespread in the western Beaufort Sea region (Bailey 1948). Today, large numbers of Snow Geese occur only in the central Beaufort Sea region of the Arctic Coastal Plain, in northeastern Alaska, and in the Yukon Territory, where a large portion of the western arctic Snow Goose population stages during fall (Johnson and Herter 1989).

NESTING

In 1995, one Snow Goose nest was seen during the aerial nesting survey for Tundra Swans; in both 1994 and 1993, two Snow Goose nests were encountered during ground-based searches (ABR, unpubl. data). In all cases, the nests were located <5 km from the coast in the Outer Delta survey area

BROOD-REARING

Twelve Snow Geese without broods were observed during a brood-rearing survey of the Outer Delta in late July 1995. No other observations of brood-rearing Snow Geese were recorded during surveys of the study in 1993 or 1992.

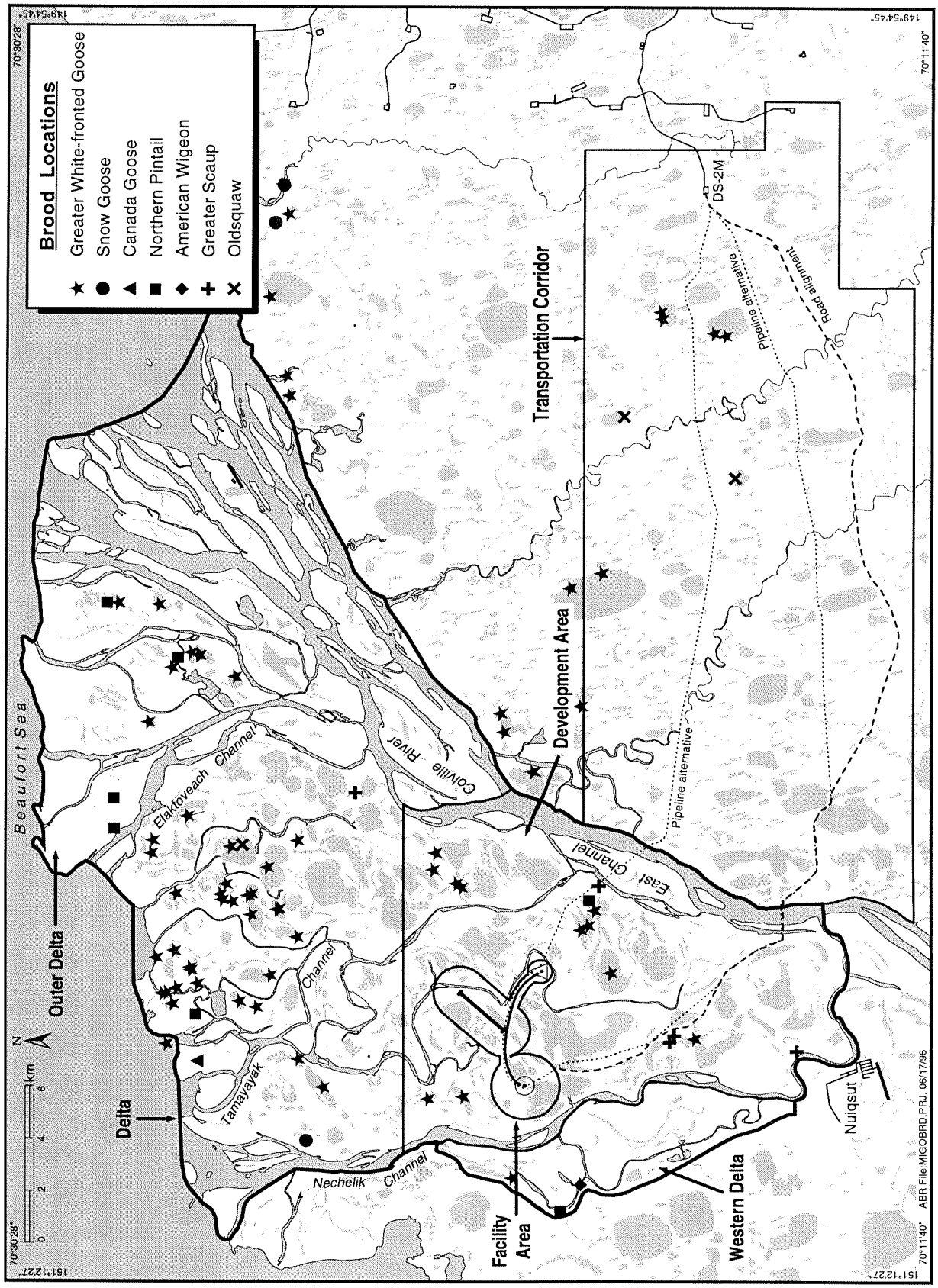


Figure 16. Distribution of brood and molting groups of various goose and duck species observed in July during aerial surveys for Brant, eiders, and loons in the Delta and Transportation Corridor survey areas, Colville River Delta, 1992–1993 and 1995. Locations are from ABR (1992–1993, unpubl. data) and this study.

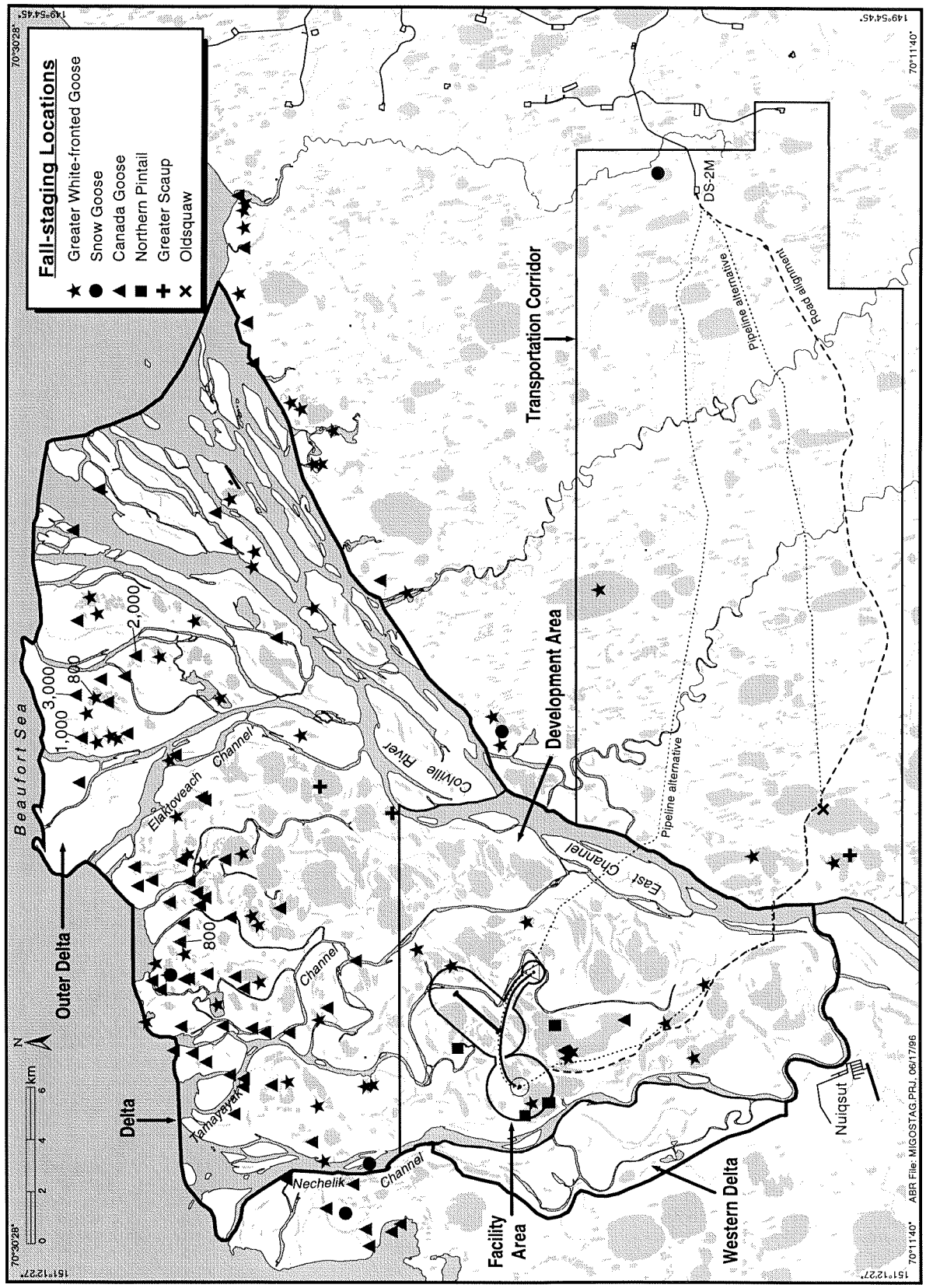


Figure 17. Distribution of fall-staging groups of various goose and duck species observed in August during miscellaneous aerial surveys for geese and Tundra Swans in the Delta and Transportation Corridor survey areas, Colville River Delta, 1988, 1990–1993, and 1995. Numbers indicate size of groups greater than 500. Locations are from ABR (1988, 1990–1993, unpubl. data) and this study.

FALL STAGING

Snow Geese were observed during staging only in 1991 (6 birds in the Transportation Corridor; ABR, unpubl. data) and 1995 (20 birds in 3 groups in the Outer Delta survey area and 12 birds in 1 group in the Transportation Corridor). No Snow Geese were observed during staging surveys in 1993 or 1992.

CANADA GEESE

Several hundred Canada Geese nest along the banks and bluffs of the upper Colville River (Kessel and Cade 1958); however, Canadian Geese have not previously been reported nesting either on the Colville Delta or in the NPR-A. Canada Geese nest on the Arctic Coastal Plain east of the Kuparuk River (Ritchie et al. 1991) and commonly nest on islands in coastal wetlands in the Prudhoe Bay area (Troy 1985, Murphy and Anderson 1993). A major molting area for these geese is located near Teshekpuk Lake, west of the Colville Delta (Derksen et al. 1979). The delta itself has not been identified as an important molting or brood-rearing area for Canada Geese, however. The Colville Delta is important during fall migration (Smith et al. 1994), when geese migrating along the Beaufort Sea coast stop to rest and feed (Johnson and Richardson 1981, Garner and Reynolds 1986).

In 1995, we found no Canada Geese in two surveys in late July 1995, when they would have been molting or rearing young. However, we saw 923 Canada Geese on the delta during 20–22 August (Figure 17). Most (848) of these staging geese were seen in the Outer Delta survey area. As has been found with the other geese, the coastal areas of the Outer Delta receive more use during fall staging than do other areas on the delta. The number seen in 1995 was greater than that seen in 1993 (825 birds) and 1991 (310 birds), but was considerably less than in 1992 (10,957 birds). It is unclear what influences the variability in numbers of Canada Geese and their use of the Colville Delta during fall staging, but some of this variability may reflect the timing of aerial surveys.

Only one group of 75 Canada Geese was observed in the Development Area in 1995, just southeast of the Facility Area. The only other observation of this species within the Development Area was in 1991, when 65 geese were seen; 30 of which occurred in the Facility Area. No staging groups of Canada Geese were seen in the Transportation Corridor in any year.

OTHER WATERBIRDS

NESTING

During intensive ground-based searches for nests of Spectacled Eiders in the vicinity of the Facility Area in June 1995, we located nests of birds other than the focal species (Figure 18). The other species observed included Oldsquaw (*Clangula hyemalis*; 4 nests), Northern Pintail (*Anas acuta*; 2 nests), Glaucous Gull (*Larus hyperboreus*; 2 nests), Arctic Tern (*Sterna paradisaea*; 2 nests), and Sabine's Gull (*Xema sabini*; 1 nest). Because our surveys were not designed specifically to locate nests of these other birds, and because some habitats may have been missed or less extensively searched than others, these nest locations should only be considered to be an indication of the presence of the birds in the area and not an accurate estimate of their abundance.

BROOD-REARING

Sightings of broods and molting groups of waterfowl broods other than geese were recorded opportunistically during aerial surveys (on 24–27 July 1995; Figure 16). We recorded 115 Greater Scaup (*Aythya marila*), of which 64 were on the Outer Delta and 51 were in the Development Area. Oldsquaws also were recorded on that survey (30 in the Outer Delta and 105 in the Transportation Corridor). Northern Pintails were seen only on the delta, 161 (135 in the Outer Delta, 6 in the Development Area, and 20 in the Western Delta) during 24–27 July. We also saw a flock of 85 American Wigeons (*Anas americana*) on the Western Delta.

FALL STAGING

During fall-staging aerial surveys on 18–21 August 1995, we counted 540 Northern Pintails (all in the Development Area, with 75 in the Facility Area) (Figure 17). On the Outer Delta, we saw 600 Greater Scaup. An additional 6 Greater Scaup and 50 Oldsquaws were seen in the Transportation Corridor.

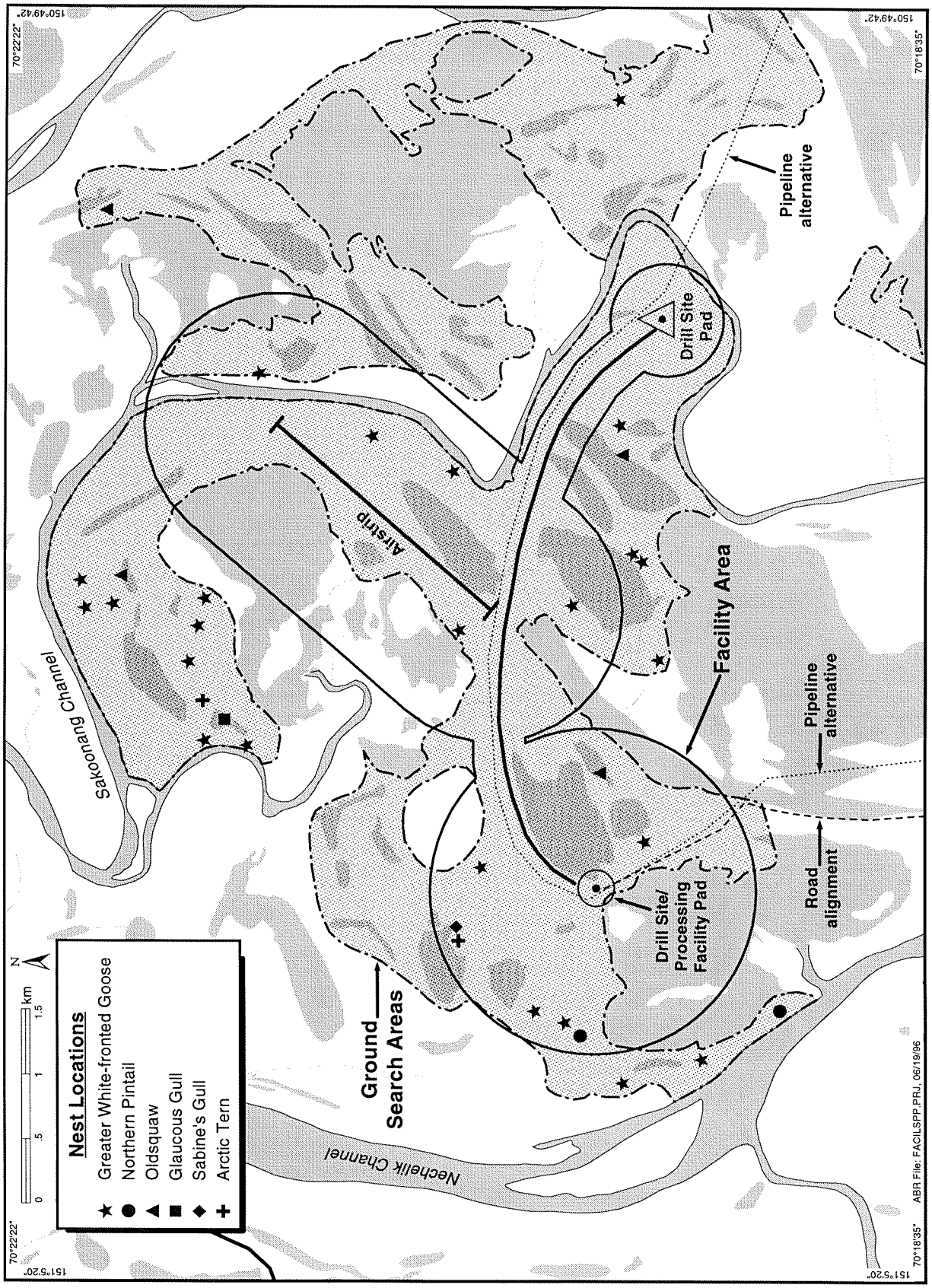


Figure 18. Distribution of nests of selected waterbirds, located during ground searches in late June in the vicinity of the proposed Facility Area, Colville River Delta, Alaska, 1995.

CARIBOU

BACKGROUND

The Colville Delta lies at the western edge of the summer range of the Central Arctic Herd (CAH) of caribou, and at the eastern periphery of the summer range of the Teshekpuk Lake Herd (TLH). The CAH generally ranges between the Colville and Itkillik rivers on the west and the Canning and Tamayariak rivers on the east (Cameron and Whitten 1979, Lawhead and Curatolo 1984, Shideler 1986). The distribution of caribou within this range varies seasonally, with most of the herd moving onto the coastal plain in summer and into the Brooks Range and its northern foothills in winter (Cameron and Whitten 1979, Carruthers et al. 1987). Pregnant cows of the CAH disperse widely across the coastal plain during calving season, which begins in late May and ends in mid-June; peak calving occurs in the first week of June (Curatolo and Reges 1984, Whitten and Cameron 1985, Lawhead and Cameron 1988). The TLH calves and summers in a core area surrounding Teshekpuk Lake (Silva 1985), about 80 km west of the Colville Delta, and disperses across the coastal plain in winter (Carroll 1992).

Because of its location at the edges of these two herds, the Colville Delta generally has not been surveyed routinely in the past. Except for partial (33%) coverage in 1981 and one other year in the 1978–1980 period (Whitten and Cameron 1985), calving surveys of the CAH by ADFG ended at or east of the Eastern Channel (Whitten and Cameron 1985, Lawhead and Cameron 1988). Survey coverage in the area of the Transportation Corridor during the calving season in the late 1970s and 1980s was much lower than in the Kuparuk Oilfield, which has been the focus of intensive survey efforts (Curatolo and Reges 1984, Cameron et al. 1985, Cameron et al. 1988, Lawhead and Cameron 1988). Similarly, past surveys of the TLH stopped at the west bank of the Nechelik Channel (Reynolds 1982). Complete surveys over the Colville Delta during calving season were conducted as part of Colville wildlife studies in 1992 (Smith et al. 1993), 1993 (Smith et al. 1994), and 1995 (this study).

Use of the Colville Delta for insect relief by CAH caribou during midsummer has been documented sporadically since 1983 (Lawhead and Curatolo 1984, Cameron et al. 1995). Use of the delta for insect relief has been highest when insect harassment occurred during periods of westerly winds (Cameron et al. 1989, Smith et al. 1993). The frequency of use of the delta by radio-collared CAH caribou appeared to increase during the late 1980s (R. Cameron, ADFG, unpubl. data), when the herd was increasing. In addition, telemetry surveys in the 1990s have demonstrated that some TLH caribou occasionally use the delta during periods of mosquito harassment (G. Carroll, ADFG, pers. comm.). The extent of contact and exchange of individuals between these two herds has not been quantified, but a limited amount of interchange of collared caribou has occurred (G. Carroll, ADFG, pers. comm.).

The CAH numbered at least 18,093 caribou in July 1995 (ADFG, unpubl. data), a figure 23% lower than the previous photo-count estimate of 23,444 caribou in July 1992. The herd increased at a high rate during the 1970s and early 1980s (Whitten and Cameron 1983), but growth had slowed by the late 1980s (Cameron 1994). The TLH was last counted in July 1993, when it numbered 27,686 caribou (Hicks 1994), an increase of 14% per year since the previous count of 16,649 caribou in July 1989.

CALVING SEASON

Snow melt in 1995 occurred during the normal period of ablation in early June, similar to the timing observed in 1993 (Smith et al. 1994); in contrast, snow melt in 1992 was earlier than normal (Smith et al. 1993). Sightability of caribou generally was low due to patchy snow cover during the first survey (3–5 June). In 1993, we calculated that close to half of all adult and yearling caribou present were not detected by aerial observers in a fixed-wing airplane when snow cover ranged between 20% and 70%, and calf detectability was even lower (Smith et al. 1994). Snow cover varied between those values in the Colville East and Colville Inland areas again during 4–5 June 1995. Therefore, we adjusted the population estimates from the first survey in those two survey areas using the sightability correction factor (SCF = 1.88) developed in 1993. Sightability was higher in the Colville Delta survey area due to the lower snow cover resulting from earlier snow melt. The sightability of all caribou was high

enough on the delta and during the second survey (12–13 June) in all the areas that the SCF was unneeded to obtain population estimates.

Very few caribou were seen on the Colville Delta during the 1995 calving season (Table 34), consistent with survey results in previous years. The two observers on the 3 June transect survey counted one group of four caribou in the 142 km^2 surveyed, giving an expanded estimate (±80% CI) of 18 (±20) caribou and a density of 0.03 caribou/km^2 for the entire 636 km^2 of the Colville Delta survey area. Similarly, the observer on the 18 May fox den survey of the Development Area (169 km^2) detected five cow caribou, all in one group along the Sakoonang Channel east of the proposed drill-site pad. The Colville Delta survey area was not sampled on the second (12–13 June) caribou survey because the entire delta had just been covered completely on 10 and 12 June during the eider pre-nesting survey, when only two cow caribou had been found. No calves were observed on the Colville Delta in the 1995 calving season.

These low numbers on the Colville Delta are consistent with the results of past surveys. No calves were seen on the delta in either the 1992 or 1993 calving season. Three adult caribou were seen on a survey of the delta on 28 May 1993, but none were found on the delta on 10 June, the second survey that year (Smith et al. 1994). No caribou were seen on two surveys of the delta on 4 and 16 June 1992 (Smith et al. 1993). Two transect surveys of portions of the Colville Delta in the 1979–1981 period found very few caribou on the delta itself; instead, most of the small number found (0–12 per transect for five transects) were farther than 16 km inland (Whitten and Cameron 1985). As was observed by Whitten and Cameron (1985), the low occurrence of caribou during calving probably is due to the extent of spring breakup flooding on the Colville Delta. In addition, the relatively low occurrence of upland tussock tundra, the habitat type preferred most by cow caribou during calving (Kuropat and Bryant 1980), probably contributes to the low densities of caribou on the delta at that time of year.

In contrast to the Colville Delta, relatively large numbers of caribou were found in the other survey areas during the 1995 calving season. The first survey yielded an SCF-adjusted estimate of 564 caribou in the combined Colville East and Colville Inland areas (Table 34), for an estimated density of 0.26 caribou/km^2 over the 2,164-km^2 area. The distribution of caribou on the first survey tended to cluster in the southeastern quadrant of the Colville East area and in the northeastern quadrant of the Colville Inland area (Figures 19 and 20); for this reason, the survey area was extended eastward for the second survey. Caribou numbers in the Colville East area increased from 3–5 June to 12–13 June, with the total density on the latter survey being nearly six times higher than on the earlier survey (even after accounting for sightability differences).

The highest numbers of caribou observed during the 1995 calving season occurred in the Kuparuk Inland and the expanded Colville East (including the Transportation Corridor) survey areas on 12–13 June (Figures 21 and 22). We estimated the total number of caribou (adults and calves) in the 1,896-km^2 area surveyed on those two days at 4,826 caribou (2,769 [±373] in the Kuparuk Inland area, plus 2,057 [±282] in the expanded Colville East area; Table 34), representing 27% of the July 1995 count of the entire CAH. Estimated densities were highest in the Kuparuk Inland survey area: 5.1 total caribou/km^2 and 1.0 calves/km^2. Estimated densities were much lower in the expanded Colville East area, at 1.5 total caribou/km^2 and 0.2 calves/km^2, and most caribou were clustered near the eastern edge of the survey area.

Comparison of our 1995 calving survey results with those from 1993 and 1992 revealed increases in peak numbers and densities among the survey areas. The proportion of the CAH calving in the area surveyed was substantially higher in 1995 than in the other two years of Colville caribou surveys. The average density of 5.1 caribou/km^2 in the Kuparuk Inland area in mid-June 1995 was by far the highest recorded in these three years. The adjustment of our survey area between the first and second surveys achieved our intended purpose of locating the area of highest density on the east side of our study area. The total number (2,057 caribou) and average density (1.5/km^2) in the Colville East area in mid-June 1995 were somewhat lower than the 1993 results for that survey area, when 2,181 total caribou were seen in an area of 910 km^2 on 11 June, for an average density of 2.4 caribou/km^2 (Appendix Figure C1; Smith et al. 1994). The Colville Inland survey area had lower numbers and densities than the Colville East area in both years it was surveyed

Table 34. Counts and population estimates of caribou (±80% CI) during the 1995 calving season in the vicinity of the Colville Delta, Alaska.

Survey Area[a]	Date	Area Surveyed[b] (km^2)	Counts		Total Area[d] (km^2)	Population Estimate[e]				Adjusted Population Estimate[f]	
						Total		Calves		Large Caribou[g]	
			Total[c]	Calves		No.	±CI	No.	±CI	No.	±CI
Colville Delta	3 June	141.7	4	0	636.5	18.0	20.3	0.0	-	-	-
Colville Inland	5 June	278.2	43	4	1,106.6	171.1	68.6	15.9	10.7	291.2	136.0
Colville East	4–5 June	530.6	84	11	1,057.2	167.4	31.2	21.9	6.4	273.0	87.3
Colville East (expanded)	12–13 June	685.1	1,045	155	1,348.5	2,056.9	282.5	305.1	70.1	-	-
Kuparuk Inland	13 June	278.2	1,407	270	547.5	2,769.3	373.0	531.4	149.4	-	-

[a] Refer to Figures 19 and 21 for locations.
[b] Area of transect segments that were surveyed.
[c] Total = bulls + cows + yearlings + calves.
[d] Area within boundaries of the survey area.
[e] Counts of caribou in the area surveyed, expanded to the total area.
[f] The population estimate adjusted by the sightability correction factor (1.88) from Smith et al. (1994).
[g] Large caribou = bulls + cows + yearlings.

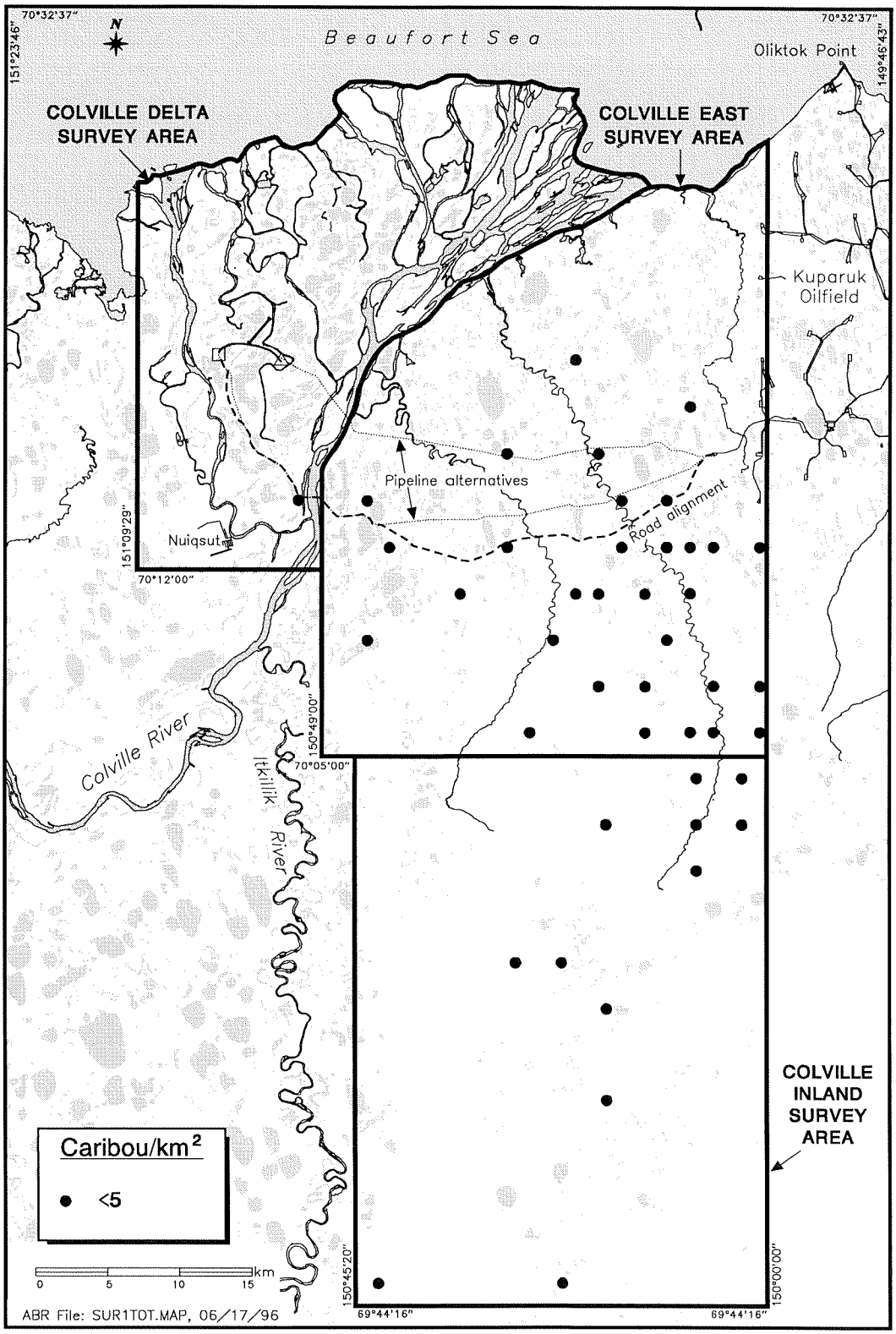


Figure 19. Distribution and density of caribou (adults and calves) in the Colville Delta, Colville East, and Colville Inland survey areas near the peak of the calving season, 3–5 June 1995.

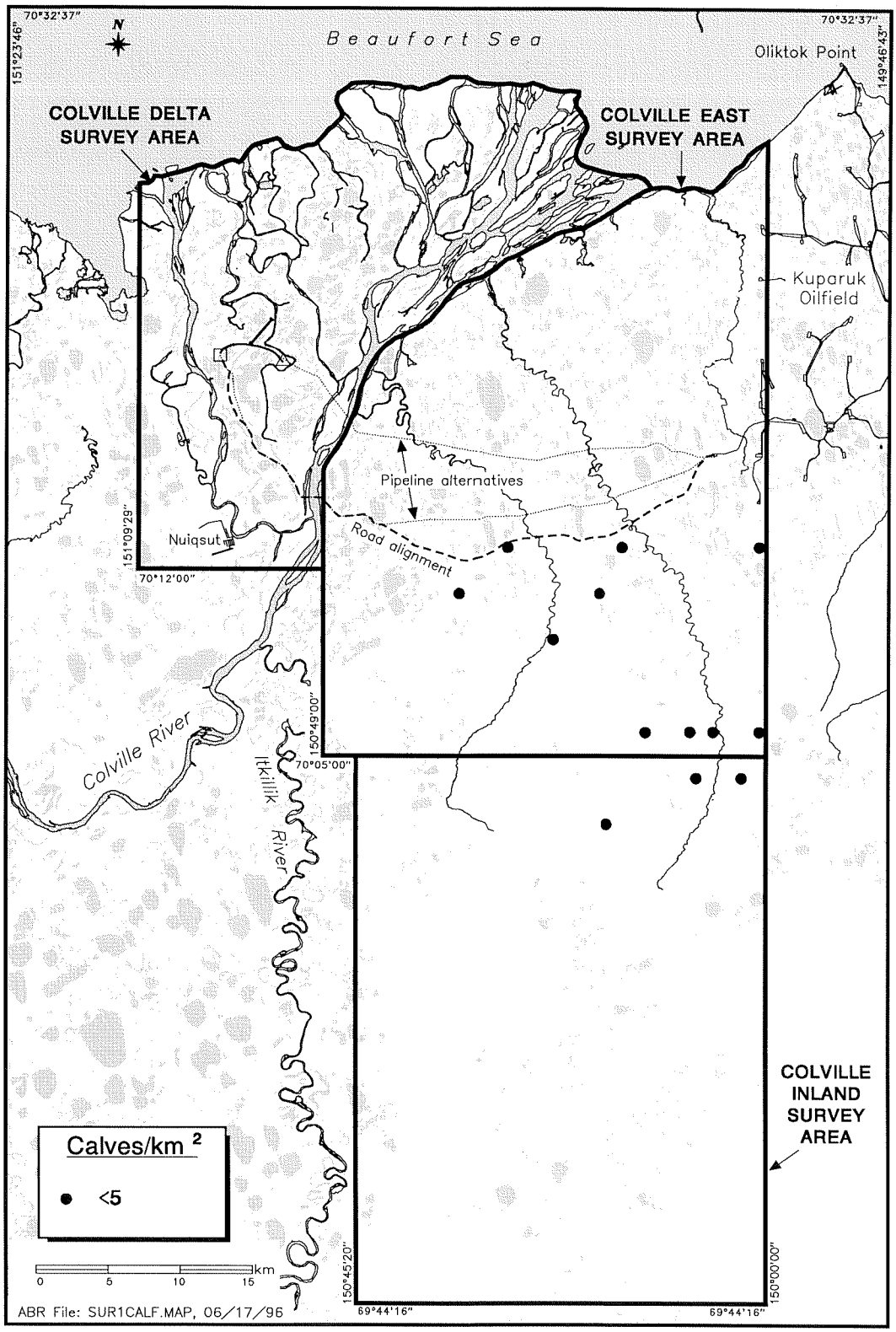


Figure 20. Distribution and density of calf caribou in the Colville Delta, Colville East, and Colville Inland survey areas near the peak of the calving season, 3–5 June 1995.

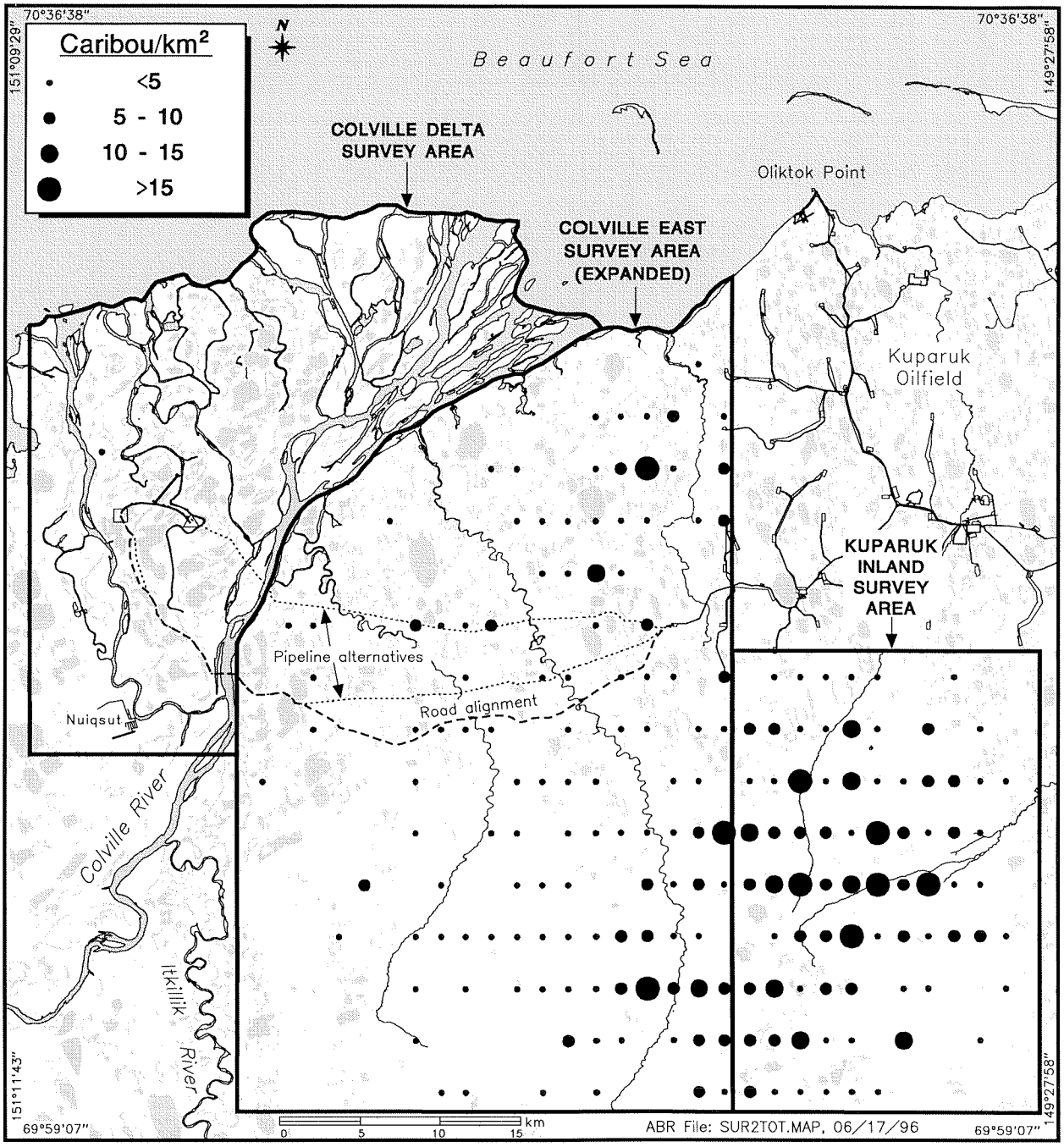


Figure 21. Distribution and density of caribou (adults and calves) in the Colville Delta, Colville East (expanded), and Kuparuk Inland survey areas near the end of the calving season, 12–13 June 1995.

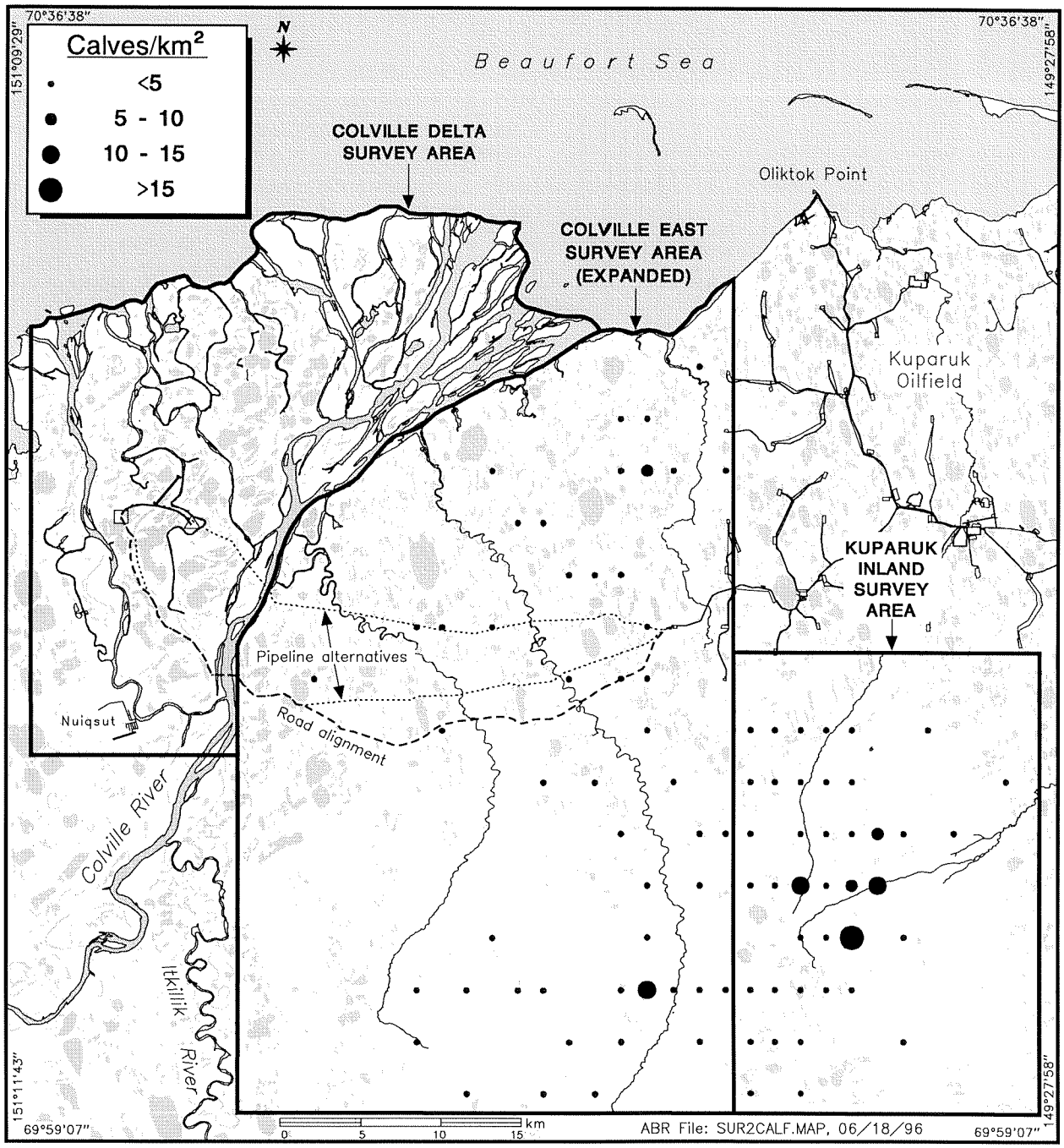


Figure 22. Distribution and density of calf caribou in the Colville Delta, Colville East (expanded), and Kuparuk Inland survey areas near the end of the calving season, 12–13 June 1995.

(1993 and 1995). In 1992, the average density estimated in the entire Colville survey area (which was smaller than in 1993 and 1995; Appendix Figure C2) on the mid-June survey was 2.0 caribou/km^2 (Smith et al. 1993).

From the time detailed surveys began in 1978 until 1987, calving by the CAH tended to be concentrated in two general locations: between the Colville and the Kuparuk rivers west of Prudhoe Bay (the "Kuparuk concentration area") and between the Shaviovik and Canning rivers east of Prudhoe Bay (Curatolo and Reges 1984, Lawhead and Curatolo 1984, Whitten and Cameron 1985, Lawhead and Cameron 1988, Cameron et al. 1992). However, the area between the Colville River and the western edge of the Kuparuk Oilfield has become increasingly important for calving by the western segment of the CAH since 1987 (Smith and Cameron 1992; R. Cameron, ADFG, pers. comm.). The pattern seen in 1995 and 1993, where the highest densities occur south and west of the Kuparuk Oilfield (including the Transportation Corridor) and east of the Colville River, is consistent with this observation that there has been a shift in calving distribution from the Kuparuk concentration area. In addition, reconnaissance-level observations conducted on 14–15 June in the Kuparuk Oilfield revealed fewer than 300 caribou in the area between the Oliktok Point Road and Milne Point Road (ABR, unpubl. data), although the caribou present included a high proportion of cows with calves.

The percentage of calves observed on calving surveys in 1995 was low, as in 1993. In fact, the percentage of calves (17% of total caribou, or 21 calves:100 adults) recorded on 12–13 June in the Kuparuk Inland and expanded Colville East survey areas was the lowest recorded in our six years of comparable fixed-wing surveys: 1983 (Lawhead and Curatolo 1984), 1984 (Curatolo and Reges 1984), 1987 (Lawhead and Cameron 1988), 1992 (Smith et al. 1993), 1993 (Smith et al. 1994), and 1995 (this study). In comparison, the calf percentage in the Kuparuk Oilfield and surrounding areas was never lower than 28% of total caribou from 1978 to 1990 (Valkenburg 1992).

Because our survey method did not differentiate among sex and age classes other than calves, we do not have specific information on the calf:cow ratio in 1995. However, the low percentage of calves that we recorded is consistent with the preliminary estimated ratio of approximately 50 calves:100 cows for the CAH in 1995, based on ADFG's small sample of radio-collared cows (R. Cameron, pers. comm.) and a cursory count by ADFG on 29 June (J. Woolington, ADFG, pers. comm.). During 1978–1990, ratios ranged from 48 to 89 calves:100 cows (Valkenburg 1992). The two lowest ratios recorded previously for the CAH occurred in 1989 (48:100; Valkenburg 1992) and 1991 (45:100; K. Whitten, ADFG, pers. comm.).

Cameron (1994) noted a general decrease in the productivity of the CAH in recent years that appears to be related to a decline in the body condition of females. Delayed parturition is one possible result of poor condition in late pregnancy (Cameron et al. 1993), raising the possibility that calving may have been delayed in 1995, and thereby resulting in low ratios being detected at the time of our surveys. For instance, the proportion of calves (11%) observed on our surveys was low during 3–5 June (even considering low sightability), dates that should have been near the peak of calving. Machida (1993) reported that the Teshekpuk Lake Herd continued to calve past 18 June 1993, nearly two weeks later than usual for that herd. Continued calving past our 12–13 June survey dates would have depressed the proportion of calves in our sample.

INSECT SEASON

Following calving, caribou of the CAH generally remain within 30 km of the coast throughout the mosquito season (Lawhead and Curatolo 1984). Caribou movements during midsummer are influenced predominantly by mosquitoes and oestrid flies (*Hypoderma tarandi* and *Cephenemyia trompe*) (White et al. 1975, Roby 1978). Mosquitoes typically emerge in numbers near the coast by the end of June or beginning of July and persist to the end of July. Mosquito activity is lowest at the coast due to low ambient air temperature and elevated wind speeds near the Beaufort Sea (White et al. 1975, Dau 1986). Caribou normally move to the coast in response to mosquito harassment. Mosquito-harassed caribou will move coastward, and upwind, but only as far as is necessary to reach insect-free habitat (Lawhead and Curatolo 1984, Dau 1986). With the cessation

of insect harassment due to low temperatures or windy weather, CAH caribou move inland to the south or southwest (White et al. 1975, Lawhead and Curatolo 1984).

Oestrid fly harassment of caribou typically lasts from mid-July well into August (Dau 1986). Fly-harassed caribou use unvegetated and elevated sites as relief habitat, such as pingos, mud flats, river bars and roads. By the beginning of August, CAH caribou begin to disperse southward after mosquito harassment abates and coastal habitat becomes less important (Lawhead and Curatolo 1984, Dau 1986). This inland dispersal continues through September and into the rutting season in October.

Surveys during the insect season in 1995 concentrated on the Development Area and Transportation Corridor, which are located south of the outer portions of the Colville Delta that were surveyed most often in the 1992 and 1993 insect seasons. Aerial surveys of caribou in the Development Area and the Transportation Corridor were conducted from 30 June to 28 July 1995. During this period, systematic transect surveys were flown on 1, 18, 21, 22, and 23 July. Non-systematic, reconnaissance surveys of portions of the survey area and larger Colville Delta were flown on all other days in July except 5 and 15 July, when no surveys of either type were flown.

The occurrence of caribou in the Development Area and Transportation Corridor during the insect season was restricted to the early (late June) and late (latter half of July) portions of the season. The onset of insect harassment was earlier than normal in 1995. Mosquito harassment occurred in the Kuparuk Oilfield as early as 19 June (B. Anderson, ABR, pers. comm.), more than a week earlier than the typical dates of 27–29 June noted in recent years in the Kuparuk Oilfield (Lawhead and Flint 1993, Lawhead et al. 1994). Because of the early emergence of mosquitoes, coastward movements by small groups of caribou into and through the Transportation Corridor occurred in late June before our formal surveys began. Observers during bird surveys on 25 June noted small-scale northeasterly movements in response to mild harassment (R. Ritchie, ABR, pers. comm.), and a loose aggregation of approximately 3,000 caribou was scattered through the CPF-2 (southwestern) region of the Kuparuk Oilfield on 27 June (J. King, ABR, pers. comm.). Many of those caribou probably had moved northeastward through the eastern portion of the Transportation Corridor within the period of 25–27 June.

Following those initial movements, little caribou activity was noted in the survey area until mid-July. Between 30 June and 13 July, very few caribou (<20) were observed in the Development Area and the Transportation Corridor (Figure 23). Instead, caribou activity in the first half of July was concentrated in the eastern portion of the Kuparuk Oilfield and the western Prudhoe Bay Oilfield, generally between the Kuparuk River and the Milne Point facilities, in response to the combination of warm weather, mosquito harassment, and easterly winds. No indications of use of the Colville Delta by caribou from the Teshekpuk Herd were noted during the 1995 insect season, although numerous recent tracks (estimated to represent at least 500 caribou) were seen along the coast at the mouth of the Kalikpik River, approximately 15 miles west of the Colville Delta, on 5 July. During our first systematic aerial survey on 1 July, no caribou were observed in the Development Area or in the Transportation Corridor (Table 35), although up to 4,000 were aggregated approximately 65 km east, near the Kuparuk River. After this date, systematic surveys were flown only when we knew that caribou were present in the Colville study area.

Most of the western segment of the CAH aggregated in the eastern Kuparuk and western Prudhoe Bay oilfields and along the lower Kuparuk River in the first two weeks of July. Up to 9,000 caribou were observed in the area from the Milne Point Road to the Kuparuk River delta in the first week of July. Recurring mosquito harassment and prevailing northeasterly winds kept most of these animals in the well-documented pattern of movements to and from the coast between the Oliktok Point Road and the Kuparuk River (Robus 1983, Lawhead and Curatolo 1984). On 6 July, however, the animals that had been in the Kuparuk Oilfield crossed the Kuparuk River, and an aggregation of 7,000 animals moved into the area along the Spine Road in the western portion of the Prudhoe Bay Oilfield. By 7 July, these animals had moved back across the Kuparuk River and were aggregated near Milne Point.

The easterly distribution pattern persisted until 8 July, when westerly winds and mild mosquito harassment caused a westerly shift of caribou.

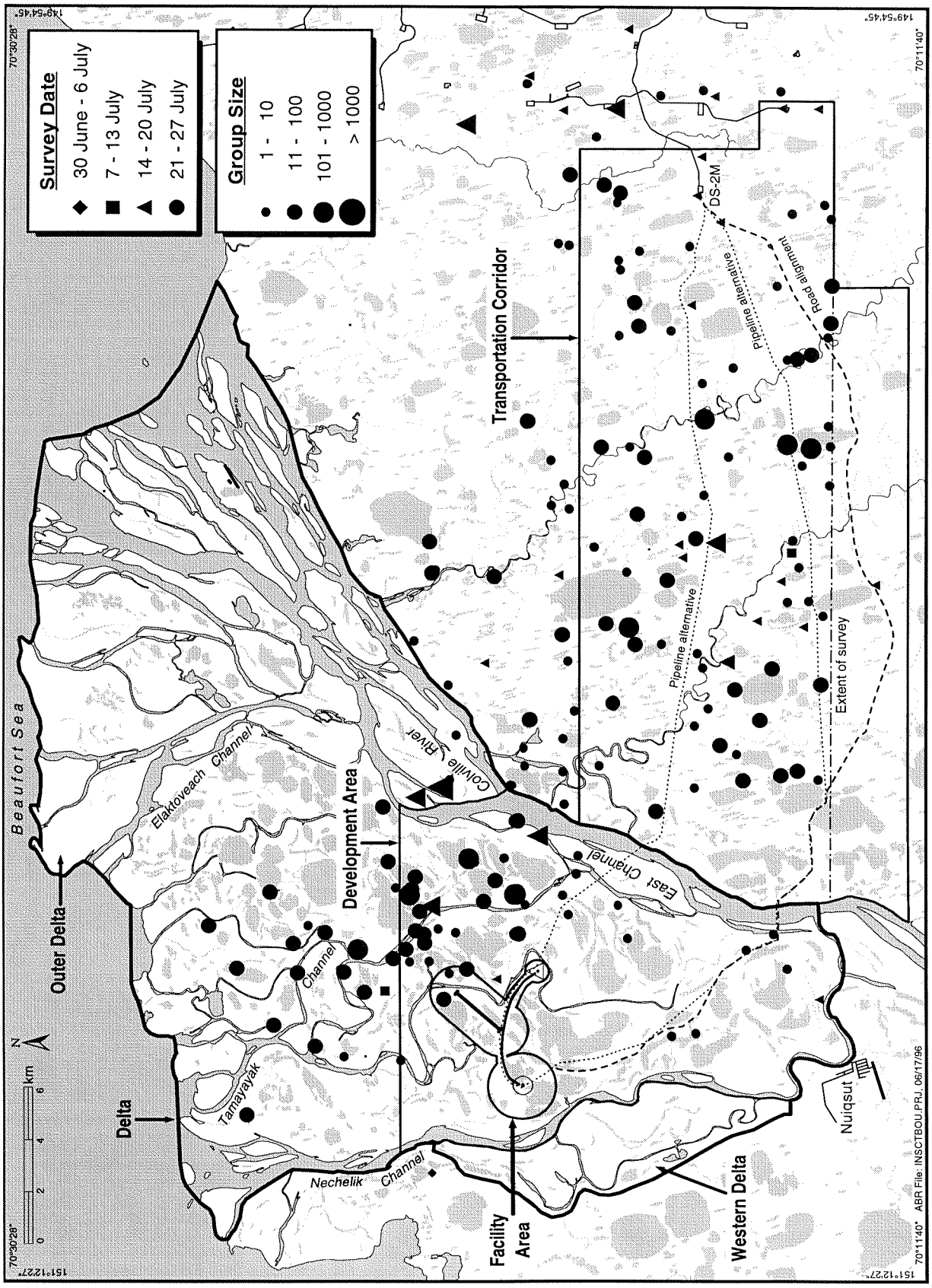


Figure 23. Distribution of caribou in the Development Area and Transportation Corridor during the insect season, Colville River Delta, Alaska, 30 June–27 July 1995, based on systematic and opportunistic observations during aerial surveys.

Table 35. Numbers of caribou observed during systematic aerial surveys (100% coverage) of the Development Area and Transportation Corridor during the 1995 insect season, Colville River Delta, Alaska.

Date	Development Area	Transportation Corridor	Total	Comments
1 July	0	0	0	≥4,000 near Kuparuk R. delta
18 July	110	306	416	severe mosquitoes & westerly breeze—western movement
21 July	502	123	625	mild insects—no movement
22 July	514	421	935	mild insects—no movement
23 July	120	889	1,009	mild insects & easterly wind—eastern movement

Because caribou often seek relief from mosquito harassment by moving into the prevailing wind, caribou moved to the west toward the Colville Delta. Caribou activity increased in the Kuparuk Oilfield during the period from 8 to 17 July, and large aggregations broke down into smaller groups as mosquito activity varied in response to fluctuating temperatures and light winds. The first oestrid flies of the season were observed on 14 July. Caribou groups remained east of the survey area until 17 July, when mild insect harassment and a westerly breeze brought caribou back into the southwestern Kuparuk Oilfield. During a systematic aerial survey on 18 July, we recorded 110 caribou in the Development Area and 306 caribou in the Transportation Corridor (Table 35); nearly all of these animals were in two large groups. At the time of this survey, >1,000 animals were seen in large groups in the western Kuparuk Oilfield just east of the Transportation Corridor. One of those groups (~450) was densely packed on Kuparuk Drill Site 2-A, exhibiting a response typical of combined harassment by mosquitoes and oestrid flies.

Insect harassment was mild on 19–21 July as fog and cool temperatures restricted insect activity. Westerly winds persisted during this period and caribou remained in the vicinity of the Colville Delta. Virtually no caribou were observed in the western Kuparuk Oilfield on these days, and over 1,000 caribou were observed feeding and lying in and around the Development Area and the Transportation Corridor (Figure 23). A large group of 1,100 animals was observed on 19 July near the Eastern Channel of the Colville, just outside the Development Area.

We recorded 625 caribou in 19 groups on a systematic aerial survey on 21 July: 502 caribou were in the Development Area and 123 were in the Transportation Corridor (Table 35). Approximately 400 additional animals were observed just outside the survey areas. Insect harassment also was mild on 22–23 July due to cool temperatures, but the wind had shifted back to the northeast. We conducted systematic surveys on both of those days and recorded peak numbers of caribou in the survey areas. On 22 July, we observed 935 caribou in 33 groups, with roughly half occurring in the Development Area and half in the Transportation Corridor (Table 35). On 23 July, we observed 1,009 caribou in 51 groups, 88% of which were in the Transportation Corridor. As insect harassment abated, caribou were relatively sedentary, and large mixed groups began to break down into smaller groups segregated by sex. When the wind shifted to the east, these smaller groups dispersed from the Colville Delta toward the Kuparuk Oilfield.

Systematic surveys were not conducted after 23 July, but reconnaissance surveys indicated that small groups were scattered through the Development Area and the Transportation Corridor.

On the eider brood survey during 24–28 July, several groups of up to 100 individuals were observed on the Outer Delta (Figure 23). Our surveys in 1995 did not routinely cover the Outer Delta as we had in 1992 and 1993, so the extent of use of that area for relief from insect harassment in 1995 is undocumented. Based on the use observed in the past (Smith et al. 1993, 1994), however, it is probable that the Outer Delta was used as insect-relief habitat. CAH caribou frequently use the outer fringes of major river deltas for insect relief during the periods of most intense harassment (Cameron 1983, Lawhead and Curatolo 1984, Lawhead et al. 1993).

Information on use of the Colville Delta by caribou during the insect season in previous years is available primarily from 1992 and 1993 (Smith et al. 1993, 1994) and from anecdotal information from local residents. Systematic surveys in 1992 and 1993 (five were done each year) covered a larger geographic area than did the 1995 surveys. In 1992, survey efforts were focused on the Outer Delta, although comprehensive surveys of the entire Colville Delta and area to the east (including the Development Area and Transportation Corridor) also were conducted (Smith et al. 1993). Most observations of caribou that year were concentrated on the Outer Delta, and included 2,300 caribou in four groups near the Nechelik Channel on 16 July and 3,300 caribou in five groups near the Kupigruak Channel on 18 July (Smith et al. 1993). These aggregations, the largest that we recorded on the delta during our three years of surveys, appeared to be CAH animals (based on previous and subsequent movements observed in the Kuparuk Oilfield; Lawhead and Flint 1993), although a radio-collared caribou from the TCH was located near the Nechelik Channel on the latter date. The large aggregations observed in 1992 were north of the Development Area and the Transportation Corridor, but it is possible that they moved south into those areas during cooler periods after insect harassment abated.

In 1993, most of the caribou seen during aerial surveys of the Colville Delta were scattered across the Outer Delta, and all of those groups contained fewer than 100 animals (Smith et al. 1994). No large aggregations of caribou were observed in 1993 in the Development Area or the Transportation Corridor. On 14 July 1993, two large groups (1,600 and 1,100 caribou) aggregated on drill sites in the Kuparuk Oilfield CPF-3 area near the mouth of Kalubik Creek, just east of the Outer Delta. It is possible that some of these caribou used the Outer Delta in mid-July; several hundred caribou were seen on Nuekshat Island on 13 July 1993 (J. Helmericks, pers. comm.) and tracks of at least several hundred animals were found along the Tamayayak Channel on 17 July 1993 (Smith et al. 1994).

From these three years of survey data (1992, 1993, 1995) and from discussions with local residents and incidental observations in past years' surveys (e.g., Lawhead and Curatolo 1984), it is evident that the Colville Delta is used annually by CAH caribou for insect relief. In most years, the Outer Delta receives the greatest use by caribou because the tidal flats provide the best relief from mosquito harassment. Under certain rare combinations of weather conditions (e.g., strong southerly or westerly winds and warm temperatures) and insect harassment, however, large aggregations (>1,000 animals) of caribou can be expected to occur in the Development Area. Small groups and individuals harassed by oestrid flies in the second half of July and early August find a wide variety of fly-relief habitats in the elevated landforms and unvegetated flats and dunes throughout the delta.

Use of the Transportation Corridor by caribou during the insect season in 1995 was greater than has been noted in previous years, probably because of the greater observation effort expended there. The southwesterly movements by caribou in mid-July 1995 resulted in a high level of use of the corridor by a large number of animals. The corridor not only was traversed by moving groups of insect-harassed caribou, but also was used for feeding and resting during periods when insect harassment abated. Because the corridor is located relatively far inland from the coast (compared to the normal range of daily movements by caribou during the insect season), it is more likely to be used by small groups for feeding and resting during insect-free periods than it is to be used throughout the insect season by large aggregations of insect-harassed caribou. However, during the annual onset of insect harassment, large numbers of insect-harassed caribou can be expected to traverse the Transportation Corridor as small groups coalesce in the first major coastward movement of the season.

FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. The arctic fox is the most common predatory mammal in the region. It is important both as a predator of birds and small mammals and as a carrier of rabies, particularly because it is attracted to and habituates readily to human activity and artificial food sources (Eberhardt et al. 1982). Population estimates are not available, but cyclical population fluctuations over a span of several years are common in response to fluctuating populations of prey species and rabies epizootics (Follmann and Fay 1981).

Arctic foxes breed in March or April and pups are born between May and early July, 7–8 weeks after mating (Chesemore 1975). Dens are occupied from late spring until pups disperse in August (Chesemore 1975). Throughout the species range, litters average 4–8 pups, but can reach 12 pups in years when food is abundant (Chesemore 1975, Follmann and Fay 1981). Survival of fox pups to weaning is highest in years when small mammals are abundant. Besides starvation, predation (mostly by Golden Eagles [*Aquila chysaetos*] and grizzly bears) is an important cause of mortality (Garrott and Eberhardt 1982, Burgess et al. 1993).

The red fox is common in the foothills and mountains of the Brooks Range, but is much less common than the arctic fox on the Arctic Coastal Plain, where it is restricted largely to major drainages such as the Colville and Sagavanirktok rivers (Eberhardt 1977). Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Schamel and Tracy 1986, Hersteinsson and Macdonald 1992). For instance, a traditional arctic fox den site near the Sagavanirktok River in the eastern Prudhoe Bay Oilfield was appropriated by red foxes in 1988 and has been used consistently by red foxes since then (ABR, unpubl. data). Because both species have similar denning requirements and will use the same den sites, we included both in our analysis of habitat selection.

For both arctic and red foxes, small mammals (collared lemmings [*Dicrostonyx rubricatus*], brown lemmings [*Lemmus sibiricus*]), singing voles [*Microtus miurus*], and tundra voles [*M. oeconomus*]) are the most important year-round prey, supplemented by caribou and marine mammal carcasses and, in summer, by nesting birds, their eggs, and arctic ground squirrels (*Spermophilus parryii*); garbage is eaten when available (Chesemore 1968, Eberhardt 1977, Garrott et al. 1983b). Several researchers have reported that birds constituted a higher proportion of the diet of red foxes on coastal tundra than of arctic foxes (Eberhardt 1977, Smits et al. 1989).

Several studies of arctic foxes in and near the North Slope oilfields have been conducted since the late 1970s, including work by W. Eberhardt (1977), L. Eberhardt and Hanson (Eberhardt et al. 1982, 1983), Fine (1980), and Burgess et al. (1993). Besides the previous surveys by ABR (Smith et al. 1993, 1994), the research of greatest relevance in the Colville Delta was that by Garrott (1980; also see Garrott et al. 1983a), who studied arctic foxes in the undeveloped Colville Delta region in the late 1970s. Garrott and his coworkers located at least 50 dens in a 1,700-km^2 study area centered on the Colville Delta during 1976–1980 (Eberhardt et al. 1983); their study area extended 30 km farther west but only half as far inland as ours. Although we have been unsuccessful in locating the original maps showing those dens, Garrott was able to provide nine approximate locations from memory (Smith et al. 1993). Following the 1995 field season, M. North (pers. comm.) provided a map showing seven den locations from 1983–1984, five of which had been located during the 1992, 1993, and 1995 surveys by ABR.

DISTRIBUTION AND ABUNDANCE OF DENS

The objective of conducting den surveys in mid-May was to increase searching efficiency before snow melt by enabling the observer to detect dark soil plumes at cleaned-out den entrances against the prevailing white background (Burgess and Banyas 1993). Dens were difficult to detect on 18 May 1995, however, due to the earlier snow melt on the delta (compared with the area east of the Colville) and the profusion of exposed burrow complexes of arctic ground squirrels. Nevertheless, three new den site prospects (two of which later turned out to be ground squirrel burrows) were located on that survey, and the status of 22 previously located sites

(of the 24 listed by Smith et al. 1994) was evaluated in the Delta survey area, Transportation Corridor, and adjacent areas.

After the mid-May survey and the next in early July, we concluded that future searches of the delta would be most efficient either earlier (late April–early May) in the season, when snow cover is greater, or later (mid- to late June), when vegetation green-up is occurring at most den sites but not in adjacent tundra. The disturbance and fertilization of den sites by fox activities results in a characteristic, lush flora at den sites that makes them easily visible from the air after green-up (Chesemore 1969, Garrott et al. 1983a). Helicopter searches of suitable-looking habitats in early July (in conjunction with aerial reconnaissance surveys for caribou) were especially useful in locating additional sites in 1995. The abundance of ground squirrels on the Colville Delta and along the Kachemach and Miluveach rivers caused difficulties in discriminating fox dens, although the helicopter allowed close approach and rapid identification of squirrel burrows.

In all, aerial surveys in 1995 added 14 more confirmed den locations to our database, ground observations by the ELS crew added another (E. Pullman, ABR, pers. comm.), and two others were added after the field season based on information provided by M. North (pers. comm.). We increased survey effort in each year of baseline study, and the number of dens known increased accordingly, from 6 in 1992 (Smith et al. 1993) to 23 in 1993 (excluding one site that was not a fox den; Smith et al. 1994) and finally to 40 in 1995. We expect that additional sites will be found in the future with additional surveys.

During three years of surveys, we located 36 arctic fox dens and 4 red fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield (Figure 24). Fourteen of the arctic fox dens and all of the red fox dens are on the Delta, 10 are in the Transportation Corridor, and the remaining 12 arctic fox dens are located either north or south of the corridor. Based on the results of our surveys, we concluded that 13 (38%) of the 34 arctic fox dens we examined in 1995 were active: 9 (26%) were natal dens, 4 (12%) were secondary dens, and the remaining 21 (62%) were inactive (Table 36). Half of the arctic fox dens on the delta were active, compared with 40% of those in the Transportation Corridor and 25% of those outside of either area.

Den occupancy varies substantially among years and regions in relation to food abundance (Macpherson 1969, Chesemore 1975, Garrott 1980, Eberhardt et al. 1983). In the 1993 Colville study area, 5 of 24 (21%) dens were judged to be natal dens and 9 (38%) (including secondary dens) were occupied by fox families (Smith et al. 1994); these percentages were nearly identical with those from 1995. The number of active dens recorded in 1992 was too low to calculate meaningful percentages due to the low-intensity survey coverage late in the season. Eberhardt et al. (1983) reported that the percentage of dens containing juveniles (comparable to our natal and secondary categories combined) in their Colville study area ranged from 6 to 55% among five consecutive years, whereas 56–67% showed signs of activity by adults alone. Burgess et al. (1993) estimated that 45–58% of the dens in their study area in the Prudhoe Bay Oilfield produced litters in 1992, although only 21% still were occupied by families at the time of ground visits in late July–early August. Despite a high density of dens on Herschel Island in the northern Yukon (Smith et al. 1992), only 3–19% of a sample of 32 were used as natal dens among five consecutive years (Smits and Slough 1993). Based on these reports, it appears that the percentage of active dens in the Colville–Prudhoe Bay region can be expected to be in the 20–50% range in most years.

The density of arctic fox dens (active and inactive) in the Delta survey area (1 den/39.4 km^2) is slightly lower than in the Transportation Corridor (1 den/34.3 km^2) (Table 37), and the overall density for the two survey areas combined is 1 den/37.3 km^2. These figures closely match the densities of 1 den/42 km^2 reported by Garrott (1980) and 1 den/34 km^2 reported by Eberhardt et al. (1983) for their Colville study area. The latter density was higher than the former because Eberhardt et al. (1983) included additional dens found after Garrott's data collection. The densities we found are intermediate between those reported for developed areas of the Prudhoe Bay Oilfield (1 den/12–13 km^2; Eberhardt et al. 1983, Burgess et al. 1993) and undeveloped areas nearby (1 den/72 km^2; Burgess et al. 1993), and are similar to average densities reported for large areas of tundra in the Northwest Territories and Siberia (Table 37).

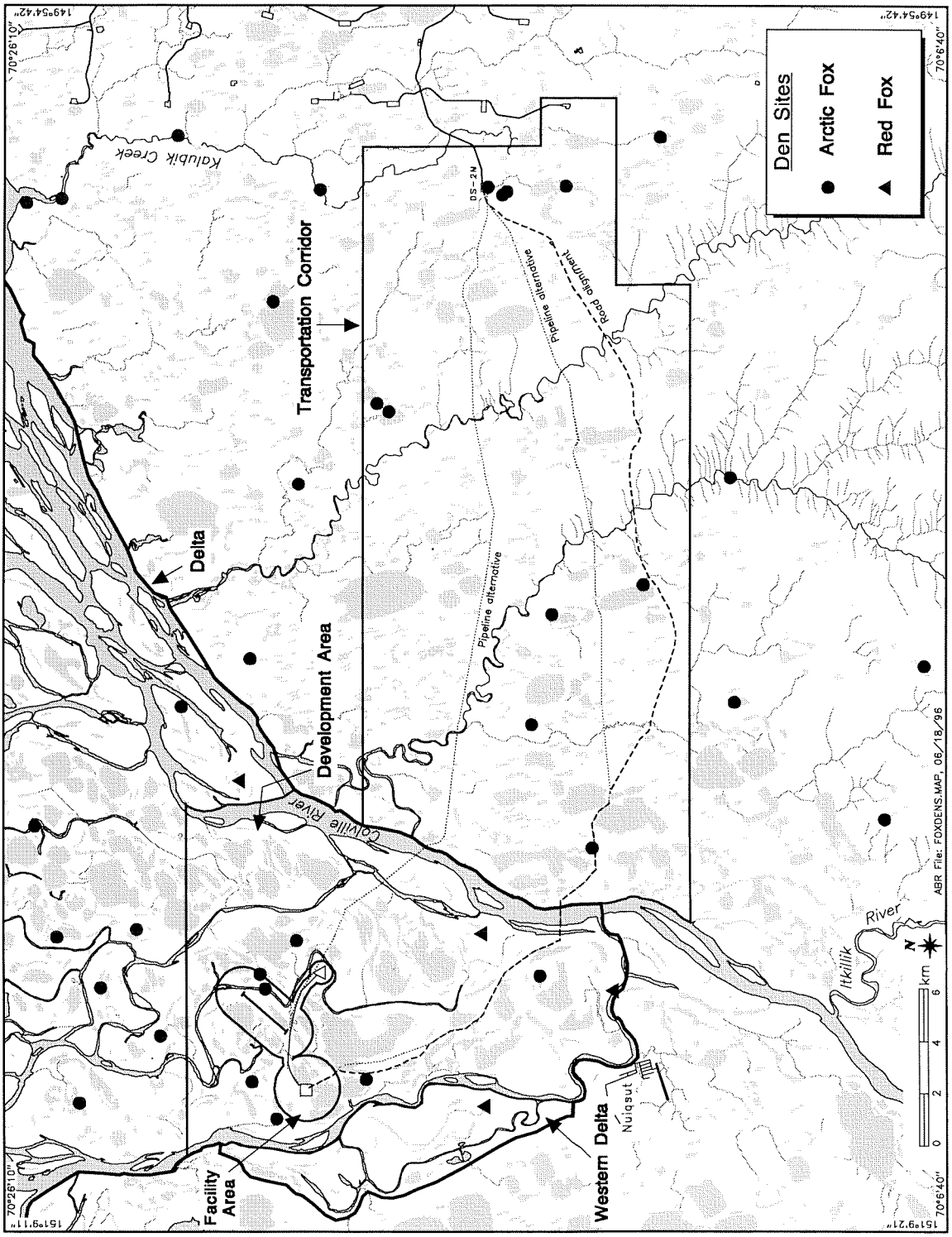


Figure 24. Distribution of arctic and red fox dens found during aerial and ground surveys in 1992, 1993, and 1995 in the vicinity of the Development Area and Transportation Corridor, Colville River Delta, Alaska.

Table 36. Landforms, status, and number of pups at fox dens on the Colville River Delta and adjacent areas of the Arctic Coastal Plain, Alaska.

Site No.[a]	Species	Location[b]	Landform	1995 Status[c]	Min. No. of Pups (1995)	1993 Status[d]	1992 Status[d]
1	arctic	CRD	dune	inactive	--	natal	inactive
2	arctic	CRD	dune	natal	3?	natal	natal
4	arctic	TC	pingo	secondary	no data	adults only	not checked
5	arctic	TC	pingo	natal	3	inactive	not checked
6	arctic	out	pingo	inactive	--	inactive	not checked
7	arctic	out	pingo	natal	5	secondary	not checked
8	arctic	TC	stream bank	natal	5	natal	--
10	arctic	CRD	dune/lake bank	inactive	--	natal	--
11	arctic	CRD	lake bank	inactive	--	inactive	--
15	arctic	out	pingo	inactive	--	inactive	--
16	arctic	out	stream bank	inactive	--	natal	--
26	arctic	CRD	dune/lake bank	inactive	--	inactive	--
30	arctic	out	old lake bank	inactive	--	inactive	--
33	arctic	CRD	dune/lake bank	natal	no data	inactive	--
34	arctic	CRD	dune/lake bank	secondary?	no data	adults only	--
35	arctic	TC	old lake bank	inactive	--	secondary	--
36	arctic	TC	pingo	inactive	--	inactive	--
37	arctic	TC	lake bank	natal	2	secondary	--
38	arctic	TC	low lake bank	inactive?	--	secondary	--
39	arctic	out	old lake bank	inactive?	--	secondary	--
42	arctic	out	old gravel pad	inactive	--	inactive	--
43	arctic	TC	low ridge	inactive	--	secondary	--
44	arctic	TC	low ridge	inactive	--	secondary	--
45	arctic	CRD	dune ridge	natal	3	--	--
48	red	CRD	sand dunes	natal	no data	--	--
49	red	CRD	sand dunes	secondary?	no data	--	--
50	arctic	out	lake bank	inactive?	--	--	--
51	arctic	out	stream bank	natal	3	--	--
52	arctic	out	stream bank	inactive	--	--	--
53	arctic	TC	old lake bank	inactive	--	--	--
54	arctic	CRD	dune mound	inactive	--	--	--
55	red	CRD	river cutbank	natal	5	--	--
56	arctic	out	stream bank	inactive	--	--	--
57	arctic	out	old lake bank	natal	no data	--	--
58	arctic	CRD	dune/cutbank	secondary	3	--	--
59	arctic	CRD	dune/cutbank	inactive	--	--	--
60	red	CRD	sand dune	natal	2	--	--
61	arctic	CRD	low ridge	secondary?	1	--	--
62	arctic	CRD	(unknown)	not checked	--	--	--
63	arctic	CRD	(unknown)	not checked	--	--	--

[a] Sites 62 and 63 were added after the 1995 field season, based on information from M. R. North (pers. comm.).
[b] CRD = Delta survey area; TC = Transportation Corridor; out = outside study area.
[c] Question marks indicate uncertainty regarding status classification.
[d] Sources: Smith et al. (1993) for 1992 status, Smith et al. (1994) for 1993 status.

The density of active (natal and secondary) dens in 1995 was 1 den/92 km^2 in the Delta survey area and 1 den/85 km^2 in the Transportation Corridor, for an overall density of 1 active den/89 km^2 in the two areas combined. Comparable densities of active dens are not available from Garrott (1980) or Eberhardt et al. (1983), but Burgess et al. (1993) reported 1 active den/24 km^2 in the developed portion of the Prudhoe Bay Oilfield and 1 active den/117 km^2 in undeveloped areas bordering the oilfield.

Our estimate of pup production for 1995 is minimal because of the amount of time required to obtain reliable counts of pups, which often remain underground for extended periods. We did not devote long periods of time to observing active dens and were unable to count pups at six of the active dens in the study area (Table 36). Twenty-eight pups were counted at 9 arctic fox dens, for an average of 3.1 pups/den. Pup counts ranged from one to five for arctic foxes. Five pups were counted at one red fox den and two at the other, an average of 3.5 pups/den. These averages are comparable to the average litter size of 3.1 for arctic foxes recorded in 1993 on the Colville Delta by Smith et al. (1994). In 1978, a year when small mammals were relatively abundant on the delta, Garrott (1980) closely observed seven litters (from a total of 23 active dens); litters ranged in size from two to eight pups and averaged 6.1 pups/den. In contrast, he only observed one litter the year before (from two active dens), when small mammals were scarce, and was unable to obtain a reliable count.

In general, the reliability of pup production figures is compromised by the use of secondary dens, due to the potential for use of multiple sites by one family and potential splitting of litters across sites (Garrott 1980, Eberhardt et al. 1983). Garrott (1980) noted that movements from natal dens to secondary dens typically occurred after early to mid-July when the young were 5–7 weeks old, and that interchange of young between dens occurred after the initial move. Such movements may have occurred in 1995 between at least two pairs of natal and secondary dens on the delta. If so, the counts of active dens above would be inflated and pup production might be biased unpredictably by duplication or splitting of litters between dens.

Table 37. Densities of arctic fox dens on the Delta survey area and Transportation Corridor, compared with densities reported from other tundra areas. Table was modified from Burgess et al. (1993: Table 3); Russian sources were cited in Macpherson (1969) and Garrott (1980).

Location	Den Density (1 den/no. of km^2)	Source
Colville Delta	39	This study
Transportation Corridor	34	This study
Colville Delta & adjacent areas	42	Garrott 1980
Colville Delta & adjacent areas	34	Eberhardt et al. 1983
Prudhoe Bay Oilfield	12	Eberhardt et al. 1983
Prudhoe Bay Oilfield (developed areas)	13	Burgess et al. 1993
Undeveloped tundra near Prudhoe Bay	72	Burgess et al. 1993
Sagavanirktok River delta	25	Burgess and Stickney 1992
Okpilak River, ANWR	13	Spindler 1978
Yukon coastal plain	22	Smith et al. 1992
Herschel Island, Yukon	3	Smith et al. 1992
Banks Island, NWT	22–141	Urquhart 1973
Northwest Territories	36	Macpherson 1969
Yukon–Kuskokwim Delta	1	Anthony et al. 1985
Taimyr Peninsula, Russia	0.5	Sdobnikov 1958
Bolshezemeskaya, Russia	2	Danilov 1968
Bolshezemeskaya, Russia	16	Dementyeff 1958
Siberia ("tundra zone")	32	Boitzov 1937

HABITAT SELECTION

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have the greatest depth of seasonally thawed soils. Foxes locate dens on raised landforms with well-drained soil; ridges, dunes, lake and stream shorelines, and pingos all are used on the Arctic Coastal Plain (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993). On the Colville Delta, the landforms used most are banks of streams and lakes (including old banks along drained-lake basins), dunes, ridges, and pingos (Table 36; Garrott 1980, Eberhardt et al. 1983). Pingos were commonly used as den sites in the Prudhoe Bay area (Burgess et al. 1993) but accounted for only a small percentage of the known sites in the Colville area (Eberhardt et al. 1983). In the Teshekpuk Lake area, low mounds are used most often for den sites (Chesemore 1969).

In both the Delta survey area and Transportation Corridor, arctic and red foxes strongly preferred the Riverine or Upland Shrub habitat type for denning, followed by Moist Sedge–Shrub Meadow. Dens in Moist Sedge–Shrub Meadows were located in small patches of higher microrelief that were below the minimum size of habitat area mapped. Small numbers of dens occurred in other habitats, but those also were located in sites with higher microrelief. This observation underscores the fact that the primary habitat requirement for den construction is well-drained soil with a texture conducive to burrowing; these conditions occur at elevated microsites within a variety of larger habitat types.

Delta

Twelve of the 16 dens located on the delta were used most recently by arctic foxes and the other 4 were used by red foxes. Dens were located in only 3 of 13 available terrestrial habitats (Table 38). Twelve dens (75% of total) were located in Riverine or Upland Shrub, which was the most preferred denning habitat; all dens were actually in Upland Shrub (none occurred in Riverine Shrub). The other preferred habitat on the delta was Moist Sedge–Shrub Meadow, but the preference resulted from a single den located in this relatively uncommon habitat type. Wet Sedge–Willow Meadow contained three dens and was used in approximate proportion to its occurrence.

Transportation Corridor

Ten arctic fox dens were located in the Transportation Corridor (Table 39), but no red fox dens were found in this area. Dens were located in 4 of 10 types of available terrestrial habitat. Eight dens were located in the preferred habitats: three in Riverine or Upland Shrub (all were actually in Upland Shrub) and five in Moist Sedge–Shrub Meadow. Riverine or Upland Shrub was the most preferred habitat, but was rare in the Transportation Corridor, constituting only 2.7% of terrestrial habitats. Its low availability may have limited its use by foxes. In contrast, Moist Sedge–Shrub Meadow was the second most available habitat in the Transportation Corridor (29.9% of total area), after Moist Tussock Tundra (33.4% of total area). One den was located in Moist Tussock Tundra, which was not used in proportion to its availability.

POLAR BEARS

Polar bears have a circumpolar distribution and are relatively common within 300 km of the arctic coast of Alaska (Amstrup and DeMaster 1988). Polar bears occur annually in the coastal zone in the vicinity of the Colville Delta and North Slope oilfields and occasionally feed on refuse at the North Slope Borough landfill in the Prudhoe Bay Oilfield (Shideler and Hechtel 1993). Although the species is classified as a marine mammal (under the Marine Mammal Protection Act of 1972, as amended), it also inhabits terrestrial habitats during denning.

The distribution and movements of polar bears are dictated largely by seasonal ice movements. As seasonal ice forms and spreads southward from the polar pack ice in fall, polar bears move with it, usually appearing along the Beaufort coast in October (Lentfer 1972). Polar bears are most numerous along the coast in years when multi-year pack ice moves near shore. Adult males and non-pregnant females do not use dens (except as temporary shelters during poor weather). Pregnant females enter winter dens in October or November, emerging again in late March or April (Lentfer and Hensel 1980); Amstrup and Gardner (1994) reported average dates of den entry and exit as November 11 and April 5, respectively. Cubs are born in December and January (Lentfer and Hensel 1980); litters number from one to three cubs, averaging two.

Table 38. Habitat selection for fox dens in the Delta survey area, Colville River Delta, Alaska.

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	-	-	0[c]	-	-
Brackish Water	6.50	-	-	0[c]	-	-
Tapped Lake w/ Low-water Connection	21.42	-	-	0[c]	-	-
Tapped Lake w/ High-water Connection	20.36	-	-	0[c]	-	-
Salt Marsh	16.73	0	0	4.4	-1.00	4
Tidal Flat	55.90	0	0	14.8	-1.00	4
Salt-killed Tundra	25.63	0	0	6.8	-1.00	4
Deep Open Water w/o Islands	23.31	-	-	0[c]	-	-
Deep Open Water w/ Islands or Polygonized Margins	5.13	-	-	0[c]	-	-
Shallow Open Water w/o Islands	2.32	-	-	0[c]	-	-
Shallow Open Water w/ Islands or Polygonized	0.55	-	-	0[c]	-	-
River or Stream	81.76	-	-	0[c]	-	-
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	0	0	3.6	-1.00	4
Aquatic Grass Marsh	1.37	-	-	0[c]	-	-
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	4
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	4
Nonpatterned Wet Meadow	41.98	0	0	11.1	-1.00	4
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	3	18.7	27.0	-0.18	3
Moist Sedge-Shrub Meadow	13.10	1	6.3	3.5	0.29	2
Moist Tussock Tundra	2.49	0	0	0.7	-1.00	4
Riverine or Upland Shrub	27.40	12	75.0	7.2	0.82	1
Barrens (riverine, eolian, lacustrine)	79.01	0	0	20.9	-1.00	4
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	4
Total	551.25[d]	16	100.0	100.0		

[a] Ivlev's E = (% use - % availability) / (%use + % availability).
[b] Order is increasing from high preference to high avoidance.
[c] Aquatic habitats, assigned zero availability for fox dens.
[d] Total area excluding aquatic habitats = 378.07 km^2.

About half of the dens occupied by pregnant female polar bears in the Beaufort Sea population occur on land: of 90 dens located by Amstrup and Gardner (1994), 42% were on land, 53% were on drifting pack ice (where they may be transported up to 1,000 km during the denning season), and 4% were on shorefast ice. The proportion of bears denning on land in the Beaufort Sea region is increasing, probably as a result of population recovery following prohibition of sport hunting in 1972 (Stirling and Andriashek 1992, Amstrup and Gardner 1994). Females do not re-use the same den sites from year to year, but do tend to return to the same general area and to den in the same type of habitat (Amstrup and Gardner 1994).

Polar bear dens are difficult to locate by standard survey methods, requiring extensive searching. For this reason, the information base regarding the distribution of maternity dens is relatively small and has accumulated slowly over several decades. Information drawn from several sources indicates low occurrence of polar bear dens in the vicinity of the Colville Delta. Records from the USFWS computer database (S. Amstrup, USFWS, pers. comm.) provided the approximate locations of several dens reported over the years in the terrestrial and nearshore areas from the Colville Delta to Oliktok Point (Figure 25). Recent interviews with seven hunters from Nuiqsut (USFWS 1995: Appendix A) provided additional descriptions (but no map locations) of dens in the immediate vicinity of the Colville Delta, some of which dated from the 1920s, 1940s, and 1950s:

Table 39. Habitat selection for fox dens in the Transportation Corridor, Colville River Delta, Alaska.

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	-	-	-	-	-	-
Brackish Water	-	-	-	-	-	-
Tapped Lake w/ Low-water Connection	-	-	-	-	-	-
Tapped Lake w/ High-water Connection	0.10	-	-	0[c]	-	-
Salt Marsh	-	-	-	-	-	-
Tidal Flat	-	-	-	-	-	-
Salt-killed Tundra	-	-	-	-	-	-
Deep Open Water w/o Islands	30.76	-	-	0[c]	-	-
Deep Open Water w/ Islands or Polygonized Margins	6.52	-	-	0[c]	-	-
Shallow Open Water w/o Islands	10.84	-	-	0[c]	-	-
Shallow Open Water w/ Islands or Polygonized Margins	7.36	-	-	0[c]	-	-
River or Stream	2.30	-	-	0[c]	-	-
Aquatic Sedge Marsh	0.97	-	-	0[c]	-	-
Aquatic Sedge w/ Deep Polygons	0.03	0	0	0.0	-1.00	5
Aquatic Grass Marsh	0.65	-	-	0[c]	-	-
Young Basin Wetland Complex	14.23	0	0	5.0	-1.00	5
Old Basin Wetland Complex	35.59	1	10	12.5	-0.11	3
Nonpatterned Wet Meadow	24.47	0	0	8.6	-1.00	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	7.0	-1.00	5
Moist Sedge-Shrub Meadow	84.66	5	50.0	29.9	0.25	2
Moist Tussock Tundra	94.60	1	10	33.4	-0.54	4
Riverine or Upland Shrub	7.74	3	30.0	2.7	0.83	1
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.7	-1.00	5
Artificial (water, fill, peat road)	0.47	0	0	0.2	-1.00	5
Total	343.11[d]	10	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(%use + % availability).
[b] Order is increasing from high preference to high avoidance.
[c] Aquatic habitats, assigned zero availability for fox dens.
[d] Total area excluding aquatic habitats = 283.61 km^2.

Woods Point; the mouths of Kupigruak and Nechelik channels; 8 km south and 5–8 km northeast of Nuiqsut; and the Oliktok Point area. R. Shideler (ADFG, pers. comm.) reported a polar bear den on lower Kalubik Creek, at the eastern edge of our study area, in the winter of 1991–1992; this record is the most recent one found for our study area. Seaman et al. (1981: Figure 7) showed 12 locations of dens and females with cubs recently out of dens between the lower Itkillik River and Kalubik Creek, plus five locations in the Beaufort Sea within 30 km of the mouth of the Colville River; the dates of these records were not stated, but presumably were in the 1960s and 1970s. Lentfer and Hensel (1980) reported two dens and two observations of females with cubs recently out of dens along the east side of the Colville River.

The best denning habitat on the coastal plain is terrain that accumulates and sustains deep snowdrifts through the winter. Examination of 25 den sites used by radio-collared bears revealed strong selection for bluffs along rivers, streams, and lake banks having slopes of at least 40° and at least 1 m of vertical relief (S. Amstrup, USFWS, pers. comm.). Prevailing winds in winter are from the west and southwest, so landscape features oriented perpendicular to these directions accumulate deep drifts along bluff faces.

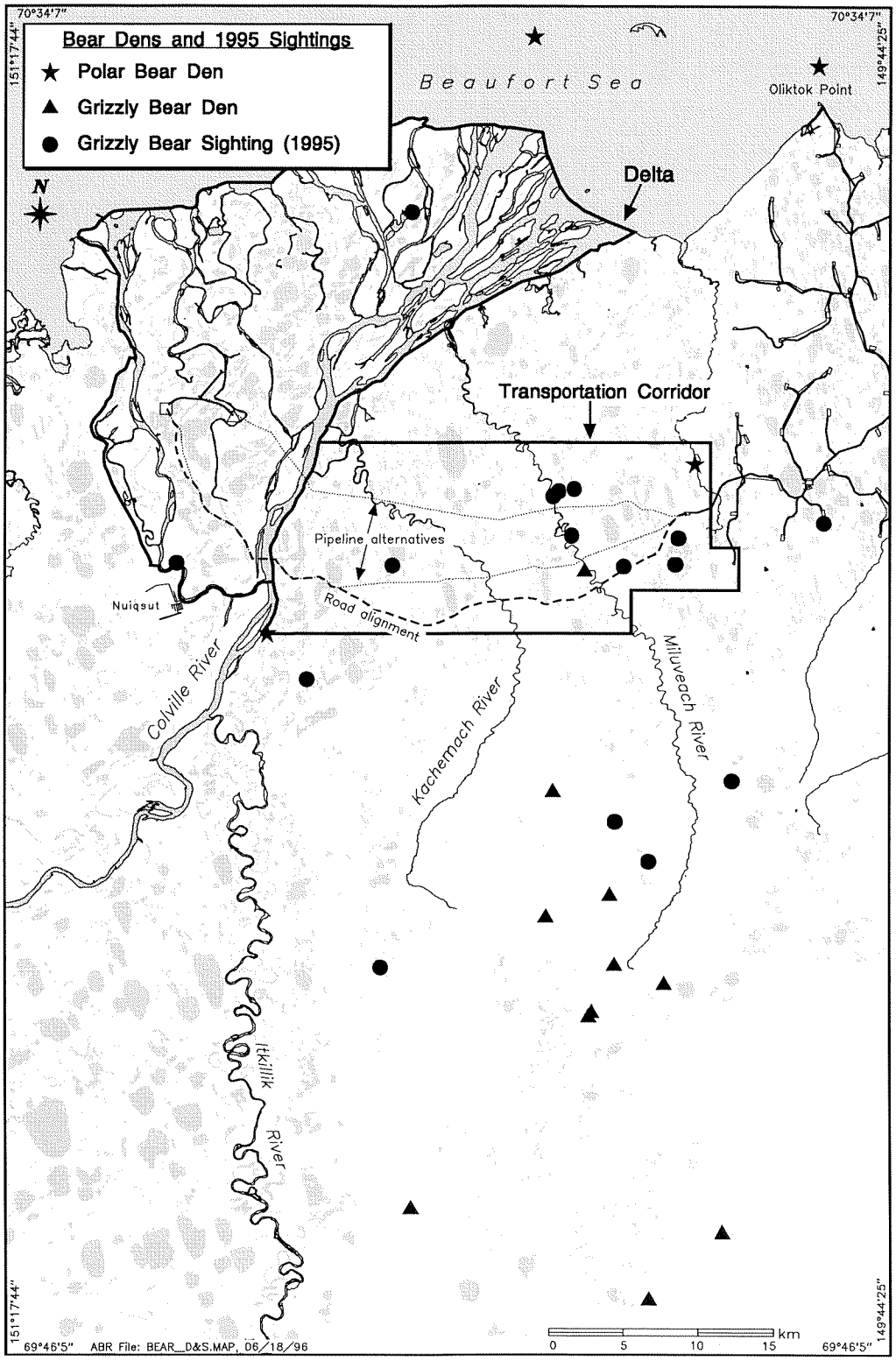


Figure 25. Distribution of winter dens of polar and grizzly bears (records from USFWS and ADFG databases) and incidental sightings of grizzly bears during aerial surveys in June–August 1995 in the vicinity of the Colville River Delta, Alaska.

GRIZZLY BEARS

Grizzly bears (brown bears) are distributed throughout northern Alaska from the Brooks Range to the coast. Population densities are highest in the mountains and foothills and are low on the coastal plain. The population using the Prudhoe Bay and Kuparuk oilfields is increasing, however, and the high proportion of young bears ensures future increases. ADFG biologists estimate that a minimum of 28 bears inhabit an area of approximately 17,400 km^2 between the Colville River on the west and the Shaviovik River on the east, and extending inland 80 km to the White Hills (Shideler and Hechtel 1995b; R. Shideler, ADFG, pers. comm.). Since 1991, 27 bears have been captured and marked by ADFG in an ongoing study of bear use of the oilfields, and additional unmarked bears are known to be present. The bears using the oilfields have large home ranges (2,600–5,200 km^2) and are very mobile, moving up to 50 km in a day (Shideler and Hechtel 1995a).

Mating in northern Alaska peaks in June, but can occur anytime from May through July (Garner et al. 1986). Males and females remain separate for most of the year, coming together only briefly to court and mate. In fact, adult males often kill cubs and are an important cause of juvenile mortality (Bunnell and Tait 1981). As in polar bears, cubs are born in dens during December and January. Litters in northern Alaska range from one to three cubs, averaging two (Reynolds 1979).

In summer 1995, grizzly bears were observed more commonly in the Transportation Corridor and the uplands south of it than on the Colville Delta (Figure 25). Between early June and early August, 16 sightings were recorded incidentally to other surveys: eight in the Transportation Corridor, six south or east of the corridor, and two on the delta. Half of those sightings involved more than one bear, and five were of females with cubs of the year or yearlings. Although most of the bears had been ear-tagged for the ADFG study, individual identification was not possible for all those sighted. The sighting records indicate that at least 14 different animals (including dependent young) were seen in the study area during the 1995 season.

Grizzly bears were observed five times on the study area during field work in 1993 (Smith et al. 1994) and once in 1992, on the Kachemach River about 20 km from the mouth (Smith et al. 1993). The increase in sightings over this time period primarily represents increased observation effort from 1992 to 1995. Nevertheless, use of the delta region by grizzlies can be expected to increase as the population in the region of the oilfields continues to expand.

Grizzly bears den from early October to late April or May in northern Alaska. Both sexes and all ages occupy winter dens, with females and cubs entering dens earlier and emerging later than males and single females (Garner and Reynolds 1986, Shideler and Hechtel 1995b). On the coastal plain, grizzlies dig dens in pingos, banks of rivers and lakes, dunes, and steep gullies in uplands (Harding 1976; Shideler and Hechtel 1995a; R. Shideler, ADFG, pers. comm.). Most of the bears studied by ADFG denned within 50 km of the oilfields, although several have denned 100–160 km inland (Shideler and Hechtel 1995a; R. Shideler, ADFG, pers. comm.). None of the bears studied by ADFG have denned on the Colville Delta. Nine dens used by five different radio-collared bears during 1992–1995 have been located by ADFG in the area between the Kuparuk Oilfield and the Colville River. Nearly all of those dens and five others discovered during a helicopter survey by ADFG are clustered in the uplands >15 km south of the Transportation Corridor, especially in the headwaters of the Miluveach and Kachemach rivers (Figure 25). One den has been located in the Transportation Corridor, on the Miluveach River.

MUSKOXEN

Muskoxen were native to Alaska but were extirpated by the late 1800s (Smith 1989b). In the mid-1930s, muskoxen from Greenland were introduced on Nunivak Island in western Alaska, and 64 animals from there subsequently were reintroduced at Barter Island in the Arctic National Wildlife Refuge (ANWR) in 1969 and at the Kavik River (between Prudhoe Bay and ANWR) in 1970. Those reintroductions established the ANWR population, which grew rapidly and expanded to both the west and east within a decade (Garner and Reynolds 1986). Another population was reestablished near Cape Thompson in northwestern Alaska in 1970 and 1977 (Smith 1989b); that population has expanded eastward, albeit more slowly than in ANWR. The typical pattern of population expansion has been for solitary bulls to

pioneer new areas, followed by groups of mixed sexes and ages (Smith 1989a, Reynolds 1995).

After 1986, the ANWR population stabilized at 350–400 muskoxen, whereas the number west of there increased rapidly (Reynolds 1992b, 1995). The population continues to increase and expand westward. Muskoxen that inhabit the Arctic Coastal Plain south of the Kuparuk and Prudhoe Bay oilfields probably originated from the ANWR population. By the mid-1980s, muskox sign had been found in the western Kuparuk Oilfield (P. Kleinleder, ABR, pers. comm.) and lone bulls were seen near the Colville River (Reynolds et al. 1986). Golden (1990) reported that a small number of muskoxen first overwintered in the Colville River area southeast of Nuiqsut in 1988–1989. Stephenson (1993) estimated that 165 muskoxen inhabited the region between the Colville River and ANWR, out of a total population of over 550 animals in northeastern Alaska and the northern Yukon.

A breeding population of muskoxen has become established in the Itkillik–Colville region since the late 1980s. Although a few muskoxen (mostly lone bulls) have been seen on the Colville Delta, the largest numbers seen incidentally during our caribou and waterfowl surveys in the summers of 1992, 1993, and 1995 were clustered in the uplands east of the Itkillik River, well to the south of the Transportation Corridor (Figure 26). Because systematic surveys of this species have not been attempted, reliable estimates of the population using the lower Colville and Itkillik drainages are not available. The largest number seen to date was 61 muskoxen (including 7 calves) in four groups on 5 June 1995 within an area of 15 km^2 in the uplands east of the Itkillik River (in the Colville Inland caribou calving survey area). A brief reconnaissance survey of the same area on 4 July 1995 found a group of 30 muskoxen, including 9 calves, and a solitary bull. It is possible that two additional calves had been born after our 5 June survey; calves in ANWR are born between late April and late June, with a peak in mid-May (Reynolds et al. 1986).

Observations later in summer suggest that small groups move north seasonally along the Colville and lower Itkillik rivers and their tributaries. Despite comprehensive aerial survey coverage of the Colville Delta and Colville East caribou survey areas during early and mid-June, muskox groups have been seen in the vicinity of the delta and Transportation Corridor only during July and August. Mixed-sex groups including calves have been seen each summer during 1992, 1993, and 1995 near the mouth of the Itkillik River and along the eastern side of the Colville River north of there; these groups included 14 animals in 1992, 4 in 1993, and at least 13 (incomplete count) in 1995. Muskox home ranges are larger and activity and movement rates are much higher during summer than winter. Long-distance movements from winter to summer range are common in mid- to late June, following river breakup and leafing out of willows along drainages (Reynolds 1992a). Group size typically decreases in summer as the breeding season (rut) approaches in August and September; most groups in ANWR ranged from 10 to 30 animals (Reynolds et al. 1986, Reynolds 1992b). Our limited observations suggest that most of the muskoxen population that resides in the Itkillik–Colville region winters in the uplands east of the Itkillik River, then disperses seasonally into smaller groups during summer, some of which move northward along the Itkillik River to the Colville delta vicinity. Southward movements and increased group sizes presumably occur during fall and winter.

In winter, muskoxen select upland habitats near ridges and bluffs with shallow, soft snow cover that permits easy access to food plants (Klein et al. 1993). In spring, muskoxen use upland tussock tundra and moist sedge–shrub tundra, apparently seeking high-quality flowering sedges (Jingfors 1980, Reynolds et al. 1986). By late spring and summer, muskoxen prefer river terraces, gravel bars, and shrub stands along rivers and tundra streams (Jingfors 1980, Robus 1981), where they eat willow leaves, (flowering herbaceous plants, especially legumes), and sedges (Robus 1984, O'Brien 1988). Thus, Riverine or Upland Shrub and Moist Sedge–Shrub Meadows are the most important habitats for muskoxen using the Colville Delta and the Transportation Corridor.

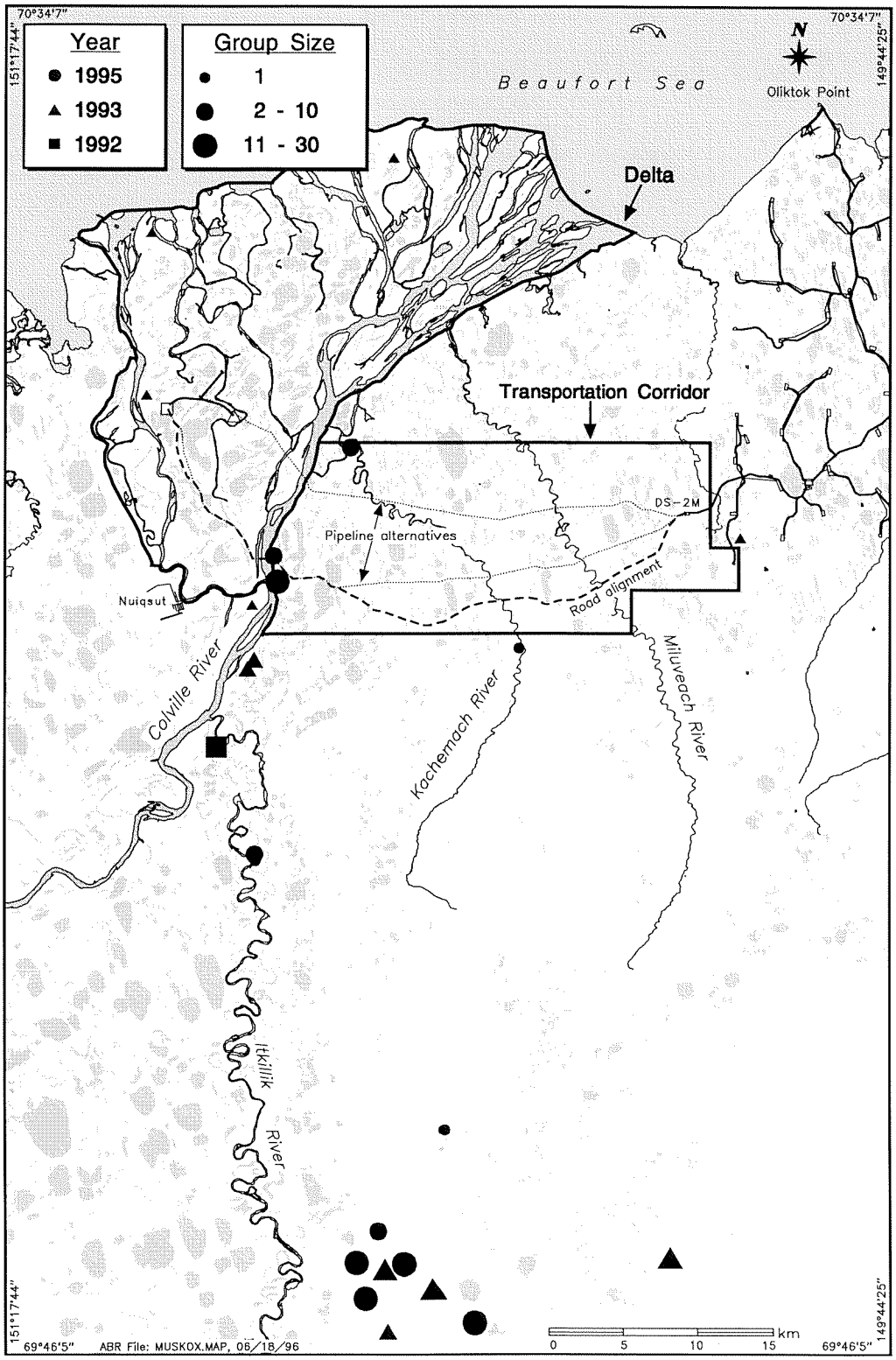


Figure 26. Distribution of incidental sightings of muskoxen during aerial surveys in May–August 1992, 1993, and 1995 in the Development Area, Transportation Corridor, and adjacent areas of the Arctic Coastal Plain, Alaska.

LITERATURE CITED

Amstrup, S. C., and C. Gardner. 1994. Polar bear maternity denning in the Beaufort Sea. J. Wildl. Manage. 58: 1–10.

Amstrup, S. C., and D. DeMaster 1988. Polar bear *Ursus maritimus*. Pages 39–56 *in* J. Lentfer, ed. Selected marine mammals of Alaska: Species accounts with research and management recommendations. Marine Mammal Commission, Washington, DC.

Anderson, B. A., and B. A. Cooper. 1994. Distribution and abundance of Spectacled Eiders in the Kuparuk and Milne Point oilfields, Alaska, 1993. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by Alaska Biological Research, Inc., Fairbanks. 71 pp.

Anderson, B. A., S. M. Murphy, M. T. Jorgenson, J. A. Ciarletta, and B. A. Kugler. 1991. GHX-1 waterbird and noise monitoring program. 1990 annual report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, and BBN Systems and Technologies Corp., Canoga Park, CA. 83 pp.

Anderson, B. A., R. J. Ritchie, and A. A. Stickney. 1996. Avian studies in the Kuparuk Oilfield, Alaska, 1995. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks. 55 pp.

Anderson, B. A., A. A. Stickney, R. J. Ritchie, and B. A. Cooper. 1995. Avian studies in the Kuparuk Oilfield, Alaska, 1994. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks. 29 pp.

Burgess, R. M., J. R. Rose, P. W. Banyas, and B. E. Lawhead. 1993. Arctic fox studies in the Prudhoe Bay Unit and adjacent undeveloped area, 1992. Final report prepared for BP Exploration (Alaska) Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 16 pp.

Anderson, R M. 1913. Report on the natural history collections of the expedition. Pages 436–527 *in* V. Stefansson. My Life with the Eskimos. MacMillan Co., New York.

Bailey, A. M. 1948. Birds of Arctic Alaska. Colorado Mus. Nat. Hist., Popular Ser., No. 8. 317 pp.

Bayha, K., R. Meehan, and T. Jennings. 1992. Synthesis of Brant data for the Colville Delta. Unpubl. rep. U. S. Fish and Wildl. Serv., Anchorage. 21 pp.

Bellrose, F. C. 1978. Ducks, Geese, and Swans of North America. Stackpole Books, Harrisburg, PA. 540 pp.

Bergman, R. D., R. L. Howard, K. F. Abraham, and M. W. Weller. 1977. Waterbirds and their wetland resources in relation to oil development at Storkersen Point, Alaska. U. S. Fish and Wildl. Serv. Resour. Publ. 129. 38 pp.

Brackney, A. W., and R. J. King. 1992. Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska: abundance and distribution of waterbirds, 1986–1990. U. S. Fish and Wildlife Service, Fairbanks, AK. 25 pp.

Bunnell, F. L., and D. E. N. Tait. 1981. Population dynamics of bears—Implications. Pages 75–98 *in* T. D. Smith and C. Fowler, eds. Dynamics of Large Mammal Populations. J. Wiley and Sons, New York.

Burgess, R. M., and P. W. Banyas. 1993. Inventory of arctic fox dens in the Prudhoe Bay region, 1992. Final report prepared for BP Exploration (Alaska) Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 89 pp.

Campbell, B. H., T. C. Rothe, and D. H. Rosenberg. 1988. Annual report of survey inventory activities. Vol. XVIII, Part XIII: Waterfowl. Annual. Rep., Fed. Aid in Wildl. Restor. Proj. W-22-6, Job 11.0, Alaska Dep. Fish and Game, Juneau.

Cameron, R. D. 1983. Issue: Caribou and petroleum development in arctic Alaska. Arctic 36: 227–231.

Cameron, R. D. 1994. Distribution and productivity of the Central Arctic caribou herd in relation to petroleum development: Case history studies with a nutritional perspective. Alaska Dep. of Fish and Game, Res. Final Rep., Fed. Aid in Wildl. Restor. Proj. W-23-1–W-23-5, W-24-1–W-24-3, Study 3.35, Juneau. 35 pp.

Cameron, R. D., E. A. Lenart, D. J. Reed, K. R. Whitten, and W. T. Smith. 1995. Abundance and movements of caribou in the oilfield complex near Prudhoe Bay. Rangifer 15: 3–7.

Cameron, R. D., D. J. Reed, J. R. Dau, and W. T. Smith. 1992. Redistribution of calving caribou in response to oil field development on the Arctic Slope of Alaska. Arctic 45: 338–342.

Cameron, R. D., W. T. Smith, and S. G. Fancy. 1989. Distribution and productivity of the Central Arctic caribou herd in relationship to petroleum development. Alaska Dep. Fish and Game, Prog. Rep., Fed. Aid in Wildl. Restor. Proj. W-23-1 and W-23-2, Study 3.35, Juneau. 52 pp.

Cameron, R. D., W. T. Smith, S. G. Fancy, K. L. Gerhart, and R. G. White. 1993. Calving success of female caribou in relation to body weight. Can. J. Zool. 71: 480–486.

Cameron, R. D., W. T. Smith, and R. T. Shideler. 1988. Variations in initial calf production of the Central Arctic caribou herd. Pages 1–7 *in* R. Cameron and J. Davis, eds. Reproduction and calf survival: Proc. 3rd North Am. Caribou Workshop. Wildl. Tech. Bull. No. 8, Alaska Dep. Fish and Game, Juneau.

Cameron, R. D., and K. R. Whitten. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. Can. Field-Nat. 93: 155–162.

Cameron, R. D., K. R. Whitten, W. T. Smith, and D. J. Reed. 1985. Sampling errors associated with aerial transect surveys of caribou. Pages 273–283 *in* T. C. Meredith and A. M. Martell, eds. Proc. 2nd North Am. Caribou Workshop. McGill Subarctic Res. Paper No. 40, McGill Univ., Montreal.

Carroll, G. 1992. Teshekpuk Lake Caribou Herd, Game Management Unit 26A. Pages 177–185 *in* S. M. Abbott, ed. Survey–Inventory Management Report, 1 July 1989–30 June 1991. Alaska Dep. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-23-3 and W-23-4, Study 3.0, Juneau.

Carruthers, D. R., S. H. Ferguson, and L. G. Sopuck. 1987. Distribution and movements of caribou, *Rangifer tarandus*, in the Central Arctic region of Alaska. Can. Field-Nat. 101: 423–432.

Caughley, G. 1974. Bias in aerial survey. J. Wildl. Manage. 38: 921–933.

Caughley, G. 1977. Sampling in aerial survey. J. Wildl. Manage. 41: 605–615.

Chesemore, D. L. 1968. Notes on the food habits of arctic foxes in northern Alaska. Can. J. Zool. 46: 1127–1130.

Chesemore, D. L. 1969. Den ecology of the arctic fox in northern Alaska. Can. J. Zool. 47: 121–129.

Chesemore, D. L. 1975. Ecology of the arctic fox (*Alopex lagopus*) in North America—A review. Pages 143–163 *in* M. W. Fox, ed. The Wild Canids: Their Systematics, Behavioral Ecology and Evolution. Van Nostrand Reinhold Co., New York.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biol. Serv., U. S. Fish and Wildl. Serv., Washington, DC. 103 pp.

Crum, H. A., and L. E. Anderson. 1981. Mosses of Eastern North America. Columbia University Press, New York. Vol. 1 & 2. 1328 pp.

Curatolo, J. A., and A. E. Reges. 1984. The calving ground of the Central Arctic Caribou Herd, 1984. Final report to ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Fairbanks. 55 pp.

Dau, J. R. 1986. Distribution and behavior of barren-ground caribou in relation to weather and parasitic insects. M. S. thesis, Univ. Alaska, Fairbanks. 149 pp.

Derksen, D. V., W. D. Eldridge, and T. C. Rothe. 1979. Waterbird and wetland habitat studies. Pages 229–331 *in* Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR–A 1977–1978. Vol. 2. NPR–A Work Group 3, U. S. Dep. Interior, Anchorage.

Derksen, D. V., T. C. Rothe, and W. D. Eldridge. 1981. Use of wetland habitats by birds in the National Petroleum Reserve–Alaska. U. S. Fish and Wildl. Serv. Resour. Publ. 141, Washington, DC. 25 pp.

Eberhardt, W. L. 1977. The biology of arctic and red foxes on the North Slope. M. S. Thesis, Univ. Alaska, Fairbanks. 125 pp.

Eberhardt, L. E., R. A. Garrott, and W. C. Hanson. 1983. Den use by arctic foxes in northern Alaska. J. Mammalogy 64: 97–102.

Eberhardt, L. E., W. C. Hanson, J. L. Bengtson, R. A. Garrott, and E. E. Hanson. 1982. Arctic fox home range characteristics in an oil-development area. J. Wildl. Manage. 46: 183–190.

Everett, K. R. 1980. Landforms. Pages 14-19 *in* Geobotanical atlas of the Prudhoe Bay region, Alaska. CRREL Report 80-14. U. S. Army Corps of Engineers, Cold Reg. Res. and Eng., Lab., Hanover, NH.

Fine, H. 1980. Ecology of arctic foxes at Prudhoe Bay, Alaska. M. S. thesis, Univ. Alaska, Fairbanks. 76 pp.

Follmann, E. H., and F. H. Fay. 1981. The arctic fox (*Alopex lagopus*). Unpubl. ms. of final report for the Alaska OCS Project Office. 25 pp.

Gabrielson, I. N., and F. C. Lincoln. 1959. The Birds of Alaska. The Stackpole Company and the Wildlife Management Institute, Harrisburg, PA, and Washington, DC. 922 pp.

Garner, G. W., and P. E. Reynolds. 1986. Mammals. Chap. 5 *in* G. W. Garner and P. E. Reynolds, eds. Arctic National Wildlife Refuge coastal plain resource assessment, Final report—Baseline study of fish, wildlife, and their habitats. Vol. 1. U. S. Fish and Wildl. Serv., Anchorage.

Garner, G. W., H. V. Reynolds, M. K. Phillips, G. E. Muehlenhardt, and M. A. Masteller. 1986. Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge. ANWR Prog. Report No. FY86-12. Pages 665–690 *in* G. W. Garner and P. E. Reynolds, eds. 1987. Arctic National Wildlife Refuge coastal plain resource assessment, 1985 update report—Baseline study of the fish, wildlife, and their habitats. Vol. 2. U. S. Fish and Wildl. Service, Anchorage.

Garrott, R. A. 1980. Den characteristics, productivity, food habits and behavior of arctic foxes in northern Alaska. M. S. thesis, Penn. State Univ., College Station. 95 pp.

Garrott, R. A., and L. E. Eberhardt. 1982. Mortality of arctic fox pups in northern Alaska. J. Mammal. 63: 173–174.

Garrott, R. A., L. E. Eberhardt. and W. C. Hanson. 1983a. Arctic fox den identification and characteristics in northern Alaska. Can. J. Zool. 61: 423–426.

Garrott, R. A., L. E. Eberhardt and W. C. Hanson. 1983b. Summer food habits of juvenile arctic foxes in northern Alaska. J. Wildl. Manage. 47: 540–544.

Gasaway, W. C., S. D. DuBois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biol. Papers, Univ. Alaska, Fairbanks, No. 22. 108 pp.

Gerhardt, F., R. Field, and J. Parker. 1988. Bird–habitat associations on the North Slope, Alaska: Chronological species summaries, 1987. U. S. Fish and Wildl. Serv., Anchorage. 55 pp.

Golden, H. 1990. Unit 26B and 26C muskoxen survey–inventory report. *in* S. O. Morgan, ed. Annual report of survey–inventory activities, 1 July 1988–30 June 1989. Alaska Dep. Fish and Game, Prog. Report, Fed. Aid in Wildl. Restor., Prog. W-23-2, Juneau.

Harding, L. E. 1976. Den-site characteristics of arctic coastal grizzly bears (*Ursus arctos* L.) on Richards Island, Northwest Territories, Canada. Can. J. Zool. 54: 1357–1363.

Hawkins, L. L. 1983. Tundra Swan study, 1983 progress report. U. S. Fish and Wildl. Serv., Anchorage. 6 pp.

Hersteinsson, P., and D. Macdonald. 1992. Interspecific competition and the geographical distribution of red and arctic foxes *Vulpes vulpes* and *Alopex lagopus*. Oikos 64: 505–515.

Hicks, M. V., ed. 1994. Caribou. Annual performance report of survey and inventory activities. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor., Grant W-24-2, Study 3.0, Juneau. 26 pp.

Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press, Stanford, CA. 1008 pp.

Ivlev, J. S. 1961. Experimental ecology of the feeding of fishes, Yale Univ. Press, New Haven.

Jingfors, K. T. 1980. Habitat relationships and activity patterns of a reintroduced muskox population. M. S. thesis, Univ. Alaska, Fairbanks. 116 pp.

Johnson, C. B. 1995. Abundance and distribution of eiders on the Colville River delta, Alaska, 1994. Final report prepared for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks. 12 pp.

Johnson, C. B., S. M. Murphy, C. L. Cranor, M. T. Jorgenson, and B. A. Kugler. 1990. Point McIntyre waterbird and noise monitoring program. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, and Acentech, Inc., Canoga Park, CA. 132 pp.

Johnson, S. R., and D. R. Herter. 1989. The Birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage. 372 pp.

Johnson, S. R., and W. J. Richardson. 1981. Beaufort Sea barrier island–lagoon ecological process studies: Final report, Simpson Lagoon. U. S. Dep. Commer., NOAA, OCSEAP Final Rep. 7: 109–383.

Jorgenson, M. T., J. W. Aldrich, J. G. Kidd, and M. D. Smith. 1993. Geomorphology and hydrology of the Colville River Delta, Alaska, 1992. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., and Arctic Hydrologic Consultants, Fairbanks. 79 pp.

Jorgenson, M. T., J. W. Aldrich, E. Pullman, S. Ray, M. D. Smith, Y. Shur, and H. J. Walker. 1996. Geomorphology and hydrology of the Colville River Delta, Alaska, 1995. Final report prepared for ARCO Alaska, Inc., Anchorage, by ABR, Inc., and Shannon and Wilson, Inc., Fairbanks.

Jorgenson, M. T., S. M. Murphy, and B. A. Anderson. 1989. A hierarchical classification of avian habitats on the North Slope, Alaska. Paper presented at the Third Alaska Bird Conf. and Workshop, 20–22 March 1989, Univ. Alaska, Fairbanks. [abstract]

Katasonov, E. M. 1969. Composition and cryogenic structure of permafrost. Pages 25–36 *in* Permafrost Investigations in the Field. National Research Council of Canada, Ottawa. Technical Translation 1358.

Kessel, B. 1979. Avian habitat classification for Alaska. Murrelet 60: 86–94.

Kessel, B., and T. J. Cade. 1958. Birds of the Colville River, northern Alaska. Biol. Papers, Univ. Alaska, Fairbanks, No. 2. 83 pp.

Kiera, E. F. W. 1979. Feeding ecology of Black Brant on the North Slope of Alaska. M. S. thesis, Western Washington Univ., Bellingham. 50 pp.

King, J. G. 1970. The swans and geese of Alaska's Arctic Slope. Wildfowl 21: 11–17.

Klein, D. R., G. D. Yakushkin, and E. B. Pospelova. 1993. Comparative habitat selection by muskoxen introduced to northeastern Alaska and the Taimyr Peninsula, Russia. Rangifer 13: 21–25.

Kreig, R. A., and R. D. Reger. 1982. Air-photo analysis and summary of land-form soil properties along the route of the Trans-Alaska pipeline system. Alaska Division of Geological and Geophysical Surveys, Geologic Report 66. 149 pp.

Kuropat, P., and J. P. Bryant. 1980. Foraging behavior of cow caribou on the Utukok calving grounds in northwestern Alaska. Pages 64–70 *in* E. Reimers, E. Gaare, and S. Skjenneberg, eds. Proc. 2nd Intl. Reindeer/Caribou Symp., 1979, Røros, Norway.

Lawhead, B. E., L. C. Byrne, and C. B. Johnson. 1993. Caribou synthesis. 1987–90 Endicott Environmental Monitoring Program, U. S. Army Corps of Engineers, Alaska Dist., Anchorage. Final report prepared for Science Applications Intl. Corp., Anchorage, by Alaska Biological Research, Inc., Fairbanks.

Lawhead, B. E., and R. D. Cameron. 1988. Caribou distribution on the calving grounds of the Central Arctic Herd, 1987. Final report prepared for ARCO Alaska, Inc., and Kuparuk River Unit, Anchorage, by Alaska Biological Research, Inc., and Alaska Dep. Fish and Game, Fairbanks. 59 pp.

Lawhead, B. E., and J. A. Curatolo. 1984. Distribution and movements of the Central Arctic caribou herd, summer 1983. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Fairbanks. 52 pp.

Lawhead, B. E., and D. A. Flint. 1993. Caribou movements in the vicinity of the planned Drill Site 3-T facilities, Kuparuk Oilfield, Alaska, 1991–92. Prog. report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by Alaska Biological Research, Inc., Fairbanks. 62 pp.

Lawhead, B. E., C. B. Johnson, and L. C. Byrne. 1994. Caribou surveys in the Kuparuk Oilfield during the 1993 calving and insect seasons. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by Alaska Biological Research, Inc., Fairbanks.

Lensink, C. J. 1973. Population structure and productivity of Whistling Swans on the Yukon Delta, Alaska. Wildfowl 24: 21–25.

Lentfer. 1972. Polar bear–sea ice relationships. Intl. Conf. on Bear Res. and Manage. 2: 165–171.

Lentfer, J. W., and R. J. Hensel. 1980. Alaskan polar bear denning. Intl. Conf. on Bear Res. and Manage. 4: 101–108.

Machida, S. 1993. Western and arctic Alaska caribou survey and inventory. Pages 22–28 *in* S. M. Abbott, ed. Annual performance report of survey–inventory activities, 1 July 1992–30 June 1993: Caribou. Volume 24, Part 11. Alaska Dep. of Fish and Game, Fed. Aid in Wildl. Restor. Proj. W-24-1, Study 3.0, Juneau.

Macpherson. 1969. The dynamics of Canadian arctic fox populations. Can. Wildl. Serv. Report Ser., No. 8. 52 pp.

Martin, P. D., and C. S. Moitoret. 1981. Bird populations and habitat use, Canning River delta, Alaska. U. S. Fish and Wildl. Service, Arctic National Wildlife Refuge, Fairbanks. 188 pp.

McLaren, M. A., and P . L. McLaren. 1984. Tundra Swans in northeastern Keewatin District, N.W.T. Wilson Bull. 96: 6–11.

Meehan, R. 1986. Colville River delta, overview of bird use. U. S. Fish and Wildl. Serv., Alaska Investigations—Wetlands and Marine Ecology, Anchorage. 30 pp.

Meehan, R., and T. W. Jennings. 1988. Characterization and value ranking of waterbird habitat on the Colville River delta, Alaska. U. S. Fish and Wildl. Serv., Alaska Investigations, Branch of Wetlands and Marine Ecology, Anchorage. 105 pp.

Monda, M. J. 1991. Reproductive ecology of Tundra Swans on the Arctic National Wildlife Refuge, Alaska. Ph. D. dissertation, Univ. Idaho, Moscow. 95 pp.

Monda, M. J., and J. T. Ratti. 1990. Reproductive ecology of Tundra Swans on the Arctic National Wildlife Refuge. Pages 136–141 *in* T. R. McCabe, ed. Terrestrial research: 1002 area, ANWR. Annual prog. report, 1989. U. S. Fish and Wildl. Serv., Anchorage. 167 pp.

Mueller-Dombrois, D., and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York, NY. 547 pp.

Murphy, S. M., and B. A. Anderson. 1993. Lisburne Terrestrial Monitoring Program: The effects of the Lisburne Development Project on geese and swans, 1985–1989. Final synthesis report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 202 pp.

Murphy, S. M., B. A. Anderson, C. L. Cranor, and M. T. Jorgenson. 1989. Lisburne Terrestrial Monitoring Program—1988: The effects of the Lisburne Development Project on geese and swans. Fourth annual report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 255 pp.

Murton, J. B., and H. M. French. 1994. Cryostructures in permafrost, Tuktoyaktuk coastlands, western arctic Canada. Canadian Journal Earth Science 31: 737–747.

National Wetlands Working Group. 1988. Wetlands of Canada. Environment Canada, Montreal, Quebec. Ecological Land Classification Series, No. 24. 452 pp.

Nickles, J. R., R. Field, J. Parker, R. Lipkin, and J. Bart. 1987. Bird–habitat associations on the North Slope, Alaska. Prog. Report, Fiscal Year 1986. U. S. Fish and Wildlife Service, Alaska Investigations, Branch of Wetlands and Marine Ecology, Anchorage, Alaska. 96 pp.

North, M. R. 1986. Breeding biology of Yellow-billed Loons on the Colville River delta, arctic Alaska. M. S. thesis, North Dakota State Univ., Fargo. 109 pp.

North, M. R., and M. R. Ryan. 1988. Yellow-billed Loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska. Can. Field-Nat. 102: 485–490.

North, M. R., J. L. Schwerin, and G. A. Hiemenz. 1984. Waterbird studies on the Colville River delta, Alaska: 1984 summary report. Office of Special Studies, U. S. Fish and Wildl. Serv., Anchorage. 18 pp.

O'Brien, C. O. 1988. Characterization of muskox habitat in northeastern Alaska. M. S. thesis, Univ. Alaska, Fairbanks. 114 pp.

Palmer, R. S., ed. 1976. Handbook of North American Birds. Vol. 2. Waterfowl (Part 1). Yale Univ. Press, New Haven, CT. 567 pp.

Pennycuick, C. J., and D. Western. 1972. An investigation of some sources of bias in aerial transect sampling of large mammal populations. E. Afr. Wildl. J. 10: 175–191.

Philainen, J. A., and G. H. Johnston. 1963. Guide to a field description of permafrost. Associate Committee on Soil and Snow Mechanics, National Research Council, Ottawa. Tech. Memo. 79.

Platte, R. M., and A. W. Brackney. 1987. Tundra Swan surveys. Pages 16–17 *in* G. W. Garner and P. E. Reynolds, eds. Arctic National Wildlife Refuge coastal plain resource assessment, 1985 update report — Baseline study of fish, wildlife, and their habitats. U. S. Fish and Wildl. Serv., Anchorage.

Rawlinson, S. E. 1993. Surficial geology and morphology of the Alaskan Central Arctic Coastal Plain. Alaska Div. Geol. and Geophy. Surv., Fairbanks, Ak. Report of Investigations 93-1. 172 p.

Renken, R., M. R. North, and S. G. Simpson. 1983. Waterbird studies on the Colville River delta, Alaska: 1983 summary report. Office of Special Studies, U. S. Fish and Wildl. Serv., Anchorage. 19 pp.

Reynolds, H. V. 1979. Population biology, movements, distribution and habitat utilization of a grizzly bear population in NPR–A. Pages 129–182 *in* Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR–A 1977–1978. Vol. 1. NPR–A Work Group 3, Field Study 3, U. S. Dep. Interior, Anchorage.

Reynolds, P. E. 1982. Preliminary report on the status of the Teshekpuk Caribou Herd. Unpubl. rep., U. S. Dep. Interior, Bur. Land Manage., Fairbanks. 20 pp.

Reynolds, P. E. 1992a. Seasonal differences in the distribution and movements of muskoxen (*Ovibos moschatus*) in northeastern Alaska. Rangifer 13: 171–172.

Reynolds, P. E. 1992b. Population dynamics of muskoxen on the Arctic Coastal Plain: Productivity and dispersal as a natural regulator of population size in the 1002 area of the Arctic National Wildlife Refuge. Work subunit IVb. Pages 148–164 *in* T. R. McCabe, B. Griffith, N. E. Walsh, and D. D. Young, eds. Terrestrial research: 1002 area — Arctic National Wildlife Refuge, interim report, 1988–1990. U. S. Fish and Wildl. Serv., Anchorage.

Reynolds, P. E. 1995. Patterns of dispersal in an expanding muskox population in northeastern Alaska. Paper presented at Second Intl. Arctic Ungulate Conf., 13–17 Aug. 1995, Fairbanks, AK. [abstract]

Reynolds, P. E., J. D. Herriges, and M. A. Masteller. 1986. Ecology of muskoxen *in* the Arctic National Wildlife Refuge, Alaska, 1982–1985. ANWR Prog. Report FY86-2. Pages 573–631 in G. W. Garner and P. E. Reynolds, eds. Arctic National Wildlife Refuge coastal plain resource assessment, 1985 update report—Baseline study of the fish, wildlife, and their habitats. Vol. 2. U. S. Fish and Wildl. Service, Anchorage.

Ritchie, R. J., P. W. Banyas, A. A. Stickney, R. M. Burgess, and J. G. King. 1990. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1989. Final report prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 138 pp.

Ritchie, R. J., and R. M. Burgess. 1993. Aerial surveys for Snow Geese on the Arctic Coastal Plain of northwest Alaska, 1993. Third annual report prepared for North Slope Borough, Barrow, by Alaska Biological Research, Inc., Fairbanks. 13 pp.

Ritchie, R. J., J. G. King, and P. W. Banyas. 1989. Aerial waterfowl surveys in the Kuparuk River Unit and Oil and Gas Lease Sale 54. Report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 26 pp.

Ritchie, R. J., A. A. Stickney, P. W. Banyas, and J. G. King. 1991. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1990. Final report prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 103 pp.

Robus, M. A. 1981. Muskox habitat and use patterns in northeastern Alaska. M. S. thesis, Univ. Alaska, Fairbanks. 116 pp.

Robus, M. A. 1983. Caribou movements in the CPF-2–Oliktok region, Kuparuk Oilfield, Alaska, 1982. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Fairbanks. 74 pp.

Robus, M. A. 1984. Summer food habits of muskoxen in northeastern Alaska. Pages 81–85 *in* D. R. Klein, R. G. White, and S. Keller, eds. Proc. First Intl. Muskox Symp. Biol. Papers, Univ. Alaska, Special Rep. No. 4, Fairbanks.

Roby, D. D. 1978. Behavioral patterns of barren-ground caribou of the Central Arctic Herd adjacent to the Trans-Alaska Oil Pipeline. M. S. thesis, Univ. Alaska, Fairbanks. 200 pp.

Rothe, T. C., C. J. Markon, L. L. Hawkins, and P. S. Koehl. 1983. Waterbird populations and habitat analysis of the Colville River delta, Alaska: 1981 summary report. Office of Special Studies, U. S. Fish and Wildl. Serv., Anchorage. 131 pp.

Schamel, D., and D. M. Tracy. 1986. Encounters between arctic foxes, *Alopex lagopus*, and red foxes, *Vulpes vulpes*. Can. Field-Nat. 100: 562–563.

Seaman, G. A., G. F. Tande, D. L. Clausen, and L. L. Trasky. 1981. Mid-Beaufort coastal habitat evaluation study: Colville River to Kuparuk River. Report prepared for North Slope Borough, Barrow, by Alaska Dep. Fish and Game, Habitat Division, Anchorage. 199 pp.

Shideler, R. T. 1986. Impacts of human developments and land use on caribou: A literature review. Vol. 2—Impacts of oil and gas development on the Central Arctic Herd. Tech. Report No. 86-3, Alaska Dep. Fish and Game, Habitat Division, Juneau. 128 pp.

Shideler, R., and J. Hechtel. 1993. Oilfield grizzly project—1993 summary. Alaska Dep. Fish and Game, Fairbanks. 6 pp.

Shideler, R., and J. Hechtel. 1995a. Grizzly bear use of the North Slope oil fields. Paper presented at North Slope Environmental Studies Conf., 9–10 Mar. 1995, BP Exploration (Alaska) Inc., Anchorage. [abstract]

Shideler, R., and J. Hechtel. 1995b. Grizzly bear use of oilfields around Prudhoe Bay, Alaska. Paper presented at 10th Intl. Conf. on Bear Res. and Manage., 16–20 July 1995, Fairbanks, AK. [abstract]

Silva, J. B., ed. 1985. Teshekpuk Lake Special Area study: Habitat evaluation. U. S. Dep. Interior, Bur. Land Manage., Arctic Resource Area, BLM-AK-PT-85-018-1620-029, Fairbanks, AK. 135 pp. + appendices.

Simpson, S. G. 1983. White-fronted Geese on the Colville River Delta, Alaska: 1983 progress report. Office of Special Studies, U. S. Fish and Wildl. Serv., Anchorage. 3 pp.

Simpson, S. G., J. Barzen, L. Hawkins, and T. Pogson. 1982. Waterbird studies on the Colville River delta, Alaska: 1982 summary report. Office of Special Studies, U. S. Fish and Wildl. Serv., Anchorage. 24 pp.

Simpson, S. G., and T. Pogson. 1982. White-fronted Goose nesting and productivity, Colville River delta—1982. Office of Special Studies, U. S. Fish and Wildl. Serv., Anchorage. 5 pp.

Smith, T. E. 1989a. The role of bulls in pioneering new habitats in an expanding muskox population on the Seward Peninsula, Alaska. Can. J. Zool. 67: 1096–1101.

Smith, T. E. 1989b. The status of muskoxen in Alaska. Pages A23–A25 *in* P. F. Flood, ed. Proc. Second Intl. Muskox Symp., Saskatoon, Saskatchewan, 1–4 Oct. 1987. Natl. Res. Council of Canada, Ottawa.

Smith, L. N., L. C. Byrne, C. B. Johnson, and A. A. Stickney. 1994. Wildlife studies on the Colville River delta, Alaska, 1993. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 95 pp.

Smith, L. N., L. C. Byrne, and R. J. Ritchie. 1993. Wildlife studies on the Colville River delta, Alaska, 1992. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 69 pp.

Smith, W. T., and R. D. Cameron. 1992. Caribou responses to development infrastructures and mitigation measures implemented in the Central Arctic region. Pages 79–86 *in* T. R. McCabe, B. Griffith, N. E. Walsh, and D. D. Young, eds. Terrestrial research: 1002 area — Arctic National Wildlife Refuge, interim report 1988–1990. U. S. Fish and Wildl. Serv. Anchorage.

Smith, C. A. S., C. M. M. Smits, and B. G. Slough. 1992. Landform selection and soil modifications associated with arctic fox (*Alopex lagopus*) den sites in Yukon Territory, Canada. Arctic and Alpine Research 24: 324–328.

Smits, C. M. M., and B. G. Slough. 1993. Abundance and summer occupancy of arctic fox, *Alopex lagopus*, and red fox, *Vulpes vulpes*, dens in the northern Yukon Territory, 1984–1990. Can. Field-Nat. 107: 13–18.

Smits, C. M. M., B. G. Slough, and C. A. Yasui. 1989. Summer food habits of sympatric arctic foxes, *Alopex lagopus*, and red foxes, *Vulpes vulpes*, in the northern Yukon Territory. Can. Field-Nat. 103: 363–367.

Soil Survey Division Staff. 1993. Soil Survey Manual. U. S. Dept. Agric., Washington, DC. Handbook No. 18. 437 pp.

Spindler, M. A., P. A. Miller, and C. S. Moitoret. 1984. Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge. Pages 107–200 *in* G. W. Garner and P. E. Reynolds, eds. 1982 update report — Baseline study of fish, wildlife, and their habitats. U. S. Fish and Wildl. Serv., Anchorage.

Stephenson, R. O. 1993. Subunits 26B and 26C — Central and eastern Arctic Slope. Pages 33–40 *in* S. M. Abbott, ed. Muskox. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor., Survey–Inventory Manage. Report, 1 July 1990–30 June 1992, Proj. W-23-4 and W-23-5, Study 16.0, Juneau.

Stickney, A. A., and R. J. Ritchie. 1996. Distribution and abundance of Brant (*Branta bernicla*) on the central Arctic Coastal Plain of Alaska. Arctic 49: 45–52.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, and D. A. Flint. 1994. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Sagavanirktok River, 1993. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 62 pp.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, D. A. Flint, P. W. Banyas, and J. G. King. 1993. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1992. Final report prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 82 pp.

Stickney, A. A., R. J. Ritchie, P. W. Banyas, and J. G. King. 1992. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1991. Final report prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks. 81 pp.

Stirling, I., and D. Andriashek. 1992. Terrestrial maternity denning of polar bears in the eastern Beaufort Sea area. Arctic 45: 363–366.

Thomson, J. W. 1984. American Arctic Lichens, 1984. The Macrolichens. Columbia University Press, New York. 504 pp.

Troy, D. M. 1985. Birds of Prudhoe Bay and vicinity. Prepared for Standard Alaska Production Co., Inc., Anchorage, by LGL Alaska Research Assoc., Anchorage.

Troy, D. M. 1988. Bird use of the Prudhoe Bay Oil Field during the 1986 nesting season. Report prepared for Alaska Oil and Gas Assn., Anchorage, by LGL Alaska Research Assoc., Anchorage. 96 pp.

Troy, D. M., D. R. Herter, and R. M. Burgess. 1983. Tundra Bird Monitoring Program. Chap. 7 *in* Prudhoe Bay Waterflood Project Environmental Monitoring Program, 1982. Final report prepared for U. S. Army Corps of Engineers, Alaska District, Anchorage, by LGL Alaska Research Assoc., Anchorage.

(TERA) Troy Ecological Research Associates. 1995. Distribution and abundance of Spectacled Eiders in the vicinity of Prudhoe Bay, Alaska: 1991–1993. Final report prepared for BP Exploration (Alaska) Inc., Anchorage. 20 pp.

USFWS (U. S. Fish and Wildlife Service). 1987a. Trumpeter and Tundra swan survey protocol update. Office of Migratory Bird Manage., Juneau. 8 pp.

USFWS. 1987b. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. Migratory Bird and Habitat Res. Lab., Patuxent Wildl. Res. Center, Laurel, MD. 96 pp.

USFWS. 1991. Trumpeter and Tundra swan survey protocol. Office of Migratory Bird Manage., Juneau. 4 pp.

USFWS. 1995. Habitat conservation strategy for polar bears in Alaska. U. S. Fish and Wildl. Serv., Alaska Region, Anchorage.

Valkenburg, P. 1992. Central Arctic Caribou Herd. Pages 187–195 *in* S. M. Abbott, ed. Annual performance report of survey–inventory activities, 1 July 1989–30 June 1991: Caribou. Alaska Dep. of Fish and Game, Fed Aid in Wildl. Restor. Proj. W-23-3, W-23-4, Study 3.0, Juneau.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska Vegetation Classification. Pacific Northwest Research Station, U. S. Forest Service, Portland, OR. Gen. Tech. Rep. PNW-GTR-286. 278 pp.

Walker, D. A., and W. Acevedo. 1987. Vegetation and a Landsat-derived land cover map of the Beechey Point Quadrangle, Arctic Coastal Plain, Alaska. CRREL Rep. 87-5, U. S. Army Corps of Engineers, Cold Reg. Res. and Eng. Lab., Hanover, NH. 63 pp.

Walker, D. A., K. R. Everett, P. J. Webber, and J. Brown. 1980. Geobotanical atlas of the Prudhoe Bay region, Alaska. CRREL Rep. 80-14, U. S. Army Corps of Engineers, Cold Reg. Res. and Eng. Lab., Hanover, NH. 69 pp.

Walker, H. J. 1976. Depositional environments in the Colville River delta. Pages C1–C22 *in* T. P. Miller, ed. Recent and ancient sedimentary environments in Alaska. Alaska Geol. Soc., Anchorage.

Walker, H. J. 1978. Lake tapping in the Colville River Delta, Alaska. Pages 233–238 *in* Proc. Third Intl. Conf. on Permafrost, Vol. 1. Natl. Res. Council Canada, Edmonton, AB.

Walker, H. J. 1983. Guidebook to permafrost and related features of the Colville River delta, Alaska. Guidebook 2. Alaska Div. Geol. and Geophys. Surv., Anchorage. 34 pp.

Walker, H. J., and H. H. Morgan. 1964. Unusual weather and river bank erosion in the delta of the Colville River, Alaska. Arctic 17: 41–47.

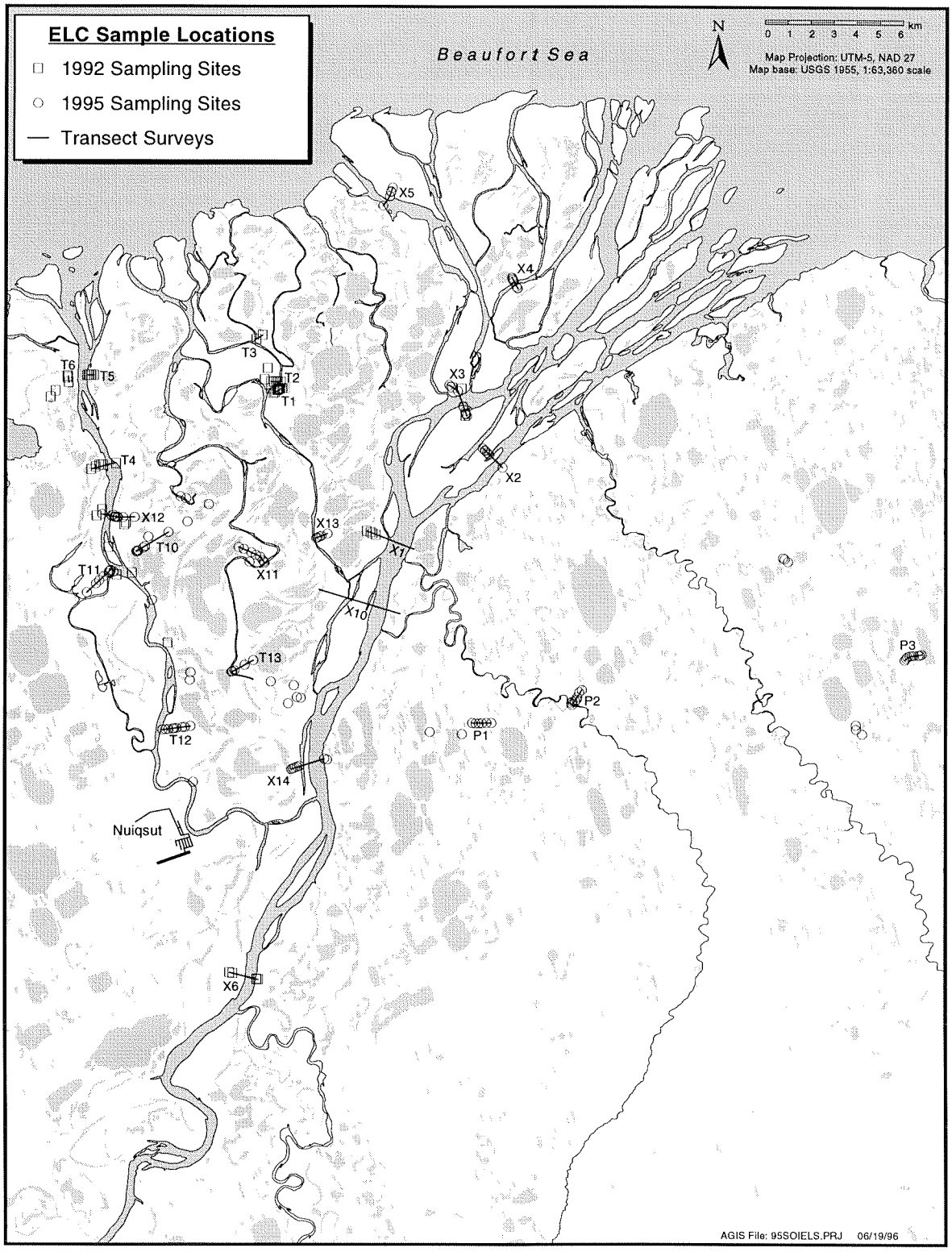
Washburn, A. L. 1973. Periglacial Processes and Environments. Edward Arnold, London, England. 320 pp.

White, R. G., B. R. Thomson, T. Skogland, S. J. Person, D. E. Russell, D. F. Holleman, and J. R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. Pages 151–201 *in* J. Brown, ed. Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska. Biol. Pap. Univ. Alaska, Fairbanks, Spec. Rep. No. 2.

Whitten, K. R., and R. D. Cameron. 1983. Population dynamics of the Central Arctic Herd, 1975–1981. Acta Zool. Fennica 175: 159–161.

Whitten, K. R., and R. D. Cameron. 1985. Distribution of calving caribou in relation to the Prudhoe Bay oil field. Pages 35–39 *in* A. M. Martell and D. E. Russell, eds. Caribou and human activity: Proc. 1st North American Caribou Workshop. Can. Wildl. Serv. Publ., Ottawa, Ont.

Appendix A. Supporting documentation for ecological land classification, Colville River Delta, Alaska, 1995.



Appendix Figure A1. Sampling locations for ecological land classification used in 1992 and 1995, Colville River Delta, Alaska.

Table A1. Coding system of an ecological land classification system for mapping of the Colville River Delta.

Code	Abbr.	Class
TERRAIN UNIT		
DEPOSITS		
380	Es	Eolian sand dunes
411	Fdrm	Delta, riverbed and sandbars
413	Fdrh	Delta, high-water channel
415	Fdca	Delta, active cover deposit
416	Fdci	Delta, inactive cover deposit
417	Fda	Delta, abandoned floodplain
441	Fpr	Floodplain, riverbed deposit
443	Fpca	Floodplain, active cover deposit
444	Fpci	Floodplain, inactive cover deposit
545	Fto	Alluvial terrace (ancient floodplain)
595	FGp	Alluvial plain deposit (undifferentiated)
816	Ltn	Thaw basin, ice-poor
817	Lti	Thaw basin, ice-rich
818	Ltdn	Delta thaw basin, ice-poor
819	Ltdi	Delta thaw basin, ice-rich
860	Mp	Alluvial-marine terrace
862	Mt	Tidal flat
872	Hfg	Fill, gravel
874	Hfp	Fill, peat (peat roads)
WATERBODIES (with original mapping codes)		
905	Rt	River, tidal
910	Rl	River, lower perennial
918	Rb	River, thermokarst (beaded stream)
922	Ldi	Deep isolated lake
925	Ldir	Deep isolated lake, riverine
930	Ldc	Deep connected lake
941	Lsi	Shallow isolated pond
416/7/336		Shallow isolated w/ deep polygon centers
943	Lsir	Shallow isolated pond, riverine
948	Lsid	Shallow isolated pond, dune depression
950	Lsc	Shallow connected pond
963	En	Nearshore water
983	Etdl	Deep tapped lake w/ low-water connection
984	Etdh	Deep tapped lake w/ high-water connection
986	Etsl	Shallow tapped lake w/ low-water connect.
987	Etsh	Shallow tapped lake w/ high-water connect.
989	Ep	Brackish ponds (tidal affected)
996	Hl	Sewage lagoon
997	Hr	Reserve pit

EXAMPLE OF CODING SYSTEM
Landform, Surface-form, Vegetation
412/6/331 or 941/96/337

Code	Abbr.	Class
SURFACE-FORM		
0	N	Nonpatterned
2	Pd	Polygons, disjunct
3	Pf	Polygons, flat-centered
5	Plll	Polygons, low-center, low-relief, low density
6	Pllh	Polygons, low-center, low-relief, high density
7	Plhl	Polygons, low-center, high-relief, low density
8	Plhh	Polygons, low-center, high-relief, high density
9	Pm	Polygons, mixed high and low
11	Phl	Polygons, high-centered, low-relief
12	Phh	Polygons, high-centered, high-relief
17	Tm	Mixed pits and polygons
21	Fh	Hummocks
23	Ff	Frost scars
31	Mud	Mounds, undifferentiated, dense
35	Mpi	Pingos
39	Ms	Strang
62	Ek	Dunes, streaked
81	Dw	Water tracks
85	Db	Streambank
96	Si	Islands present
97	Sm	Water w/ highly polygonized margin
98	L	Cliff or bluff
101	Cb	Basin complex
VEGETATION CLASS		
0	B	Barren (<5% vegetated)
10	P	Partially vegetated (hairgrass, *Elymus*)
221	Stcw	Closed tall willow
231	Stow	Open tall willow
242	Slcw	Closed low willow
260	Slow	Open low willow (can include sedges)
270	Sdd	*Dryas* tundra (also w/ sedge or lichens)
295	Sdwh	Halophytic dwarf willow (coastal)
314	Hmt	Tussock tundra
320	Hmss	Moist sedge-shrub tundra (*Dryas*/willow)
328	Hmsk	Moist salt-killed meadow
334	Hwsw	Wet sedge-willow tundra (also w/o willow)
336	Has	Fresh sedge marsh
337	Hag	Fresh grass marsh
345	Hwhg	Halophytic grass wet meadow
346	Hwhs	Halophytic sedge wet meadow
348	Hwhk	Salt-killed wet meadow
411	Cby	Basin wetland complex, young
412	Cbo	Basin wetland complex, old

Table A2. Descriptions of terrestrial terrain units mapped within the Delta survey area and Transportation Corridor, Colville River Delta, Alaska (adapted from Kreig and Reger 1982, Rawlinson 1993).

Unit	Description
Eolian Sand Dunes	Unconsolidated, wind-deposited accumulations of primarily very fine and fine sand. Surficial patterns associated with ice-aggradation generally are absent. These active sand dunes are being built by deposition of sand from adjacent sandbars and are prone to wind erosion, giving them distinctive, highly dissected patterns. Active dunes occur at the inner edge of extensive mudflats, the outer delta, and along the western and southwestern sides of river channel bars. Only distinct dunes were mapped, whereas smooth sand sheets overlying other deposits were not.
Delta, Riverbed and Sandbars	Silty and sandy riverbed or lateral accretion deposits laid down from the bed load of a river in areas of channeled flow. Riverbed alluvium includes point bars, lateral bars, mid-channel bars, unvegetated high-water channels, and broad riverbed/sandbars exposed during low water. In general, texture of the sediments decreases in a seaward direction along the distributaries and in a bankward direction from the thalweg. Organic matter, including driftwood (mostly small willows), peat shreds, and other plant remains, usually is interbedded with the sediments. Only those riverbed deposits that are exposed at low water are mapped, but they also occur under rivers and cover deposits. Frequent flooding (every 1–2 yr) prevents the establishment of permanent vegetation.
Delta, High-water Channel	Riverbed deposits that occur in channels flooded only during periods of high flow. Because of river meandering, these channels no longer are active during low-flow conditions. Deposits in this unit are similar to those described for riverbed alluvium. These old channels show little surface polygonization indicative of ice-wedge development, although there infrequently are high-water channels that are older and have developed disjunct polygon rims. Very old channels that have distinct low-centered polygons are not included in this unit.
Delta, Active Cover Deposit	Thin (0.5–1 m) fine-grained cover deposits (primarily silt) that are laid down over sandier riverbed deposits during flood stages. Deposition occurs sufficiently frequently (every 3–4 yr) to prevent the development of a surface organic horizon. Supra-permafrost groundwater generally is absent or occurs only at the bottom of the active layer during mid-summer. This unit usually occurs on the upper portions of point and lateral bars and supports riverine willow vegetation.
Delta, Inactive Cover Deposit	Fine-grained cover or vertical accretion deposits of a braided floodplain that are laid down over coarser riverbed deposits by streams at bank overflow (flood) stages. The surface contains a sequence (0.3–1.0 m thick) of interbedded organic and silt layers near the surface, indicating occasional flood deposition. Under the organic horizons is a thick layer (0.3–1.5 m thick) of silty cover deposits overlying riverbed deposits. Surface forms range from nonpatterned to disjunct and low-density, low-centered polygons. Lenticular and reticulate forms of segregated ice and massive ice in the form of ice wedges are common.
Delta, Abandoned Floodplain	Peat, silt, or fine sand (or mixtures or interbeds of all three), deposited in a deltaic overbank environment by fluvial, eolian, and organic processes. These deposits generally consist of an accumulation of peat 0.5–2 m thick that overlies cover and riverbed alluvium. Because these are older surfaces, eolian silt and sand may be common as distinct layers or as intermixed sediments. The surface layer, however, lacks interbedded silt layers associated with occasional flood deposition. Lenticular and reticulate forms of segregated ice and massive ice in the form of ice wedges are common in these deposits. The surface is characterized by high density, low-relief polygons and represents the oldest surface on the floodplain.
Floodplain, Riverbed Deposit	Sandy gravel, and occasionally sand, deposited as lateral accretion deposits in channels of active floodplains by fluvial processes. Subrounded to rounded pebbles and cobbles are common in the sandy gravel. Frequent deposition and scouring from flooding prevents the establishment of vegetation. The channel has a meandering configuration.
Floodplain, Active Cover Deposit	Thin (0.5–1 m), fine-grained cover deposits (primarily silt) that are laid down over sandy or gravelly riverbed deposits during flood stages. Deposition occurs sufficiently frequently (probably every 3–4 m) to prevent the development of a surface organic horizon. This unit usually occurs on the upper portions of point and lateral bars and supports riverine willow vegetation.

Table A2. Continued

Unit	Description
Floodplain, Inactive Cover Deposit	Interbedded layers of peat and silty very fine sand material (0.5–2 m thick), indicating a low frequency of flood deposition. Cover deposits below this layer generally consist of silt but may include pebbly silt and sand and usually are in sharp contact with underlying gravelly riverbed deposits. This unit has substantial segregated and massive ice, as indicated by the occurrence ice-wedge polygons.
Alluvial Terrace	Fluvial gravelly sand, sand, silty sand, and peat. The old terraces were deposited at an earlier age and are not subject to flooding under the current regime. Deposits usually are overlain by eolian silt and sand and organic-rich thaw basin deposits. This unit has a high content of segregated and massive ice, as indicated by the presence of ice-wedge polygons and the abundance of thaw ponds.
Alluvial Plain Deposit	Peat, eolian loess and sand, lacustrine sediments, and sandy gravel deposited by braided river processes on an alluvial plain. A typical sequence consists of 0.3–0.7 m of peat or mixed sand and peat typical of lacustrine material, 1–2 m of sand and pebbly fine sand (Beechey Sand), and thick beds (below 2–3 m) of sandy gravel and gravel (Ugnuravik Gravel). The surface is ice-rich, as indicated by polygonal development and the prevalence of thaw lakes. Water depths in thaw lakes generally are 1–2 m, indicating that ice contents are high and sediments are not thaw stable.
Thaw Basin, Ice-poor	Thaw basin deposits, caused by the thawing of ground ice, typically are fine-grained and organic-rich, and the stratigraphy of the original sediments has been deformed by the subsidence. On the terraces and coastal plain west of the delta, pebbly silt or fine sand is more common. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice is low and that lake drainage has occurred recently. Ponds in these basin typically have irregular shorelines and are highly interconnected.
Thaw Basin, Ice-rich	Sediments similar to non-ice rich thaw lake deposits but having much more ground ice, as indicated by the development of low-centered or high-centered polygons. Waterbodies within these basins tend to be rectangular, to have smooth, regular shorelines, and to be poorly interconnected.
Delta Thaw Basin, Ice-poor	Deposits occurring in thaw lakes having a connection to a river or nearshore water (tapped lake); they occur only in deltaic environments. Most connections occur when a meandering distributary cuts through a lake's bank; once connected, the lake is influenced by changes in river level. During breakup, large quantities of sediment-laden water flow into the lake, forming a lake delta at the point of breakthrough. Sediments typically consist of fine sands, silts, and clays and typically are slightly saline.
Delta Thaw Basin , Ice-rich	Similar to the above unit, except that sediments are ice-rich, as indicated by the development of ice-wedge polygons. Typically, the sediments contain a sequence of a thick (0.3–0.7 m) layer of interbedded silt and peat, fine-grained cover deposits, and silty clay lacustrine deposits. They still are subject to flooding.
Alluvial-Marine Terrace	A sequence of alluvial and marine terraces (A, B, and C of Rawlinson 1993) that have variable composition but generally consist of undifferentiated gravelly sand overlain by fluvial gravelly sand, silty sand, and organic silt. Stratified layers of marine gravelly sand, silty sand, silt and minor clay occur in some locations beneath the fluvial deposits. The deposits generally are overlaid by pebbly eolian sand and silt and organic-rich lacustrine deposits. This unit is not subject to flooding.
Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal flats occur on seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal flats frequently are associated with lagoons and estuaries and may vary widely in actual salinity, depending on how exposed the flat is to salt-water incursion and the rate of influx of fresh water.
Fill, Gravel and Peat	Gravel and sandy gravel that has been placed as fill for roads and pads in the village of Nuiqsit and the Kuparuk Oilfield. Peat fill ("peat road") includes a mixture of organic and fine-grained sediments that has been obtained by taking peat material from the active layer and piling it into a roadbed

Table A3. Characteristics used in classifying waterbody terrain units mapped within the Delta survey area and Transportation Corridor, Colville River Delta, Alaska.

Property	Class	Description
Depth	Shallow	Water < 1.5 m deep, freezes to the bottom during winter.
	Deep	Water > 1.5 m deep, unfrozen water persists during winter.
Connectivity	Isolated	No distinct outlet.
	Low-water Connection	Outlet has water present throughout year.
	High-water Connection	Outlet has water present only during flooding events.
Salinity	Saline	Salinity > 30 ppt (>45,000 µS/cm).
	Brackish	Salinity = 0.5–30 ppt (800–45,000 .
	Fresh	Salinity < 0.5 ppt (<800 µS/cm).
Size	Small	Surface area < 10 ha.
	Large	Surface area > 10 ha.
Emergents (denoted by vegetation code)	Without	Emergent grasses, sedges or forbs do not form sufficiently large stands (< 0.25 ha) to map.
	With	Emergent grasses, sedges or forbs form sufficiently large stands (≥ 0.25 ha) to map.
Genesis	Riverine	Related to river processes and includes deltaic, channel, oxbow, point bar, and terrace flank ponds and lakes.
	Thaw Lake	Related to melting of ice-rich deposits and impoundment of water.
	Bedrock	Shoreline and water level controlled by bedrock.
	Kettle Lake	Depressions in glacial deposits related to melting of glacial ice.
	Dune	Depressions in dune fields.
	Other	Other
Islands (denoted by surface form code)	Without	Isolated terrestrial patches or islands insufficiently large (≤ 0.5 m^2 or ≤ 2 m from shore) or numerous to map.
	With	Islands > 0.5 m^2 in size and > 2 m from shore.
Shoreline (denoted by surface form code)	Smooth	Lacking peninsulas, bays, and indentations.
	Undulating	Peninsulas, bays, and indentations abundant.
	Polygonized Margins	Highly irregular shoreline formed by rims of ice-wedge polygons.

Table A4. Descriptions of ELC surface forms found in the Delta survey area and Transportation Corridor, Colville River Delta, Alaska (adapted from Washburn 1973, Everett 1980, National Wetlands Working Group 1988).

Class	Description
Nonpatterned	No distinct microtopographic pattern evident on aerial photography.
Polygons, disjunct	Disjunct system of ridges (<50 cm high) associated with initial stages of ice-wedge development. Typically found in young drained-lake basins and on lower floodplain steps.
Polygons, low-centered, low-relief, low density	Closed, roughly equidimensional features associated with ice-wedge development that consist of three elements, the flat central basin, low rims surrounding the basin, and the trough between the rims. Rims are <50 cm high and the basins typically range from 15–30 m in diameter. This pattern represents a mature stage of polygonal development.
Polygons, low-centered, low-relief, high density	Similar to above except basin diameters typically range from 5–15 m in diameter. This pattern represents an older stage of polygon development where initial polygons have been subdivided by further cracking and ice-wedge development.
Polygons, low-centered, high-relief, low density	Similar to above except polygon centers usually are deeper than 50 cm and basin are 15–30 m in diameter. This class typically used to denote areas where centers of low density polygons have melted down leaving deep polygon centers with permanent standing water.
Polygons, low-centered, high-relief, high density	Similar to above except polygons rims typically are >50 cm high and basins are 5–15 m in diameter. Represents the oldest stage of polygonal development. At the oldest stage the rims are so close that they appear to coalesce.
Polygons, mixed high and low	A mixture of high-centered and low-centered ice-wedge polygons. Relief generally is <50 cm and polygon diameters can be highly variable.
Polygons, high-centered, low-relief	Features associated with ice-wedge development and frequently thermal degradation of ice-wedges. High centers can result either from degradation of ice-wedges, leaving the centers up to 50 cm higher than troughs, or from development of segregated ice that raises the center of the polygon. Rims are absent or indistinct. This class also includes "flat-centered" polygons where the centers may be only 10–30 cm above the polygonal cracks.
Polygons, high-centered, high-relief	Similar to above except that polygons centers mostly >50 cm higher than bottom of troughs.
Mixed pits and polygons	Mixture of thermokarst pits and high-centered polygons, indicative of thermally unstable terrain. The pits are small (1–5 m across), moderately deep (0.5–1.5 m), and usually occurring at the intersection of ice-wedges.
Hummocks	A nonsorted form of net, characterized by a knob-like shape and vegetation cover. Class includes both earth hummocks with a core of mineral soil and turf hummocks consisting of vegetation and organic material. Common on slopes, streambanks, and pingos.
Frost scars	Small patches of bare or partially vegetated soil produced by frost action occurring with a vegetated matrix. Also includes frost boils which are sufficiently active as to prevent establishment of vegetation.
Mounds, undifferentiated, dense	Scattered to dense fields of mounds where genesis is uncertain. In the study area, this class typically occurs in recently drained lake beds (partially associated with water eroded high-centered polygons) and barren riverbars.

Table A4. Continued

Class	Description
Pingos	A perennial, conical shaped, ice-cored mound as much as 65 m high and 1000 m in diameter. Class can be subdivided into steep and gently sloped pingos. Generally found in drained lake basins, although open system pingos can be associated with mountain valleys.
Strang	Narrow, long, undulating small ridges associated with wet meadows and bogs. Strangs frequently are oriented normal to the hydrologic gradient and may interconnect into a net pattern. Composed of peat material.
Dunes, streaked	Thin elongated strip patterns associated with active and stabilized dunes. In the study area, this form is found on dunes in the Colville Delta.
Water tracks	A fluvial pattern associated with suprapermafrost movement of groundwater on frozen slopes. The pattern may be expressed by differences in growth of shrubs and sedges or can be the result of small differences in ground height resulting from micro-channel development.
Streambank	Steep slopes associated with a stream channel. May be affected by snow accumulation.
Islands present	Islands are present in waterbodies. An important habitat characteristic for some waterbirds. Islands are >0.5 m in diameter and >2 m from the shoreline.
Water with highly polygonized margin	Shorelines of shallow waterbodies that have a highly irregular shoreline associated with the persistence of rims of ice-wedge polygons. An important habitat characteristic for some waterbirds.
Bluff	Very steep slope made of unconsolidated material or with residual soil on top.
Basin complex	An association of nonpatterned, polygonal surface forms, and small waterbodies that form a diverse mosaic drained lake basins.

Table A5. Descriptions of vegetation classes found in the Delta survey area and Transportation Corridor, Colville River Delta, Alaska (adapted from Viereck et al. 1992, Walker and Acevedo 1987).

Class	Description
Barren	Barren flats on river floodplains, sand dunes, and recently drained lake bottoms that are recently exposed or too unstable to support more than a few pioneering plants (<5% cover). Typical pioneer plants include *Salix alaxensis, Elymus arenarius,* and *Deschamspia caespitosa.* Riverine Barrens include river flats and bars, primarily within the Colville River but also found within high-energy sections of tributaries. These areas are flooded seasonally and are underlain by fine-grained sediments (primarily silt) overlying sandy gravel. Lacustrine Barrens include unvegetated margins of lakes and ponds in which water level fluctuations inhibit vegetation growth; newly drained lake basins also are included. These areas are flooded seasonally and are underlain by clay and silt. On the delta, sediments usually are slightly saline and are being colonized by salt-marsh plant species.
Partially Vegetated	Riverbanks, sand dunes, and recently drained lake basins that have 5–30% vegetative cover. Colonizers on riverbars include *Deschampsia caespitosa, Elymus arenarius, Alopecurus alpinus, Puccinellia phryganodes, Chrysanthemum bipinnatum, Stellaria humifusa* and *Equisetum arvense.* On sand dunes *Salix lanata, S. alaxensis, Deschampsia caespitosa,* and *Elymus arenarius* are important.
Closed Tall Willow	Riverine willows dominated by a closed tall (>1.5 m) canopy of *S. alaxensis,* although *S. lanata* can be an important component forming a low (0.2–1.5 m) canopy. Common understory species include *Bromus pumpellianus, Equisetum arvense, Hedysarum alpinum, Astragalus alpinus. Salix alaxensis* occasionally obtained heights of 2 m. This rare class usually was grouped with Closed Low Willow. Found on active-floodplain cover deposits subject to flooding and sedimentation nearly every year.
Open Tall Willow	Similar to Closed Tall Willow except shrubs form an open canopy (25–75% cover).
Closed Low Willow	Riverine willows form a closed (>75% cover) low canopy. *Salix alaxensis* and *S. glauca* are more common on better-drained active-floodplain cover deposits, whereas *S. lanata* is dominant on more organic, poorer drained inactive-floodplain cover deposits. The understory commonly includes *Arctostaphylos rubra, Dryas integrifolia, S. reticulata, Lupinus arcticus,* and *Tomenthypnum nitens* and other mosses.
Open Low Willow	Riverine or upland willow community with an open canopy (25–75% cover). On better-drained stable sand dunes, *Salix glauca* is dominant and common associates include *Dryas integrifolia, S. reticulata, Cassioppe tetragona, Arctostaphylos rubra,* and *Astragalus umbellatus.* On wetter sites such as inactive-floodplain cover deposits and drained lake basins, *Salix lanata* and *S. planifolia* are more common and sedges are an important component. Associates include *Carex aquatilis, C. bigelowii, Eriophorum angustifolium, Dupontia fisheri, Arctagrostis latifolia, Dryas integrifolia, S. reticulata, Lupinus arcticus*, and mosses such as *Tomenthypnum nitens.*
Dryas tundra	The dwarf shrub *Dryas integrifolia* forms an open to closed cover. Other common species include *Salix reticulata, S. phlebophylla, Carex bigelowii*; forbs are found on moister sites; and lichens on drier sites. *Tomenthypnum nitens* is a common moss in this class. This class is found on well drained sites, usually ridges, pingos, and occasionally stream terraces.

Table A5. Continued

Class	Description
Halophytic Dwarf Willow	The dwarf willow *Salix ovalifolia* forms an open to closed mat along margins of salt-affected tidal flats and delta river bars. Other common species *include Deschampsia caespitosa, Puccinellia andersonii, Dupontia fisheri, Arctagrostis latifolia, Alopecurus alpinus, Chrysanthemum bipinnatum,* and *Petasites frigidus*. Usually found on active floodplain cover deposits subject to flooding and sedimentation nearly every year.
Tussock Tundra	The vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum*; associated species are *C. bigelowii*, *D. integrifolia*, *Cassiope tetragona*, and *S. reticulata*. Many of the associated species are similar to those listed for Moist Sedge-Shrub Tundra. Found on broad upper slopes of ridges on coastal plain deposits and within ice-rich basins. Water generally is absent from the active layer during midsummer but occasionally can be found near the surface (>15 cm depth).
Moist Sedge-Shrub Tundra	Vegetation is dominated by *Carex aquatilis, C. bigelowii, E. angustifolium, S. planifolia*. And *D. integrifolia*. Other common vascular species include *S. reticulata, Vaccinium vitis-idaea, Cassiope tetragona, Chrysanthemum integrifolia, Senecio atropurpureus, Pedicularis lanata, P. capitata, Polygonum viviparum,* and *Papaver macounii*. The ground surface is covered with a nearly continuous carpet of mosses usually including *Tomenthypnum nitens, Hylocomium splendens, Aulacomnium turgidum,* and *Dicranum* spp. This class combines Sedge-Willow and Sedge-*Dryas* Tundra. In high-relief areas (especially high-center polygons) vegetation communities are more complex, including wet and aquatic sedge vegetation in flooded troughs. Up to 30% of the area can have Wet Sedge-Willow Tundra. Occurs on better-drained uplands between thaw basins, on riverbanks, lower slopes of pingos, thaw-lake plains, and foothill slopes and usually is associated with high-centered polygons, nonpatterned ground, frost scars or mixed polygon areas. Soils are saturated at intermediate depths (> 15 cm) but generally are free of surface water during summer; however, some sites may be inundated briefly during break-up.
Wet Sedge-Willow Tundra	Vegetation is dominated by sedges, usually *Carex aquatilis* and *E. angustifolium,* although other sedges may be present, including *C. rotundata, C. saxatilis, C. membranacea, C. chordorriza,* and *E. russeolum*. Willows, including *Salix lanata*, *S. arctica,* and *S. planifolia*, also are abundant and may be dominant on drier polygon ridges. Sites lacking willows are included in this class. Occurs in lowland areas within drained-lake basins, level floodplains and on swales on slopes. Usually associated with low-centered and disjunct polygons, strangmoor, and nonpatterned ground on floodplains and recently drained-lake basins. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. Soils usually have a moderately thick (10–50 cm) organic layer over silt loam.
Fresh Sedge Marsh	Permanently flooded waterbodies and marshes dominated by *Carex aquatilis*. Typically, emergent sedges occur in water 10–30 cm deep. Water and bottom sediments of this shallow vegetation class freeze completely during winter, but the ice melts in early June. The sediments usually have a peat layer (10–50 cm deep) overlying silt loam.
Fresh Grass Marsh	Ponds and lake margins with emergent *Arctophila fulva*. Due to shallow water depths (0.3–1.0 m), the water freezes to the bottom in the winter and the ice melts by early June. *Arctophila* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in the thaw-lake cycle and is more productive than Fresh Sedge Marsh.

Table A5. Continued

Class	Description
Halophytic Grass Wet Meadow	Vegetation is dominated by *Dupontia fisheri,* and usually includes *Puccinellia phryganodes, P. andersonii, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.* This type occurs along the Beaufort Sea coast, delta margins, and shorelines of tapped lakes and is distributed patchily among brackish tidal pools and bare mudflats. Salinity levels and frequency of inundation usually are less than that of Halophytic Sedge Wet Meadow. The soil is composed of marine or lacustrine silt and clay.
Halophytic Sedge Wet Meadow	Similar to Halophytic Grass Wet Meadow, but is dominated by the sedges *Carex subspathacea,* and *C. ursina,* and often include *Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.*
Salt-killed Wet Meadow	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and where salt-tolerant plants are actively colonizing. Colonizing plants include *P. andersonii, D. fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, S. humifusa, Cerastium beeringianum,* and *Salix ovalifolia* This habitat typically occurs either on low-lying areas that originally supported Wet Sedge-Willow Tundra and Basin Wetland Complexes, or, less commonly, along drier coastal bluffs that originally supported Moist Sedge-Shrub Meadows. Salt-killed tundra differs from Halophytic Sedge Wet Meadow in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizers.
Young Basin Wetland Complex	Basin Wetland Complexes (both young and old) occur in drained-lake basins and are characterized by a complex mosaic of open water, fresh sedge and grass marshes, and wet and moist meadows in patches too small (<0.5 ha) to map individually. During spring breakup, deeper basins may be entirely inundated: water levels gradually recede following breakup. Basins often have distinct upland rims marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw-lake stages. Soils generally are fine-grained, organic-rich, and ice-poor. The lack of ground ice results in poorly developed polygon rims in wetter areas and indistinct edges of waterbodies. Ecological communities within younger basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating between these two types. This class has at least three vegetation types, although no single type dominates (>70% of the area). Minimum size for mapping polygon is 2 ha.
Old Basin Wetland Complex	Similar to Young Basin Wetland Complexes but characterized by well-developed low- and high-center polygons resulting from ice-wedge development and aggradation of segregated ice. The waterbodies in old complexes tend to have smoother, more rectangular shorelines and are not as interconnected as in young complexes. The vegetation types generally include Wet Sedge Willow with Low-relief Polygons, Moist Sedge-Shrub Meadows, and Moist Tussock Tundra, whereas Aquatic Sedge and Grass Marshes are absent. Soils generally have a moderately thick (0.2–0.5 m) organic layer overlying fine-grained silt or sandy silt. This class has at least three vegetation types, although no single type dominates (>70% of the area). Minimum size for mapping polygon is 2 ha.

Table A6. Ecological land classes composing each wildlife habitat type in use/availability analyses in the Delta survey area and Transportation Corridor, Colville River Delta, Alaska, 1995. Codes for classes are listed in Table A1.

Habitat Code	Habitat Name	Ecological Land Classes
205	Open Nearshore Water (coastal)	963
210	Brackish Water (deep or shallow; lakes and ponds)	989, 989/96, 989/97
232	Tapped Lake (deep or shallow) w/ Low-water Connection	983, 986
235	Tapped Lake (deep or shallow) w/ High-water Connection	984, 987
250	Salt Marsh (coastal wetland complex)	412/0/346, 413/0/345, 413/0/346, 413/2/346, 415/0/295, 818/0/295,818/0/345, 818/0/346, 818/2/346, 862/0/346
280	Tidal Flat	862/0/0
285	Salt-killed Tundra	413/0/348, 413/2/348, 416/0/348, 416/2/348, 416/5/348, 417/6/348, 818/2/348, 818/5/348
312	Deep Open Water w/o Islands	922, 925, 930, 930/96
313	Deep Open Water w/ Islands or Polygonized Margins	922/96, 922/97, 984/96
322	Shallow Open Water w/o Islands	941, 943, 948, 950
323	Shallow Open Water w/ Islands or Polygonized Margins	941/96, 941/97, 950/96, 950/97
330	River or Stream	905, 910, 918
361	Aquatic Sedge Marsh	941/0/336, 941/96/336, 950/96/336
364	Aquatic Sedge w/ Deep Polygons	416/7/336, 417/7/336, 417/8/336
371	Aquatic Grass Marsh	941/0/337, 941/96/337, 943/0/337, 950/0/337, 987/0/337
401	Young Basin Wetland Complex (ice-poor)	816/101/411
405	Old Basin Wetland Complex (ice-rich)	817/101/412
511	Nonpatterned Wet Meadow	413/0/334, 413/2/334, 416/0/334, 416/2/334, 443/0/334 444/0/334, 444/2/334, 545/0/334, 545/2/334, 816/0/334, 816/2/334, 818/0/334, 818/2/334, 860/0/334, 860/2/334

Table A6. Continued

Habitat Code	Habitat Name	Ecological Land Classes
521	Wet Sedge-Willow Meadow w/ Low-relief Polygons	380/62/334, 413/5/334, 416/5/334, 417/6/334, 444/5/334, 545/5/334, 595/5/334, 817/5/334, 818/5/334, 819/5/334, 860/5/334
542	Moist Sedge-Shrub Meadow (low- or high-relief polygons)	380/11/320, 380/62/320, 413/2/320, 416/0/320, 416/2/320, 416/5/320, 417/6/320, 444/0/320, 444/11/320, 444/12/320, 444/2/320, 444/5/320, 545/0/320, 545/11/320, 545/12/320, 545/98/320, 595/0/320, 595/11/320, 816/0/320, 816/2/320, 816/31/320, 817/11/320, 817/12/320, 817/5/320, 818/0/320, 818/2/320, 860/0/320, 860/11/320, 860/12/320, 860/2/320, 860/98/320
546	Moist Tussock Tundra (low- or high-relief polygons)	545/11/314, 545/12/314, 595/11/314, 817/11/314, 817/12/314, 817/35/314, 860/11/314, 860/12/314, 415/0/242, 416/0/242, 416/2/242,
600	Riverine or Upland Shrub	380/62/260, 380/62/270, 413/0/242, 416/2/260, 416/5/242, 416/5/260, 417/6/242, 417/6/260, 443/0/242, 444/0/242, 444/0/270, 444/11/242, 444/2/242, 444/5/242, 545/11/242, 545/11/260, 545/11/270, 545/12/242, 817/35/270, 817/5/260, 818/0/231, 818/0/242, 818/0/260, 818/2/242, 818/2/260, 818/35/270, 819/5/242, 860/11/270
800	Barrens (riverine, eolian, lacustine)	380/62/10, 412/0/0, 412/0/10, 413/0/10, 441/0/0, 441/0/10, 816/0/10, 818/0/0, 818/0/10, 862/0/10
900	Artificial (water, fill, peat road)	872/0/0, 874/17/320, 997

Table A7. List of vascular plant taxa identified in the Delta survey area and Transportation Corridor, Colville River Delta, 1995. Unless otherwise indicated, voucher specimens were collected and are available at ABR, Inc. Species in parentheses are tentative identifications without voucher specimens. Nomenclature follows Hultén (1968).

Alopecuris alpinus
Andromeda polifolia
Androsace chamaejasme Lehmanniana
Androsace septentrionalis
Antennaria Friesiana Friesiana
Arabis arenicola pubescens
(Arabis lyrata)
Arctagrostis latifolia latifolia
Arctophila fulva
Arctostaphylos alpina
Arctostaphylos rubra
Armeria maritima
Arnica alpina angustifolia
(Arnica Lessingii)
Artemisia arctica
Artemisia borealis
Artemisia tilessi tilessi
Aster sibiricus
Astragalus alpinus alpinus
Astragalus umbellatus
Betula glandulosa
Betula nana exilis
Bromus pumpellianus arcticus
Bupleurum triradiatum arcticum
Caltha palustris
Campanula uniflora
(Cardamine bellidifolia)
Cardamine hyperborea
Cardamine pratensis angustifolia
Carex aquatilis
Carex atrofusca
Carex bigelowii
Carex chordorrhiza
Carex krausei
Carex lugens
Carex maritima
Carex membranaceae
Carex misandra
Carex nardina
Carex rariflora
Carex rotundata
Carex saxatilis
Carex scirpoidea
Carex subspathacea
Carex ursina
(Carex vaginata)
Cassiope tetragona
Castilleja caudata
Cerastium beeringianum beeringianum
Chrysanthemum bipinnatum
(Chrysanthemum arcticum)
Chrysanthemum integrifolium
Cochlearia officinalis arctica
Deschampsia caespitosa glauca
Deschampsia caespitosa orientalis
Draba cinerea
Draba hirta
Dryas intregrifolia
Dupontia fisheri psilosantha
Elymus arenaris
Empetrum nigrum (no voucher specimen)
Epilobium latifoliium
Equisetum arvense
Equisetum scirpoides
Equisetum variegatum variegatum
Erigeron purpuratus
Eriophorum angustifolium
Eriophorum russeolum
Eriophorum scheuchzeri (no voucher specimen)
Eriophorum vaginatum vaginatum
Festuca rubra
Festuca vivipara
Gentiana propinqua arctophila
Gentiana propinqua propinqua
Hedysarum alpinum americanum
Hedysarum Mackenzii
Hierochloe alpina
Hierochloe pauciflora
Hippuris vulgaris
Juncus arcticus alaskanus
Juncus biglumis
Juncus castaneus (no voucher specimen)
Juncus triglumis albescens
Ledum palustre decumbens
Lupinus arcticus
Luzula arctica
(Luzula arcuata)
Luzula confusa
Luzula multiflora multiflora
Luzula tundricola
Melandrium apetalum
Minuartia arctica
Minuartia rubella
Oxytropis arctica
Oxytropis borealis
Oxytropis campestris
Oxytropis viscida
Papaver macounii
Parnassia kotzebuei
Pedicularis capitata
Pedicularis langsdorffii arctica
Pedicularis sudetica albolabiata
Pedicularis verticillata
Petasites frigidus (no voucher specimen)
Petasites hyperboreus
Plantago canescens
Poa alpina (no voucher specimen)
Poa arctica
Poa glauca
Poa viviparum
Polemonium boreale boreale
Polygonum bistorta
Polygonum viviparum
Potentilla hookeriana chamissonis
Potentilla palustris
Potentilla pulchella
Puccinellia andersoni
Puccinellia borealis
Puccinellia phryganodes
Pyrola grandifolia
Pyrola secunda
Ranunculus gmelini gmelini
Ranunculus hyperboreus hyperboreus
Ranunculus lapponicus
Ranunculus pallasii
Ranunculus parviflora
Ranunculus pedatifidus affinis
Rubus chamaemorus

Table A7. Continued

Rumex arcticus
Salix alaxensis
Salix arctica (no voucher specimen)
Salix brachycarpa niphoclada
(Salix fuscescens)
Salix glauca
Salix lanata
Salix ovalifolia
Salix phlebophylla
Salix planifolia
Salix polaris
Salix reticulata
(Salix rotundifolia)
Sausaurea angustifolia
Saxifraga bronchialis
Saxifraga caespitosa
Saxifraga cernua
Saxifraga foliosa
Saxifraga hieracifolia
Saxifraga hirculus
Saxifraga oppositifolia oppositifolia
Saxifraga punctata Nelsoniana
Sedum rosea integrifolium
Senecio atropurpureus frigidus
Senecio congestus
Senecio lugens
Senecio resedifolius
Silene acaulis
Stellaria crassifolia (no voucher specimen)
Stellaria humifusa
Stellaria laeta
Taraxacum ceratophorum
Tofieldia coccinea
Tofieldia pusilla
Trisetum spicatum spicatum
Utricularia vulgaris macrorhiza
Vaccinium uliginosum
Vaccinium vitis-idaea
Valeriana capitata
Wilhelmsia physodes

Table A8. Crosswalk of wildlife habitats classified in the Colville River Delta with other habitat and vegetation classification systems that have been used in the region.

Colville Habitats (This Study)	Bergman et al. (1977)	Martin and Moitoret (1981)	Troy et al. (1983)	Nickles et al. (1987)	Meehan and Jennings (1988)	Walker and Acevedo (1987) Level B	Cowardin et al. (1979)
Open Nearshore Water	Coastal Wetland	Lagoon Bay		Water		Open Water	Estuarine, Subtidal, Unconsolidated Bottom
Brackish Water	Coastal Wetland			Water	Discrete Lake	Open Water	Estuarine, Intertidal, Unconsolidated Shore
Tapped Lake w/ Low-water Connection	Deep Open Lake Coastal Wetland			Water	Tapped Lake	Open Water	Estuarine, Intertidal [Various Classes]
Tapped Lake w/ High-water Connection	Deep Open Lake			Water	Tapped Lakes	Open Water	Lacustrine, Limnetic, Unconsolidated Bottom Lacustrine, Littoral [Various Classes] Palustrine [Various Classes]
Salt Marsh	Coastal Wetland	Saline meadow			Brackish Flats	Wet Sedge Tundra [Saline Areas] [Various Complex types]	Estuarine, Intertidal, Unconsolidated Shore Estuarine, Intertidal, Emergent Wetland Estuarine, Intertidal, Scrub-Shrub Wetland
Tidal Flat		Mudflats			Barrens	Barren	Estuarine, Intertidal, Unconsolidated Bottom
Salt-killed Tundra	Coastal Wetland				Brackish Flats		Estuarine, Intertidal, [Various Classes]
Deep Open Water w/o Islands	Deep Open Lake		Water/Pond without emergents	Water	Discrete Lake	Open Water	Lacustrine, Limnetic, Unconsolidated Bottom Lacustrine, Littoral [Various Classes] Palustrine [Various Classes]
	Deep Open Lake	Mosaic		Water	Discrete Lake Wet-moist Flooded Tundra	Open Water [Various Complex types]	Lacustrine, Limnetic, Unconsolidated Bottom Lacustrine, Littoral [Various Classes] Palustrine [Various Classes]
Shallow Open Water w/o Islands	Shallow *Carex*		Water/pond without emergents	Water	Discrete Lake	Open Water	Palustrine [Various Classes]
Shallow Open Water w/ Islands	Shallow *Carex* Flooded Tundra	Mosaic		Water	Discrete Lake Wet-moist Flooded Tundra	Open Water [Various Complex types]	Palustrine [Various Classes]

Table A8. continued

Colville Habitats (This Study)	Bergman et al. (1977)	Martin and Moitoret (1981)	Troy et al. (1983)	Nickles et al. (1987)	Meehan and Jennings (1988)	Walker and Acevedo (1987) Level B	Cowardin et al. (1979)
River or Stream	Beaded Stream	River		Water		Open Water	Riverine, Tidal Riverine, Lower Perennial Riverine, Upper Perennial Riverine, Intermittent [Various Classes]
Aquatic Sedge Marsh	Shallow *Carex* Flooded Tundra	Flooded Sedge Pond-edge Emergent Sedge Trough-edge Emergent Sedge	Water/Pond with emergents	Water, Emergent Vegetation	Wet Graminoid Wet-moist Flooded Tundra	Aquatic Sedge Tundra	Palustrine, Emergent Wetland
Aquatic Sedge w/ Deep Polygons		Mosaic Trough-edge Emergent Sedge		High Relief LCP with Wet Sedge	Wet-moist Flooded Tundra Wet-moist Polygons	Aquatic Sedge Tundra	Palustrine, Emergent Wetland
Aquatic Grass Marsh	Shallow *Arctophila* Deep *Arctophila*		Water/Pond with emergents	Water, Emergent Vegetation	Wet Graminoid Wet-moist Flooded Tundra	Aquatic Grass Marsh	Palustrine, Emergent Wetland
Young Basin Wetland Complex	Basin Complex	Mosaic			[Various Classes]	[Various Complex Types]	Palustrine, Emergent Wetland
Old Basin Wetland Complex	Basin Complex	Mosaic			[Various Classes]	[Various ComplexTypes]	Palustrine, Emergent Wetland
Nonpatterned Wet Meadow	Flooded Tundra Shallow *Carex*	Wet sedge Flooded Sedge	Wet Tundra/Non-patterned Ground	Non-patterned Wet Sedge Water/Moist or Wet Sedge	Wet-moist Flooded Tundra Wet Graminoid	Wet Sedge Tundra	Palustrine, Emergent Wetland
Wet Sedge-Willow Meadow	Flooded Tundra Shallow *Carex*	Wet Sedge	Wet tundra/Low Relief LCP Wet Tundra/ Strangmoor Aquatic, Moist Tundra/Strangmoor Aquatic Sedge/ Strangmoor	Low Relief LCP with Wet Sedge LCP dominated by Water Low Relief LCP with Moist Sedge Water/Moist or Wet Sedge	Wet-moist Flooded Tundra Wet-moist Polygons	Wet Sedge Tundra Wet Sedge, Dwarf-shrub, Moss Tundra Wet Sedge, Low-shrub Tundra	Palustrine, Emergent Wetland Palustrine, Scrub-shrub Wetland

Table A8. continued

Colville Habitats (This Study)	Bergman et al. (1977)	Martin and Moitoret (1981)	Troy et al. (1983)	Nickles et al. (1987)	Meehan and Jennings (1988)	Walker and Acevedo (1987) Level B	Cowardin et al. (1979)
Moist Sedge-Shrub Meadow		Mesic Frost Boil Sedge Mesic Sedge Moist Sedge	Moist Tundra/HCP Moist Tundra/Frost-scar Moist Tundra/Low Relief HCP	Moist Low Shrub/Dry Dwarf Tundra High Relief LCP with Moist Sedge HCP with Moist Sedge	Wet-moist Flooded Tundra Wet-moist Polygons	Moist Non-tussock-sedge Dwarf-shrub Tundra Moist Non-tussock Sedge Mixed-shrub Tundra	Palustrine, Emergent Wetland Palustrine, Scrub-shrub Wetland
Moist Tussock Tundra				Moist Tussock Tundra	Sedge-tussock Tundra	Moist Tussock-sedge, Dwarf-shrub Tundra Moist Tussock-sedge, Mixed-shrub Tundra	Non-wetland
Riverine or Upland Shrub		Dry Sedge/Forb Upland		Dry Dwarf Shrub Forb	Shrub-dominant Areas	Dry Dwarf-shrub, Crustose-lichen Tundra Dry Dwarf-shrub, Fruticose-lichen Tundra Dry dwarf-shrub, Forb, Lichen Tundra Dry Low-shrub, Fruticose-lichen Tundra	Non-wetland
Barrens [Riverine, Eolian, Lacustrine]		Spit Barrier Island		Barren	Barrens	Barren/Sparse Vegetation [Various Complex types]	Non-wetland
Artificial [Water, Fill, Peat Road]			Impoundment				

Appendix B. Tables of annual habitat selection values for Spectacled Eiders, King Eiders, Tundra Swan, Yellow-billed Loon, and Brant.

Table B1. Habitat selection by Spectacled Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	1.9	-1.00	12
Brackish Water	6.50	1	4	7.7	1.2	0.73	1
Tapped Lake w/ Low-water Connection	21.42	3	6	23.1	3.9	0.71	2
Tapped Lake w/ High-water Connection	20.36	1	1	7.7	3.7	0.35	5
Salt Marsh	16.73	1	2	7.7	3.0	0.43	4
Tidal Flat	55.90	1	2	7.7	10.1	-0.14	9
Salt-killed Tundra	25.63	1	2	7.7	4.6	0.25	7
Deep Open Water w/o Islands	23.31	1	1	7.7	4.2	0.29	6
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0	0.9	-1.00	12
Shallow Open Water w/o Islands	2.32	0	0	0	0.4	-1.00	12
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	12
River or Stream	81.76	1	4	7.7	14.8	-0.32	10
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	1	1	7.7	2.5	0.51	3
Aquatic Grass Marsh	1.37	0	0	0	0.2	-1.00	12
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	12
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	12
Nonpatterned Wet Meadow	41.98	1	2	7.7	7.6	0.01	8
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	1	2	7.7	18.5	-0.41	11
Moist Sedge-Shrub Meadow	13.10	0	0	0	2.4	-1.00	12
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	12
Riverine or Upland Shrub	27.40	0	0	0	5.0	-1.00	12
Barrens (riverine, eolian, lacustrine)	79.01	0	0	0	14.3	-1.00	12
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	12
Total	551.25	13	27	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B2. Habitat selection by Spectacled Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1994 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	2.2	-1.00	11
Brackish Water	6.50	2	6	9.1	1.4	0.74	4
Tapped Lake w/ Low-water Connection	21.14	1	2	4.5	4.4	0.01	8
Tapped Lake w/ High-water Connection	17.34	1	2	4.5	3.6	0.11	7
Salt Marsh	16.68	1	2	4.5	3.5	0.13	6
Tidal Flat	55.90	0	0	0.0	11.7	-1.00	11
Salt-killed Tundra	25.63	5	14	22.7	5.4	0.62	5
Deep Open Water w/o Islands	17.80	0	0	0	3.7	-1.00	11
Deep Open Water w/ Islands or Polygonized Margins	4.71	0	0	0	1.0	-1.00	11
Shallow Open Water w/o Islands	2.15	1	2	4.5	0.5	0.82	3
Shallow Open Water w/ Islands or Polygonized Margins	0.46	0	0	0	0.1	-1.00	11
River or Stream	74.67	0	0	0	15.6	-1.00	11
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	12.82	6	9	27.3	2.7	0.82	2
Aquatic Grass Marsh	0.89	1	1	4.5	0.2	0.92	1
Young Basin Wetland Complex	0	-	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	-	0	-	-
Nonpatterned Wet Meadow	36.24	1	2	4.5	7.6	-0.25	10
Wet Sedge-Willow Meadow w/ Low-relief Polygons	74.77	3	13	13.6	15.6	-0.07	9
Moist Sedge-Shrub Meadow	9.63	0	0	0	2.0	-1.00	11
Moist Tussock Tundra	1.68	0	0	0	0.4	-1.00	11
Riverine or Upland Shrub	17.63	0	0	0	3.7	-1.00	11
Barrens (riverine, eolian, lacustrine)	71.16	0	0	0	14.9	-1.00	11
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	11
Total	478.29	22	53	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B3. Habitat selection by Spectacled Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	1.9	-1.00	9
Brackish Water	6.50	0	0	0	1.2	-1.00	9
Tapped Lake w/ Low-water Connection	21.42	0	0	0	4.0	-1.00	9
Tapped Lake w/ High-water Connection	19.61	1	2	7.1	3.6	0.33	6
Salt Marsh	16.73	0	0	0	3.1	-1.00	9
Tidal Flat	55.90	0	0	0	10.4	-1.00	9
Salt-killed Tundra	25.63	3	5	21.4	4.7	0.64	3
Deep Open Water w/o Islands	22.89	2	4	14.3	4.2	0.54	4
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0	0.9	-1.00	9
Shallow Open Water w/o Islands	2.29	0	0	0	0.4	-1.00	9
Shallow Open Water w/ Islands or Polygonized Margins	0.53	1	2	7.1	0.1	0.97	1
River or Stream	79.98	0	0	0	14.8	-1.00	9
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.54	3	10	21.4	2.5	0.79	2
Aquatic Grass Marsh	1.28	0	0	0	0.2	-1.00	9
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	9
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	9
Nonpatterned Wet Meadow	41.73	2	8	14.3	7.7	0.30	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	98.66	1	3	7.1	18.3	-0.44	8
Moist Sedge-Shrub Meadow	12.37	1	4	7.1	2.3	0.51	5
Moist Tussock Tundra	2.48	0	0	0	0.5	-1.00	9
Riverine or Upland Shrub	25.30	0	0	0	4.7	-1.00	9
Barrens (riverine, eolian, lacustrine)	77.64	0	0	0	14.4	-1.00	9
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	9
Total	540.08	14	38	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B4. Habitat selection by Spectacled Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0		
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	3
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	0	0	0	9.3	-1.00	3
Deep Open Water w/ Islands or Polygonized Margins	4.30	0	0	0	1.6	-1.00	3
Shallow Open Water w/o Islands	9.32	0	0	0	3.4	-1.00	3
Shallow Open Water w/ Islands or Polygonized Margins	6.73	0	0	0	2.5	-1.00	3
River or Stream	1.97	0	0	0	0.7	-1.00	3
Aquatic Sedge Marsh	0.90	0	0	0	0.3	-1.00	3
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	3
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	3
Young Basin Wetland Complex	13.21	1	1	50.0	4.8	0.82	1
Old Basin Wetland Complex	30.40	0	0	0	11.1	-1.00	3
Nonpatterned Wet Meadow	20.85	0	0	0	7.6	-1.00	3
Wet Sedge-Willow Meadow w/ Low-relief Polygons	15.98	0	0	0	5.8	-1.00	3
Moist Sedge-Shrub Meadow	64.76	1	2	50.0	23.6	0.36	2
Moist Tussock Tundra	71.03	0	0	0	25.9	-1.00	3
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	3
Barrens (riverine, eolian, lacustrine)	1.67	0	0	0	0.6	-1.00	3
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	3
Total	274.38	2	3	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B5. Habitat selection by Spectacled Eiders during pre-nesting on the Transportation Corridor survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	5
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	1	2	25.0	9.3	0.46	4
Deep Open Water w/ Islands or Polygonized Margins	4.30	0	0	0	1.6	-1.00	5
Shallow Open Water w/o Islands	9.32	0	0	0	3.4	-1.00	5
Shallow Open Water w/ Islands or Polygonized Margins	6.73	0	0	0	2.5	-1.00	5
River or Stream	1.97	0	0	0	0.7	-1.00	5
Aquatic Sedge Marsh	0.90	0	0	0	0.3	-1.00	5
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	5
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	5
Young Basin Wetland Complex	13.21	1	2	25.0	4.8	0.68	1
Old Basin Wetland Complex	30.40	0	0	0	11.1	-1.00	5
Nonpatterned Wet Meadow	20.85	1	2	25.0	7.6	0.53	3
Wet Sedge-Willow Meadow w/ Low-relief Polygons	15.98	1	2	25.0	5.8	0.62	2
Moist Sedge-Shrub Meadow	64.76	0	0	0	23.6	-1.00	5
Moist Tussock Tundra	71.03	0	0	0	25.9	-1.00	5
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	5
Barrens (riverine, eolian, lacustrine)	1.67	0	0	0	0.6	-1.00	5
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	5
Total	274.38	4	8	100.00	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B6. Habitat selection by King Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	1.9	-1.00	5
Brackish Water	6.50	0	0	0	1.2	-1.00	5
Tapped Lake w/ Low-water Connection	21.42	0	0	0	3.9	-1.00	5
Tapped Lake w/ High-water Connection	20.36	0	0	0	3.7	-1.00	5
Salt Marsh	16.73	0	0	0	3.0	-1.00	5
Tidal Flat	55.90	1	2	10.0	10.1	-0.01	4
Salt-killed Tundra	25.63	0	0	0	4.6	-1.00	5
Deep Open Water w/o Islands	23.31	0	0	0	4.2	-1.00	5
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0	0.9	-1.00	5
Shallow Open Water w/o Islands	2.32	0	0	0	0.4	-1.00	5
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	5
River or Stream	81.76	4	14	40.0	14.8	0.46	1
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	0	0	0	2.5	-1.00	5
Aquatic Grass Marsh	1.37	0	0	0	0.2	-1.00	5
Young Basin Wetland Complex	0.00	0	0	0	<0.1	-1.00	5
Old Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	5
Nonpatterned Wet Meadow	41.98	0	0	0	7.6	-1.00	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	2	4	20.0	18.5	0.04	3
Moist Sedge-Shrub Meadow	13.10	0	0	0	2.4	-1.00	5
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	5
Riverine or Upland Shrub	27.40	0	0	0	5.0	-1.00	5
Barrens (riverine, eolian, lacustrine)	79.01	3	9	30.0	14.3	0.35	2
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	5
Total	551.25	10	29	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B7. Habitat selection by King Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1994 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	1	9	10.0	2.2	0.64	1
Brackish Water	6.50	0	0	0	1.4	-1.00	7
Tapped Lake w/ Low-water Connection	21.14	1	2	10.0	4.4	0.39	4
Tapped Lake w/ High-water Connection	17.34	0	0	0	3.6	-1.00	7
Salt Marsh	16.68	0	0	0	3.5	-1.00	7
Tidal Flat	55.90	0	0	0	11.7	-1.00	7
Salt-killed Tundra	25.63	1	2	10.0	5.4	0.30	5
Deep Open Water w/o Islands	17.80	0	0	0	3.7	-1.00	7
Deep Open Water w/ Islands or Polygonized Margins	4.71	0	0	0	1.0	-1.00	7
Shallow Open Water w/o Islands	2.15	0	0	0	0.5	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0.46	0	0	0	0.1	-1.00	7
River or Stream	74.67	4	8	40.0	15.6	0.44	3
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	12.82	1	2	10.0	2.7	0.58	2
Aquatic Grass Marsh	0.89	0	0	0	0.2	-1.00	7
Young Basin Wetland Complex	0	-	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	-	0	-	-
Nonpatterned Wet Meadow	36.24	0	0	0	7.6	-1.00	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	74.77	0	0	0	15.6	-1.00	7
Moist Sedge-Shrub Meadow	9.63	0	0	0	2.0	-1.00	7
Moist Tussock Tundra	1.68	0	0	0	0.4	-1.00	7
Riverine or Upland Shrub	17.63	0	0	0	3.7	-1.00	7
Barrens (riverine, eolian, lacustrine)	71.16	2	9	20.0	14.9	0.15	6
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	7
Total	478.29	10	32	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B8. Habitat selection by King Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	1.9	-1.00	3
Brackish Water	6.50	0	0	0	1.2	-1.00	3
Tapped Lake w/ Low-water Connection	21.42	0	0	0	4.0	-1.00	3
Tapped Lake w/ High-water Connection	19.61	0	0	0	3.6	-1.00	3
Salt Marsh	16.73	0	0	0	3.1	-1.00	3
Tidal Flat	55.90	0	0	0	10.4	-1.00	3
Salt-killed Tundra	25.63	0	0	0	4.7	-1.00	3
Deep Open Water w/o Islands	22.89	0	0	0	4.2	-1.00	3
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0	0.9	-1.00	3
Shallow Open Water w/o Islands	2.29	0	0	0	0.4	-1.00	3
Shallow Open Water w/ Islands or Polygonized Margins	0.53	0	0	0	0.1	-1.00	3
River or Stream	79.98	2	21	66.7	14.8	0.64	1
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.54	0	0	0	2.5	-1.00	3
Aquatic Grass Marsh	1.28	0	0	0	0.2	-1.00	3
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	3
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	3
Nonpatterned Wet Meadow	41.73	1	1	33.3	7.7	0.62	2
Wet Sedge-Willow Meadow w/ Low-relief Polygons	98.66	0	0	0	18.3	-1.00	3
Moist Sedge-Shrub Meadow	12.37	0	0	0	2.3	-1.00	3
Moist Tussock Tundra	2.48	0	0	0	0.5	-1.00	3
Riverine or Upland Shrub	25.30	0	0	0	4.7	-1.00	3
Barrens (riverine, eolian, lacustrine)	77.64	0	0	0	14.4	-1.00	3
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	3
Total	540.08	3	22	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B9. Habitat selection by King Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	4	8	44.4	9.3	0.65	4
Deep Open Water w/ Islands or Polygonized Margins	4.30	1	3	11.1	1.6	0.75	3
Shallow Open Water w/o Islands	9.32	0	0	0	3.4	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	6.73	0	0	0	2.5	-1.00	7
River or Stream	1.97	0	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.90	1	2	11.1	0.3	0.94	1
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	7
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	7
Young Basin Wetland Complex	13.21	0	0	0	4.8	-1.00	7
Old Basin Wetland Complex	30.40	0	0	0	11.1	-1.00	7
Nonpatterned Wet Meadow	20.85	1	1	11.1	7.6	0.19	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	15.98	0	0	0	5.8	-1.00	7
Moist Sedge-Shrub Meadow	64.76	0	0	0	23.6	-1.00	7
Moist Tussock Tundra	71.03	1	2	11.1	25.9	-0.40	6
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	7
Barrens (riverine, eolian, lacustrine)	1.67	1	1	11.1	0.6	0.90	2
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	7
Total	274.38	9	17	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B10. Habitat selection by King Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	10
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	7	32	13.7	9.3	0.19	5
Deep Open Water w/ Islands or Polygonized Margins	4.30	2	4	3.9	1.6	0.43	4
Shallow Open Water w/o Islands	9.32	6	26	11.8	3.4	0.55	1
Shallow Open Water w/ Islands or Polygonized Margins	6.73	4	13	7.8	2.5	0.52	2
River or Stream	1.97	0	0	0	0.7	-1.00	10
Aquatic Sedge Marsh	0.90	0	0	0	0.3	-1.00	10
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	10
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	10
Young Basin Wetland Complex	13.21	7	30	13.7	4.8	0.48	3
Old Basin Wetland Complex	30.40	7	19	13.7	11.1	0.11	7
Nonpatterned Wet Meadow	20.85	5	17	9.8	7.6	0.13	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	15.98	0	0	0	5.8	-1.00	10
Moist Sedge-Shrub Meadow	64.76	7	26	13.7	23.6	-0.26	8
Moist Tussock Tundra	71.03	6	22	11.8	25.9	-0.38	9
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	10
Barrens (riverine, eolian, lacustrine)	1.67	0	0	0	0.6	-1.00	10
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	10
Total	274.38	51	189	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B11. Habitat selection by Spectacled Eiders during brood-rearing on the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	1.9	-1.00	2
Brackish Water	6.50	0	0	0	1.2	-1.00	2
Tapped Lake w/ Low-water Connection	21.42	0	0	0	3.9	-1.00	2
Tapped Lake w/ High-water Connection	20.36	0	0	0	3.7	-1.00	2
Salt Marsh	16.73	0	0	0	3.0	-1.00	2
Tidal Flat	55.90	0	0	0	10.1	-1.00	2
Salt-killed Tundra	25.63	1	1	100.0	4.6	0.91	1
Deep Open Water w/o Islands	23.31	0	0	0	4.2	-1.00	2
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0	0.9	-1.00	2
Shallow Open Water w/o Islands	2.32	0	0	0	0.4	-1.00	2
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	2
River or Stream	81.76	0	0	0	14.8	-1.00	2
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	0	0	0	2.5	-1.00	2
Aquatic Grass Marsh	1.37	0	0	0	0.2	-1.00	2
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	2
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	2
Nonpatterned Wet Meadow	41.98	0	0	0	7.6	-1.00	2
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	0	0	0	18.5	-1.00	2
Moist Sedge-Shrub Meadow	13.10	0	0	0	2.4	-1.00	2
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	2
Riverine or Upland Shrub	27.40	0	0	0	5.0	-1.00	2
Barrens (riverine, eolian, lacustrine)	79.01	0	0	0	14.3	-1.00	2
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	2
Total	551.25	1	1	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B12. Habitat selection by King Eiders during brood-rearing on the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	0	1.9	-1.00	2
Brackish Water	6.50	0	0	0	1.2	-1.00	2
Tapped Lake w/ Low-water Connection	21.42	0	0	0	3.9	-1.00	2
Tapped Lake w/ High-water Connection	20.36	0	0	0	3.7	-1.00	2
Salt Marsh	16.73	0	0	0	3.0	-1.00	2
Tidal Flat	55.90	0	0	0	10.1	-1.00	2
Salt-killed Tundra	25.63	0	0	0	4.6	-1.00	2
Deep Open Water w/o Islands	23.31	0	0	0	4.2	-1.00	2
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0	0.9	-1.00	2
Shallow Open Water w/o Islands	2.32	0	0	0	0.4	-1.00	2
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	2
River or Stream	81.76	0	0	0	14.8	-1.00	2
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	1	7	100.0	2.5	0.95	1
Aquatic Grass Marsh	1.37	0	0	0	0.2	-1.00	2
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	2
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	2
Nonpatterned Wet Meadow	41.98	0	0	0	7.6	-1.00	2
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	0	0	0	18.5	-1.00	2
Moist Sedge-Shrub Meadow	13.10	0	0	0	2.4	-1.00	2
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	2
Riverine or Upland Shrub	27.40	0	0	0	5.0	-1.00	2
Barrens (riverine, eolian, lacustrine)	79.01	0	0	0	14.3	-1.00	2
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	2
Total	551.25	1	7	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B13. Habitat selection by Spectacled Eiders during brood-rearing on the Transportation Corridor survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Young	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	2
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	0	0	0	9.3	-1.00	2
Deep Open Water w/ Islands or Polygonized Margins	4.30	0	0	0	1.6	-1.00	2
Shallow Open Water w/o Islands	9.32	0	0	0	3.4	-1.00	2
Shallow Open Water w/ Islands or Polygonized Margins	6.73	1	1	100.0	2.5	0.95	1
River or Stream	1.97	0	0	0	0.7	-1.00	2
Aquatic Sedge Marsh	0.90	0	0	0	0.3	-1.00	2
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	2
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	2
Young Basin Wetland Complex	13.21	0	0	0	4.8	-1.00	2
Old Basin Wetland Complex	30.40	0	0	0	11.1	-1.00	2
Nonpatterned Wet Meadow	20.85	0	0	0	7.6	-1.00	2
Wet Sedge-Willow Meadow w/ Low-relief Polygons	15.98	0	0	0	5.8	-1.00	2
Moist Sedge-Shrub Meadow	64.76	0	0	0	23.6	-1.00	2
Moist Tussock Tundra	71.03	0	0	0	25.9	-1.00	2
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	2
Barrens (riverine, eolian, lacustrine)	1.67	0	0	0	0.6	-1.00	2
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	2
Total	274.38	1	1	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B14. Habitat selection by King Eiders during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups	No. of Young	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	5	76	31.3	9.3	0.54	5
Deep Open Water w/ Islands or Polygonized Margins	4.30	1	6	6.3	1.6	0.60	4
Shallow Open Water w/o Islands	9.32	4	23	25.0	3.4	0.76	3
Shallow Open Water w/ Islands or Polygonized Margins	6.73	3	41	18.8	2.5	0.77	2
River or Stream	1.97	0	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.90	1	4	6.3	0.3	0.90	1
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	7
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	7
Young Basin Wetland Complex	13.21	2	6	12.5	4.8	0.44	6
Old Basin Wetland Complex	30.40	0	0	0	11.1	-1.00	7
Nonpatterned Wet Meadow	20.85	0	0	0	7.6	-1.00	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	15.98	0	0	0	5.8	-1.00	7
Moist Sedge-Shrub Meadow	64.76	0	0	0	23.6	-1.00	7
Moist Tussock Tundra	71.03	0	0	0	25.9	-1.00	7
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	7
Barrens (riverine, eolian, lacustrine)	1.67	0	0	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	7
Total	274.38	16	156	100.0	100.0		

[a] Ivlev's E = (%use - %availability)/(%use + %availability).
[b] Order is increasing from high preference to high avoidance.

Table B15. Habitat selection by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1992 (ABR unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	9
Brackish Water	6.50	0	0	1.2	-1.00	9
Tapped Lake w/ Low-water Connection	21.42	1	7.1	3.9	0.30	6
Tapped Lake w/ High-water Connection	20.36	0	0	3.7	-1.00	9
Salt Marsh	16.73	1	7.1	3.0	0.40	3
Tidal Flat	55.90	0	0	10.1	-1.00	9
Salt-killed Tundra	25.63	2	14.3	4.6	0.51	1
Deep Open Water w/o Islands	23.31	0	0	4.2	-1.00	9
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0.9	-1.00	9
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	9
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	9
River or Stream	81.76	0	0	14.8	-1.00	9
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	0	0	2.5	-1.00	9
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	9
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	9
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	9
Nonpatterned Wet Meadow	41.98	2	14.3	7.6	0.30	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	5	35.7	18.5	0.32	4
Moist Sedge-Shrub Meadow	13.10	1	7.1	2.4	0.50	2
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	9
Riverine or Upland Shrub	27.40	1	7.1	5.0	0.18	7
Barrens (riverine, eolian, lacustine)	79.01	1	7.1	14.3	-0.33	8
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	9
Total	551.25	14	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	10
Brackish Water	6.50	1	5.9	1.2	0.67	1
Tapped Lake w/ Low-water Connection	21.42	2	11.8	3.9	0.50	3
Tapped Lake w/ High-water Connection	20.36	2	11.8	3.7	0.52	2
Salt Marsh	16.73	1	5.9	3.0	0.32	5
Tidal Flat	55.90	0	0	10.1	-1.00	10
Salt-killed Tundra	25.63	2	11.8	4.6	0.43	4
Deep Open Water w/o Islands	23.31	1	5.9	4.2	0.16	7
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0.9	-1.00	10
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	10
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	10
River or Stream	81.76	0	0	14.8	-1.00	10
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	0	0	2.5	-1.00	10
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	10
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	10
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	10
Nonpatterned Wet Meadow	41.98	2	11.8	7.6	0.21	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	4	23.5	18.5	0.12	8
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	10
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	10
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	10
Barrens (riverine, eolian, lacustine)	79.01	2	11.8	14.3	-0.10	9
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	10
Total	551.25	17	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B16. Habitat selection by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1993.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	7
Brackish Water	6.50	0	0	1.2	-1.00	7
Tapped Lake w/ Low-water Connection	21.42	2	10.0	3.9	0.44	4
Tapped Lake w/ High-water Connection	20.36	0	0	3.7	-1.00	7
Salt Marsh	16.73	0	0	3.0	-1.00	7
Tidal Flat	55.90	0	0	10.1	-1.00	7
Salt-killed Tundra	25.63	2	14.3	4.6	0.51	3
Deep Open Water w/o Islands	23.31	3	15.0	4.2	0.56	2
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0.9	-1.00	7
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	7
River or Stream	81.76	0	0	14.8	-1.00	7
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	2	10.0	2.5	0.60	1
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	7
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	7
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	7
Nonpatterned Wet Meadow	41.98	3	15.0	7.6	0.33	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	8	40.0	18.5	0.37	5
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	7
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	7
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	7
Barrens (riverine, eolian, lacustine)	79.01	0	0	14.3	-1.00	7
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	7
Total	551.25	20	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	9
Brackish Water	6.50	1	7.1	1.2	0.72	2
Tapped Lake w/ Low-water Connection	21.42	4	28.6	3.9	0.76	1
Tapped Lake w/ High-water Connection	20.36	0	0	3.7	-1.00	9
Salt Marsh	16.73	1	7.1	3.0	0.40	6
Tidal Flat	55.90	0	0.0	10.1	-1.00	9
Salt-killed Tundra	25.63	2	11.8	4.6	0.43	5
Deep Open Water w/o Islands	23.31	3	21.4	4.2	0.67	3
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0.9	-1.00	9
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	9
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	9
River or Stream	81.76	0	0	14.8	-1.00	9
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	1	7.1	2.5	0.49	4
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	9
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	9
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	9
Nonpatterned Wet Meadow	41.98	0	0	7.6	-1.00	9
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	1	7.1	18.5	-0.44	8
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	9
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	9
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	9
Barrens (riverine, eolian, lacustine)	79.01	1	7.1	14.3	-0.33	7
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	9
Total	551.25	14	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B17. Habitat selection by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	12
Brackish Water	6.50	0	0	1.2	-1.00	12
Tapped Lake w/ Low-water Connection	21.42	0	0	3.9	-1.00	12
Tapped Lake w/ High-water Connection	20.36	1	2.6	3.7	-0.17	9
Salt Marsh	16.73	5	13.2	3.0	0.63	2
Tidal Flat	55.90	1	2.6	10.1	-0.59	10
Salt-killed Tundra	25.63	4	10.5	4.6	0.39	5
Deep Open Water w/o Islands	23.31	0	0	4.2	-1.00	12
Deep Open Water w/ Islands or Polygonized Margins	5.13	1	2.6	0.9	0.48	3
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	12
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	12
River or Stream	81.76	0	0	14.8	-1.00	12
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	1	2.6	2.5	0.03	8
Aquatic Grass Marsh	1.37	1	2.6	0.2	0.83	1
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	12
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	12
Nonpatterned Wet Meadow	41.98	4	10.5	7.6	0.16	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	17	44.7	18.5	0.41	4
Moist Sedge-Shrub Meadow	13.10	2	5.3	2.4	0.38	6
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	12
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	12
Barrens (riverine, eolian, lacustine)	79.01	1	2.6	14.3	-0.69	11
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	12
Total	551.25	38	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	11
Brackish Water	6.50	4	16.0	1.2	0.86	1
Tapped Lake w/ Low-water Connection	21.42	3	12.0	3.9	0.51	4
Tapped Lake w/ High-water Connection	20.36	1	4.0	3.7	0.04	6
Salt Marsh	16.73	3	12.0	3.0	0.60	3
Tidal Flat	55.90	0	0	10.1	-1.00	11
Salt-killed Tundra	25.63	1	4.0	4.6	-0.08	9
Deep Open Water w/o Islands	23.31	0	0	4.2	-1.00	11
Deep Open Water w/ Islands or Polygonized Margins	5.13	2	8.0	0.9	0.79	2
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	11
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	11
River or Stream	81.76	0	0	14.8	-1.00	11
Aquatic Sedge Marsh	0	-	-	0	-	
Aquatic Sedge w/ Deep Polygons	13.58	0	0	2.5	-1.00	11
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	11
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	11
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	11
Nonpatterned Wet Meadow	41.98	2	8.0	7.6	0.02	8
Wet Sedge-Willow Meadow w/ Low-relief Polygons	102.23	5	20.0	18.5	0.04	7
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	11
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	11
Riverine or Upland Shrub	27.40	2	8.0	5.0	0.23	5
Barrens (riverine, eolian, lacustine)	79.01	2	8.0	14.3	-0.28	10
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	11
Total	551.25	25	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B18. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	0	0	9.0	-1.00	7
Deep Open Water w/ Islands or Polygonized Margins	6.52	1	16.7	1.9	0.80	1
Shallow Open Water w/o Islands	10.84	1	16.7	3.2	0.68	2
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	7
River or Stream	2.30	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	7
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	7
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	7
Young Basin Wetland Complex	14.23	1	16.7	4.1	0.60	3
Old Basin Wetland Complex	35.59	1	16.7	10.4	0.23	6
Nonpatterned Wet Meadow	24.47	1	16.7	7.1	0.40	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	1	16.7	5.8	0.48	4
Moist Sedge-Shrub Meadow	84.66	0	0	24.7	-1.00	7
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	7
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	7
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	7
Total	343.11	6	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	2
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	2	100.0	9.0	0.84	1
Deep Open Water w/ Islands or Polygonized Margins	6.52	0	0	1.9	-1.00	2
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	2
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	2
River or Stream	2.30	0	0	0.7	-1.00	2
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	2
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	2
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	2
Young Basin Wetland Complex	14.23	0	0	4.1	-1.00	2
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	2
Nonpatterned Wet Meadow	24.47	0	0	7.1	-1.00	2
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	2
Moist Sedge-Shrub Meadow	84.66	0	0	24.7	-1.00	2
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	2
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	2
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	2
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	2
Total	343.11	2	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B19. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1990 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	8
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	1	9.1	9.0	0.01	6
Deep Open Water w/ Islands or Polygonized Margins	6.52	3	27.3	1.9	0.87	1
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	8
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	8
River or Stream	2.30	0	0	0.7	-1.00	8
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	8
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	8
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	8
Young Basin Wetland Complex	14.23	2	18.2	4.1	0.63	2
Old Basin Wetland Complex	35.59	2	18.2	10.4	0.27	4
Nonpatterned Wet Meadow	24.47	1	9.1	7.1	0.12	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	8
Moist Sedge-Shrub Meadow	84.66	1	9.1	24.7	-0.46	7
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	8
Riverine or Upland Shrub	7.74	1	9.1	2.3	0.60	3
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	8
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	8
Total	343.11	11	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	6	42.9	9.0	0.65	3
Deep Open Water w/ Islands or Polygonized Margins	6.52	4	28.6	1.9	0.88	2
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	7
River or Stream	2.30	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	7
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	7
Aquatic Grass Marsh	0.65	1	7.1	0.2	0.95	1
Young Basin Wetland Complex	14.23	0	0	4.1	-1.00	7
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	7
Nonpatterned Wet Meadow	24.47	0	0	7.1	-1.00	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	1	7.1	5.8	0.10	4
Moist Sedge-Shrub Meadow	84.66	1	7.1	24.7	-0.55	5
Moist Tussock Tundra	94.60	1	7.1	27.6	-0.59	6
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	7
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	7
Total	343.11	14	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B20. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1991 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	0	0	9.0	-1.00	7
Deep Open Water w/ Islands or Polygonized Margins	6.52	1	14.3	1.9	0.77	3
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	7.36	2	28.6	2.1	0.86	2
River or Stream	2.30	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	7
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	7
Aquatic Grass Marsh	0.65	1	14.3	0.2	0.97	1
Young Basin Wetland Complex	14.23	1	14.3	4.1	0.55	4
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	7
Nonpatterned Wet Meadow	24.47	1	14.3	7.1	0.33	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	7
Moist Sedge-Shrub Meadow	84.66	0	0	24.7	-1.00	7
Moist Tussock Tundra	94.60	1	14.3	27.6	-0.32	6
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	7
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	7
Total	343.11	7	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	4
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	4	66.7	9.0	0.76	2
Deep Open Water w/ Islands or Polygonized Margins	6.52	1	16.7	1.9	0.80	1
Shallow Open Water w/o Islands	10.84	1	16.7	3.2	0.68	3
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	4
River or Stream	2.30	0	0	0.7	-1.00	4
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	4
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	4
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	4
Young Basin Wetland Complex	14.23	0	0	4.1	-1.00	4
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	4
Nonpatterned Wet Meadow	24.47	0	0	7.1	-1.00	4
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	4
Moist Sedge-Shrub Meadow	84.66	0	0	24.7	-1.00	4
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	4
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	4
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	4
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	4
Total	343.11	6	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B21. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1992 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	9
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	1	8.3	9.0	-0.04	5
Deep Open Water w/ Islands or Polygonized Margins	6.52	3	25.0	1.9	0.86	1
Shallow Open Water w/o Islands	10.84	1	8.3	3.2	0.45	3
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	9
River or Stream	2.30	0	0	0.7	-1.00	9
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	9
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	9
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	9
Young Basin Wetland Complex	14.23	2	16.7	4.1	0.60	2
Old Basin Wetland Complex	35.59	1	8.3	10.4	-0.11	6
Nonpatterned Wet Meadow	24.47	2	16.7	7.1	0.40	4
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	9
Moist Sedge-Shrub Meadow	84.66	1	8.3	24.7	-0.50	7
Moist Tussock Tundra	94.60	1	8.3	27.6	-0.54	8
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	9
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	9
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	9
Total	343.11	12	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	9
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	8	47.1	9.0	0.68	4
Deep Open Water w/ Islands or Polygonized Margins	6.52	2	11.8	1.9	0.72	3
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	9
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	9
River or Stream	2.30	0	0	0.7	-1.00	9
Aquatic Sedge Marsh	0.97	1	5.9	0.3	0.91	2
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	9
Aquatic Grass Marsh	0.65	1	5.9	0.2	0.94	1
Young Basin Wetland Complex	14.23	1	5.9	4.1	0.17	6
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	9
Nonpatterned Wet Meadow	24.47	1	5.9	7.1	-0.10	7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	9
Moist Sedge-Shrub Meadow	84.66	1	5.9	24.7	-0.61	8
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	9
Riverine or Upland Shrub	7.74	2	11.8	2.3	0.68	5
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	9
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	9
Total	343.11	17	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B22. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	9
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	0	0	9.0	-1.00	9
Deep Open Water w/ Islands or Polygonized Margins	6.52	2	20.0	1.9	0.83	2
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	9
Shallow Open Water w/ Islands or Polygonized Margins	7.36	1	10.0	2.1	0.65	4
River or Stream	2.30	0	0	0.7	-1.00	9
Aquatic Sedge Marsh	0.97	1	10.0	0.3	0.95	1
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	9
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	9
Young Basin Wetland Complex	14.23	2	20.0	4.1	0.66	3
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	9
Nonpatterned Wet Meadow	24.47	1	10.0	7.1	0.17	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	1	10.0	5.8	0.27	5
Moist Sedge-Shrub Meadow	84.66	1	10.0	24.7	-0.42	7
Moist Tussock Tundra	94.60	1	10.0	27.6	-0.47	8
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	9
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	9
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	9
Total	343.11	10	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	3	30.0	9.0	0.54	3
Deep Open Water w/ Islands or Polygonized Margins	6.52	2	20.0	1.9	0.83	1
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	7.36	1	10.0	2.1	0.65	2
River or Stream	2.30	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	7
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	7
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	7
Young Basin Wetland Complex	14.23	0	0	4.1	-1.00	7
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	7
Nonpatterned Wet Meadow	24.47	1	10.0	7.1	0.17	4
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	7
Moist Sedge-Shrub Meadow	84.66	2	20.0	24.7	-0.10	5
Moist Tussock Tundra	94.60	1	10.0	27.6	-0.47	6
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	7
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	7
Total	343.11	10	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B23. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Nesting						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	9
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	0	0	9.0	-1.00	9
Deep Open Water w/ Islands or Polygonized Margins	6.52	1	5.6	1.9	0.49	5
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	9
Shallow Open Water w/ Islands or Polygonized Margins	7.36	1	5.6	2.1	0.44	6
River or Stream	2.30	0	0	0.7	-1.00	9
Aquatic Sedge Marsh	0.97	1	5.6	0.3	0.90	7
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	9
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	9
Young Basin Wetland Complex	14.23	2	11.1	4.1	0.46	4
Old Basin Wetland Complex	35.59	3	16.7	10.4	0.23	2
Nonpatterned Wet Meadow	24.47	1	5.6	7.1	-0.12	8
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	9
Moist Sedge-Shrub Meadow	84.66	3	16.7	24.7	-0.19	3
Moist Tussock Tundra	94.60	6	33.3	27.6	0.09	1
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	9
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	9
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	9
Total	343.11	18	100.0	100.0		
Brood-rearing						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	5
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	7	70.0	9.0	0.77	2
Deep Open Water w/ Islands or Polygonized Margins	6.52	0	0	1.9	-1.00	5
Shallow Open Water w/o Islands	10.84	1	10.0	3.2	0.52	3
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	5
River or Stream	2.30	0	0	0.7	-1.00	5
Aquatic Sedge Marsh	0.97	1	10.0	0.3	0.95	1
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	5
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	5
Young Basin Wetland Complex	14.23	1	10.0	4.1	0.41	4
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	5
Nonpatterned Wet Meadow	24.47	0	0	7.1	-1.00	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	19.87	0	0	5.8	-1.00	5
Moist Sedge-Shrub Meadow	84.66	0	0	24.7	-1.00	5
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	5
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	5
Barrens (riverine, eolian, lacustine)	1.93	0	0	0.6	-1.00	5
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	5
Total	343.11	10	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B24. Habitat selection of Yellow-billed Loons during nesting in the Delta survey area, Colville River Delta, Alaska, 1993 (ABR, unpubl. data).

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	2.0	-1.00	7
Brackish Water	6.50	0	0	1.3	-1.00	7
Tapped Lake w/ Low-water Connection	21.14	0	0	4.1	-1.00	7
Tapped Lake w/ High-water Connection	20.22	2	18.2	3.9	0.65	3
Salt Marsh	16.68	0	0	3.2	-1.00	7
Tidal Flat	55.90	0	0	10.7	-1.00	7
Salt-killed Tundra	25.63	0	0	4.9	-1.00	7
Deep Open Water w/o Islands	21.88	3	27.3	4.2	0.73	2
Deep Open Water w/ Islands or Polygonized Margins	4.83	1	9.1	0.9	0.81	1
Shallow Open Water w/o Islands	2.27	0	0	0.4	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0.52	0	0	0.1	-1.00	7
River or Stream	80.75	0	0	15.5	-1.00	7
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.01	1	9.1	2.5	0.57	4
Aquatic Grass Marsh	1.37	0	0	0.3	-1.00	7
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	38.41	1	9.1	7.4	0.10	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	88.55	3	27.3	17.0	0.23	5
Moist Sedge-Shrub Meadow	10.72	0	0	2.1	-1.00	7
Moist Tussock Tundra	1.69	0	0	0.3	-1.00	7
Riverine or Upland Shrub	23.25	0	0	4.5	-1.00	7
Barrens (riverine, eolian, lacustrine)	76.82	0	0	14.8	-1.00	7
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	7
Total	520.61	11	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(%use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B25. Habitat selection by Yellow-billed Loons during nesting in the Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	0	-1.00	-
Brackish Water	1.22	0	0	0.4	-1.00	7
Tapped Lake w/ Low-water Connection	19.38	0	0	6.0	-1.00	7
Tapped Lake w/ High-water Connection	19.57	2	16.7	6.1	0.47	3
Salt Marsh	5.64	0	0	1.7	-1.00	7
Tidal Flat	0.06	0	0	<0.1	-1.00	7
Salt-killed Tundra	7.48	0	0	2.3	-1.00	7
Deep Open Water w/o Islands	21.09	3	25.0	6.5	0.59	2
Deep Open Water w/ Islands or Polygonized Margins	3.58	2	16.7	1.1	0.88	1
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	7
River or Stream	38.33	0	0	11.9	-1.00	7
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	1	8.3	3.1	0.46	4
Aquatic Grass Marsh	1.20	0	0	0.4	-1.00	7
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	1	8.3	9.2	-0.05	6
Wet Sedge-Willow Meadow w/ Low-relief Polygons	80.84	3	25.0	25.0	0	5
Moist Sedge-Shrub Meadow	9.10	0	0	2.8	-1.00	7
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	7
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	7
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	7
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	12	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B26. Habitat selection by Brant during brood-rearing in the Outer Delta survey area, Colville River Delta, Alaska, 1993 (ABR, Inc., unpubl. data).

Habitat	Area (km^2)	No. of Groups or Brooks	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	0	0	4.8	-1.00	8
Brackish Water	6.29	7	41.2	2.9	0.87	1
Tapped Lake w/ Low-water Connection	5.17	0	0	2.4	-1.00	8
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1.00	8
Salt Marsh	12.61	0	0	5.8	-1.00	8
Tide Flat	55.89	4	23.5	25.5	-0.04	4
Salt-killed Tundra	22.22	1	5.9	10.2	-0.27	6
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	8
Deep Open Water w/ Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	8
Shallow Open Water w/o Islands	0.53	0	0	0.2	-1.00	8
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	8
River or Stream	43.15	2	11.8	19.7	-0.25	5
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.41	1	5.9	2.9	0.34	2
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	8
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	8
Wet Sedge-Willow Meadow w/ Low-relief Polygons	9.33	1	5.9	4.3	0.16	3
Moist Sedge-Shrub Meadow	1.73	0	0	0.8	-1.00	8
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	8
Riverine or Upland Shrub	0.81	0	0	0.4	-1.00	8
Barrens (riverine, eolian, lacustrine)	28.08	1	5.9	12.8	-0.37	7
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	8
Total	219.06	17	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Table B27. Habitat selection by Brant during brood-rearing in the Outer Delta survey area, Colville River Delta, Alaska, 1995.

Habitat	Area (km^2)	No. of Groups or Brooks	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	1	16.7	4.8	0.55	3
Brackish Water	6.29	2	33.3	2.9	0.84	1
Tapped Lake w/ Low-water Connection	5.17	0	0	2.4	-1.00	5
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1.00	5
Salt Marsh	12.61	2	33.3	5.8	0.71	2
Tide Flat	55.89	0	0.0	25.5	-1.00	5
Salt-killed Tundra	22.22	1	16.7	10.2	0.24	4
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	5
Deep Open Water w/ Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	5
Shallow Open Water w/o Islands	0.53	0	0	0.2	-1.00	5
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	5
River or Stream	43.15	0	0	19.7	-1.00	5
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.41	0	0	2.9	-1.00	5
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	5
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	5
Wet Sedge-Willow Meadow w/ Low-relief Polygons	9.33	0	0	4.3	-1.00	5
Moist Sedge-Shrub Meadow	1.73	0	0	0.8	-1.00	5
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	5
Riverine or Upland Shrub	0.81	0	0	0.4	-1.00	5
Barrens (riverine, eolian, lacustrine)	28.08	0	0	12.8	-1.00	5
Artificial (water, fill, peat road)	0.02	0	0.0	<0.1	-1.00	5
Total	219.06	6	100.0	100.0		

[a] Ivlev's E = (% use - % availability)/(% use + % availability).
[b] Order is increasing from high preference to high avoidance.

Appendix C. Distribution of caribou during the calving seasons in 1992 and 1993.

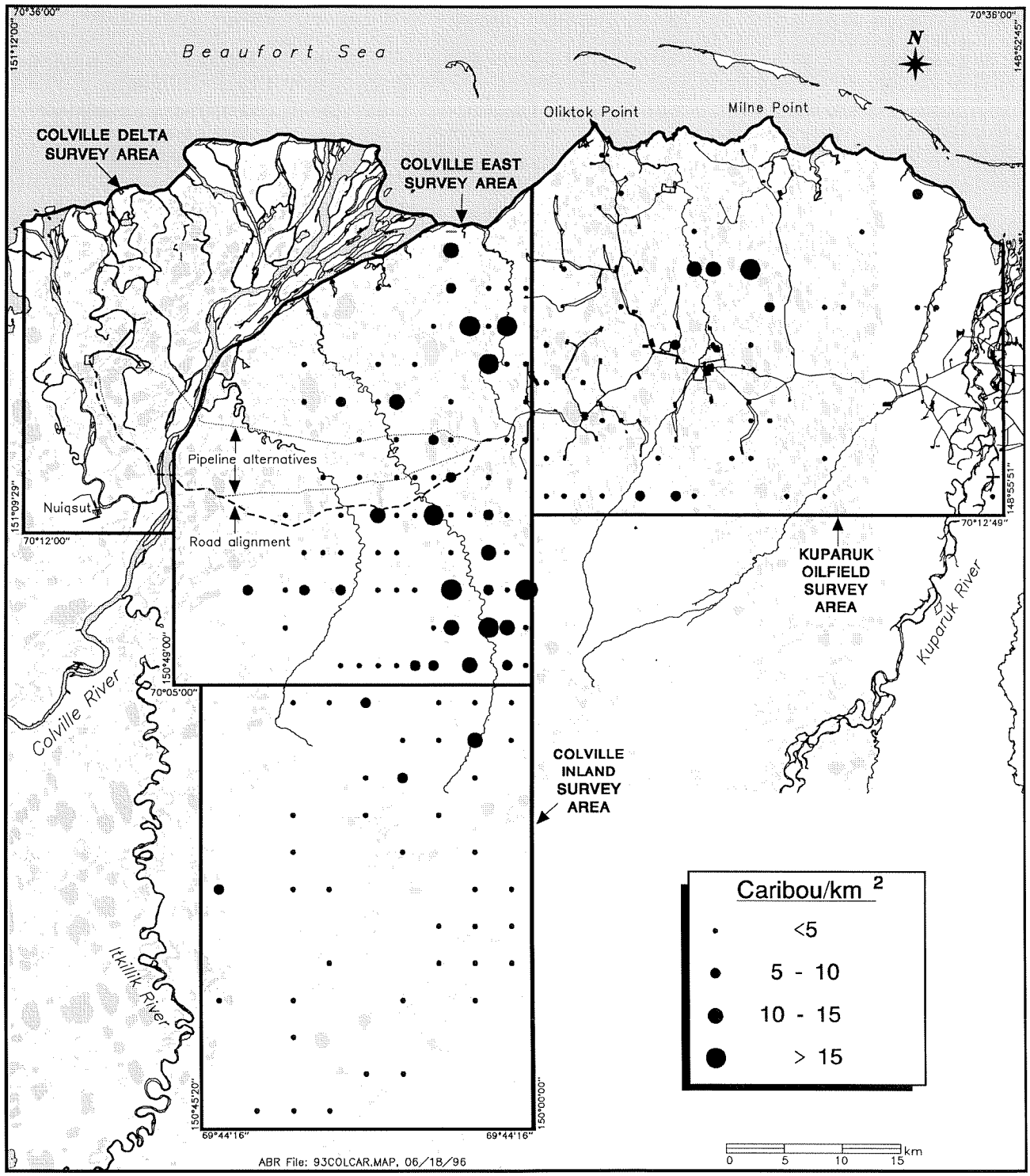


Figure C1. Distribution and density of caribou (adults and calves) in the Colville Delta, Colville East, Colville Inland, and Kuparuk Oilfield survey areas near the end of the calving season, 10-15 June 1993 (from Smith et al. 1994: Figure 20).

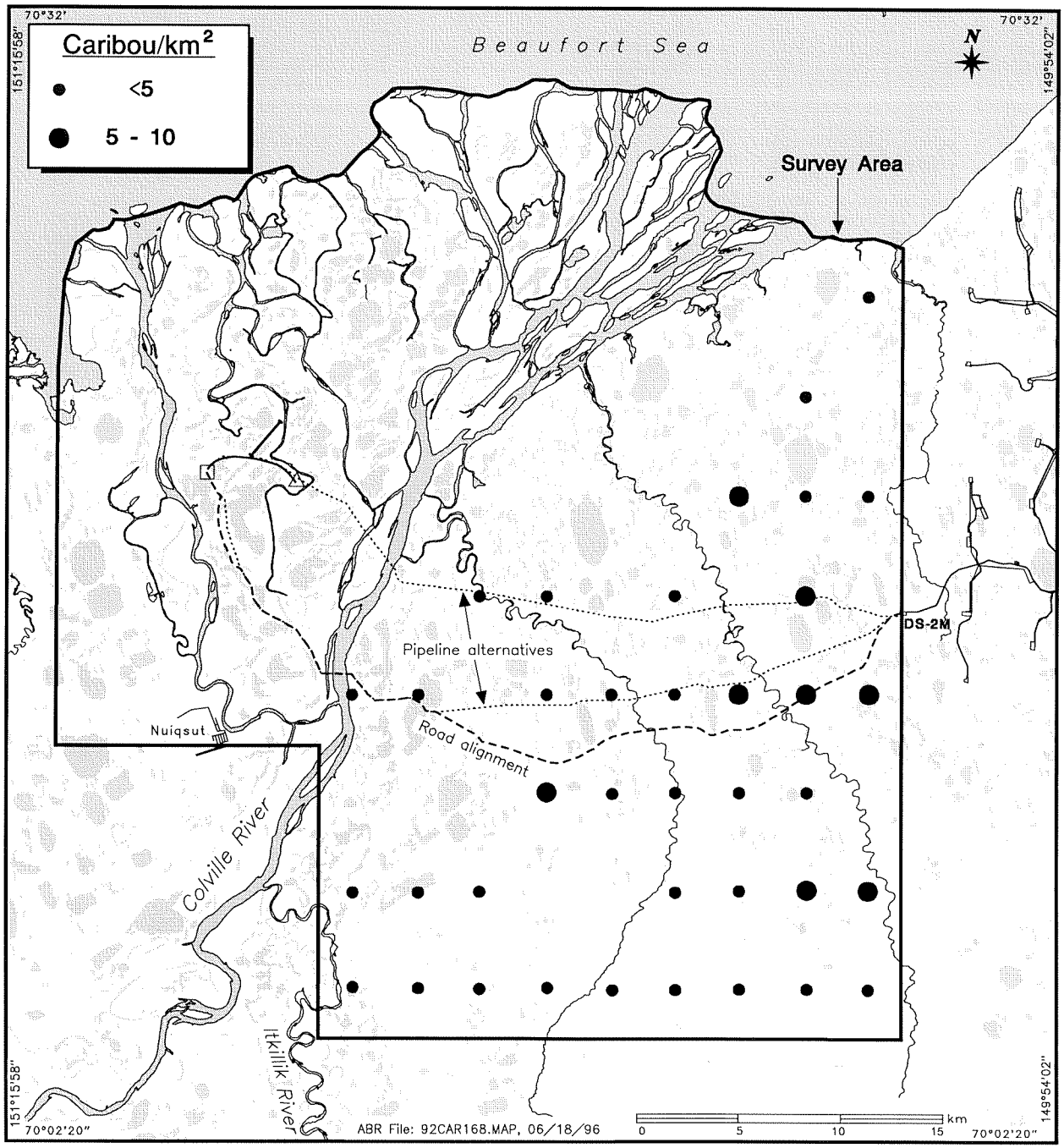


Figure C2. Distribution and density of caribou (adults and calves) in the 1992 Colville River Delta study area near the end of the calving season, 16 June 1992 (from Smith et al. 1993: Figure 23).