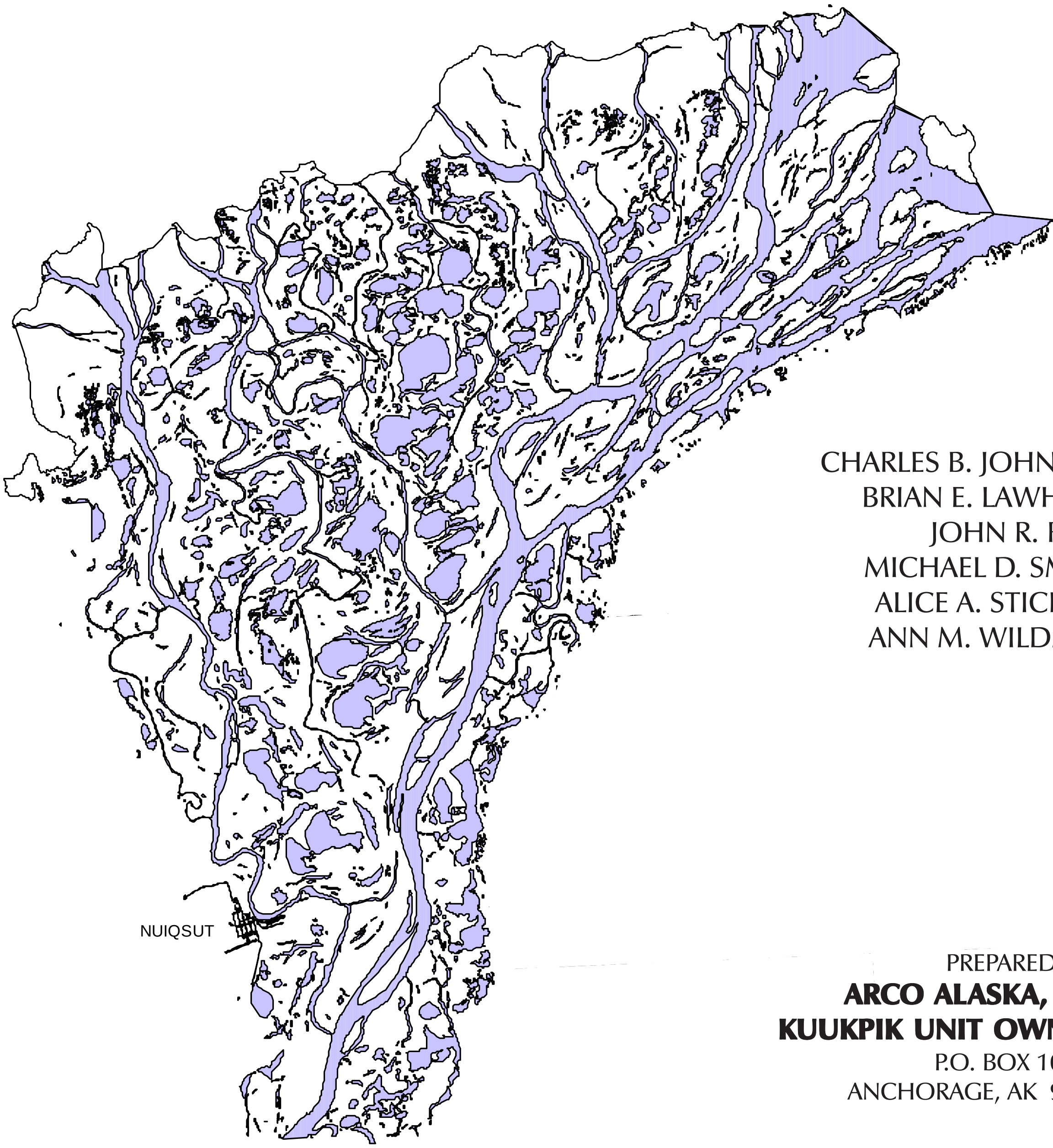
SIXTH ANNUAL REPORT

WILDLIFE STUDIES ON THE COLVILLE RIVER DELTA, ALASKA, 1997



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EXECUTIVE SUMMARY

The Colville River 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 River drains a watershed of ~53,000 km^2, which encompasses ~29% of the Arctic Coastal Plain of Alaska. 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 terrestrial habitats, lakes, and wetlands. The delta supports a wide array of wildlife and is known to be a regionally important nesting area for Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders. In spring, the delta provides some of the earliest open water and snow-free areas on the Arctic Coastal Plain of Alaska for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for feeding and staging. In addition to use by birds, the delta is used seasonally by caribou for insect-relief habitat, by arctic and red foxes for denning, and by spotted seals for fishing and haul-out sites. The Colville Delta contains 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.

ARCO Alaska, Inc. and its partner Anadarko Petroleum were granted permits for the Alpine Development Project on the central delta on 13 February 1998. ARCO initiated a number of studies in 1992 to examine the biological, physical, and cultural resources of the delta. In this annual report on the 1997 field season, we present the results of our sixth year of study of the wildlife resources of the Colville Delta.

The overall goal of the 1997 studies was to continue to collect baseline data on the use of the Colville Delta and adjacent areas by selected birds and mammals between late spring (May) and early fall (September). The primary species of concern were Spectacled Eiders, King Eiders, Tundra Swans, Brant, Yellow-billed Loons, caribou, and arctic foxes. Secondary species of concern included Pacific and Red-throated loons, Greater White-fronted Geese, other waterbirds, spotted seals, muskoxen, and red foxes. Our specific objectives were to 1) monitor the distribution, abundance, and habitat use of selected waterbird species during the pre-nesting, nesting, brood-rearing, and fall-staging seasons; 2) monitor the distribution and abundance of caribou during the calving and post-calving seasons; 3) locate fox dens and describe their habitat associations; 4) locate haulouts of spotted seals; and 5) monitor the distribution of other large mammals in the study area.

A combination of aerial and ground surveys were used to collect location data for analysis in a geographic information system. Wildlife habitats, which were classified and mapped in 1995, were used to describe vegetation and landforms that were used or selected by focal species. We included data from previous years in our assessments of distribution, abundance, and habitat use, where such data were appropriate.

Habitat Classification—We aggregated 195 ecological land classes into 24 wildlife habitats for the delta and adjacent Transportation Corridor, resulting in 12 waterbody, 10 terrestrial and 2 wetland-complex types. Large differences in availability of these habitats exist between the delta and transportation corridor as a result of differing marine and riverine processes in the two areas. On the delta, Wet Sedge–Willow Meadow, River or Stream, Barrens, and Tidal Flat occupy the majority of the area. Smaller portions consist of habitats that are unique to the delta: Brackish Water, Tapped Lake, Salt Marsh, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons. The Transportation Corridor is dominated by Moist Tussock Tundra, Moist Sedge–Shrub Meadow, Old Basin Wetland Complex, and Deep Open Water without Islands.

Spectacled Eiders—The distribution of Spectacled Eiders during the 1997 pre-nesting season was similar to that observed in previous years. Spectacled Eiders are attracted to coastal areas; the average distance of pre-nesting locations from the coastal shoreline in 1997 was 3.7 km. As in other years, Spectacled Eiders were more numerous on the delta than in the Transportation Corridor. Although Spectacled Eider numbers were up from those in 1996, no overall trend is apparent among the five years of counts. In 1997, four Spectacled Eider nests were found near the coast during abbreviated ground searches, whereas no eider nests were found during intensive ground searches near the Alpine Facility Area on the central delta. During

pre-nesting in 1993–1997, Spectacled Eiders on the delta preferred Brackish Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Aquatic Grass Marsh. During those same years Spectacled Eiders nested most often in Aquatic Sedge with Deep Polygons, Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra; nests were never more than 10 m from permanent water. During 1995–1997 in the Transportation Corridor, most Spectacled Eiders were found in Deep Open Water without Islands during pre-nesting, but no nests were found.

King Eiders—Unlike Spectacled Eiders, King Eiders were more abundant in the Transportation Corridor than on the delta during pre-nesting. King Eiders also were attracted to the coastline on the delta, averaging 6.0 km from the coast in 1997. Although annual changes in King Eider numbers on the delta have been relatively small, in the Transportation Corridor King Eiders were markedly more abundant in 1997 than in 1996. No nests of King Eiders were found on the delta in 1997, and only four nests have been found on the delta since 1994. Pre-nesting King Eiders on the delta preferred River or Stream habitat, and nested in Aquatic Sedge with Deep Polygons and Salt-killed Tundra. In the Transportation Corridor, pre-nesting King Eiders preferred Deep Open Water without Islands, both types of Shallow Open Water, and River or Stream and nested in both types of Basin Wetland Complexes, Nonpatterned Wet Meadow, and Moist Tussock Tundra.

Tundra Swan—Swan nests on the delta declined from a high of 45 in 1996 to 32 in 1997 despite more swans being present in 1997 than in the previous study years. Similarly, in the Transportation corridor, swan nests declined from 1996 (19) to 1997 (11), but non-breeding swans were not more numerous in 1997. In the Alpine Facility Area, we found two swan nests, which is similar to previous years. Numbers of broods on the delta and Transportation Corridor also declined from 1996 to 1997. However, the ratio of broods to nests (75%) was about the same as the long-term average (74.5%) on the delta and higher (100% in 1997 vs. 89% for 1989–1997) in the Transportation Corridor. We observed 287 swans during fall staging, most of which were at a commonly used congregating area near the mouth of the Miluveach River, but we were unable to survey at the most appropriate times due to inclement weather. Swans used a wide array of habitats in both the delta and Transportation Corridor. During nesting on the delta, swans preferred Wet Sedge–Willow Meadow, Nonpatterned Wet Meadow, Salt-killed Tundra, Aquatic Sedge with Deep Polygons, and Moist Sedge–Shrub Meadow. In the Transportation Corridor, nesting swans preferred Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, and Young Basin Wetland Complex. Swans appeared to be attracted to waterbodies for nesting: average distance to waterbodies was 0.1 km on the delta and 0.03 km in the Transportation Corridor. Swans on the delta preferred more saline habitats for raising broods: Brackish Water, Tapped Lake with Low-water Connections, and both types of Deep Open Water. In the Transportation Corridor, broods preferred both types of Deep Open Water, Aquatic Sedge Marsh, and Aquatic Grass Marsh.

Yellow-billed Loons—Nesting locations of Yellow-billed Loons have not changed much since the 1980s; most nests are found in the central delta between the Sakoonang and Elaktoveach channels. In 1997, we found 10 nests and 48 birds during an aerial survey of the delta, which is comparable to previous study years, and an additional four nests during follow-up aerial and ground surveys. One nest was found at a new location west of the Nechelik Channel, three nests were found east of the delta in previously used locations north of the Transportation Corridor, and none were found in the Transportation Corridor. On the delta, we found five broods containing a total of eight young in 1997. Yellow-billed Loon nests were built on peninsulas, shorelines, islands and in emergent vegetation in six habitats, three of which were preferred habitats: Tapped Lake with High-water Connections, Deep Open Water with Islands or Polygonized Margins, and Wet Sedge–Willow Meadow. Only three habitats were used during brood-rearing, of which the two Deep Open Water types were preferred.

Brant—Most brant nests (>950 nests) on the Colville Delta occur near the mouth of the East Channel in what is referred to here as the Anachlik Colony-complex. We report on additional nest sites that were scattered across the delta in other locations. We found 92 nests in 19 locations with a total of

552 Brant in 1997, which was a dramatic increase over previous years. In 1997, the Alpine Facility Area contained three nests, and the Transportation Corridor contained seven nests at one site. Despite the high number of nests outside the Anachlik Colony-complex, we counted only 254 adults/subadults and 168 goslings on the delta, which was the third lowest count since 1988. The low counts of young were probably the result of poor nesting success at the Anachlik Colony-complex. Only 227 Brant were seen during the fall-staging survey in 1997, down from 1,327 Brant in 1996. High variation in daily use of the delta by staging Brant is a likely explanation for these extreme counts. Brant nesting outside the Anachlik Colony-complex preferred Brackish Water, Salt-killed Tundra, and Aquatic Grass Marsh. During brood-rearing, Brant used salt-affected habitats and River or Stream, but showed a preference only for Brackish Water.

Other Geese—The Colville Delta is a regionally important nesting area for Greater White-fronted Geese and supports small numbers of nesting Snow geese. We found 45 Greater White-fronted Goose nests (3.2 nests/km^2) on an intensive ground search of an area (14.2 km^2) around the Alpine Facility Area. Most nests (80%) were in Wet Sedge–Willow Meadow habitat, and the average clutch size was 3.8 eggs (n = 37 nests). Eighty-two percent of the nests we revisited (n = 44) were successful. In 1997, we found one Snow Goose nest during aerial surveys of the Outer Delta. We also located one Canada Goose nest on the Outer Delta, the first record that we know of for these geese nesting on the Colville Delta. During systematic surveys for goose broods at 50% coverage, we counted 2,126 Greater White-fronted Geese on the delta and 268 in the Transportation Corridor; goslings composed 35% of the birds on the delta and 16% of the birds in the Transportation Corridor. On those same surveys we saw 12 adult and 16 gosling Snow Geese, and on ground surveys we saw two Canada Geese. On systematic surveys during fall staging, we saw 1,732 Greater White-fronted Geese distributed throughout the delta, 6 Snow Geese on the Outer Delta, and 2,101 Canada Geese primarily on the Outer Delta.

Other Birds—During an intensive ground survey of the facility footprint, we observed 23 species of birds and 205 individuals on the ground. The majority of these were passerines (Lapland Longspurs, Savannah Sparrows, Yellow Wagtails, and Common Redpolls) and shorebirds (Black-bellied and American Golden plovers, Semipalmated Sandpipers, Pectoral Sandpipers, Dunlins, Stilt Sandpipers, Long-billed Dowitchers, and Red and Red-necked phalaropes). During ground surveys around the Facility Area, we found 139 nests belonging to 21 species including Red-necked Grebe, Northern Pintail, Greater Scaup, Oldsquaw, Willow and Rock ptarmigan, Parasitic Jaeger, Glaucous Gull, and Arctic Tern, as well as most of the passerine and shorebird species found on the footprint survey. No nests of Bar-tailed Godwits were found in 1997 (one was found in 1996), but based on the behavior of pairs we saw, we suspect that one or two nests were active in the area. For the second year in a row, we observed Red-necked Grebes nesting on the Colville Delta, which had not been previously documented.

Caribou—The Colville Delta lies between the summer ranges of the Central Arctic Herd to the west and the Teshekpuk Lake Herd to the east. The delta was not used by caribou during two calving surveys in 1997 nor has use by large numbers been reported in the past, apparently because of widespread flooding that occurs at the time of calving. The highest concentrations of calving caribou in the western segment of the Central Arctic Herd were seen in the Colville East (between the Colville River and Kuparuk Oilfield) and Kuparuk South (south of the Kuparuk Oilfield) survey areas. Peak numbers in 1997 were dramatically lower than in 1996 and may be related to the late snowmelt in 1997. The total number of caribou seen in the survey areas in 1997 (~5,000) was 25% of the total herd size (19,730) compared to 52% (9,482) of the herd seen in 1996 (18,093). The percentage of the herd seen during calving in our survey area has ranged from 25–52%. Calf production in 1997 (78 calves:100 cows) was slightly higher than the average (71:100) since 1978. Large groups of caribou (1,114–2,774) were observed on seven days in mid- and late July in the Transportation Corridor and the adjacent area to the south. The delta is used annually by caribou for insect relief, but less frequently than adjacent coastal areas to the east. In 1997, we saw large groups of caribou twice on the delta; 1,035 caribou were seen on the outer islands on 23 July and 1,214 caribou were seen the Development Area on 27 July. Up to 3,340 caribou have been observed on the delta as recently as 1996. Total numbers of caribou and frequency of use of different coastal areas vary with weather conditions and insect activity.

Arctic and Red Foxes—During six years of surveys, we have confirmed the location of 51 arctic fox dens and 4 red fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield. Nineteen arctic fox dens and 4 red fox dens are on the delta, and 18 arctic fox dens are in the Transportation Corridor. Den occupancy by litters (11–25%) in 1997 was the lowest we have observed. Only five dens had confirmed litters, and two dens were strongly suspected to have litters. Two dens with litters were north of the Transportation Corridor, and the remaining five dens were on the delta. Litter size averaged 5.0 pups at three dens where litter counts were complete. In previous years, we have found 38–67% occupancy by litters with sizes averaging from 3.1 to 6.1 pups. Den sites occurred in elevated microsites where soil was well-drained and suitable for burrowing. Riverine and Upland Shrub was the only preferred habitat for fox dens on the delta and in the Transportation Corridor; it was also the most frequently used habitat on the delta, whereas most dens occurred in Moist Sedge–Shrub Meadow in the Transportation Corridor.

Polar Bear—Although polar bears primarily frequent areas of frozen sea ice, a portion of female bears make dens on land. Of 90 dens used by pregnant female polar bears, 42% were on land. The Development Area contained a den site in the winter of 1996–1997. Other den sites in the area have been reported from the lower Itkillik River to Lower Kalubik Creek and on the Beaufort Sea within 30 km of the delta. Den sites tend to be at bluffs along rivers, streams, or lakes where deep snowdrifts can persist.

Grizzly Bear—Forty-five grizzly bear dens have been located by the Alaska Department of Fish and Game between the Colville River and Kuparuk Oilfield. Twelve different bears used 29 of these dens during the 1992–1993 to 1997–1998 denning seasons. Most dens in this area are located south of the Transportation Corridor near the headwaters of the Miluveach, Kachemach, and Kuparuk rivers. During the winter of 1996–1997, two subadult bears denned along the Sakoonang Channel, and a female bear bore three cubs in a den along the East Channel. In 1997–1998, one of these subadult bears denned farther north on the delta. Since 1995, four den sites have been used along the Miluveach River. During the summer of 1997, we observed a female with 2 cubs and a subadult bear along the East Channel several times. Most of the other sightings of bears in 1997 were clustered along the Miluveach River in the Transportation Corridor. We recorded 31 sightings of bears in 1997, representing at least 10 different bears.

Muskox—Muskoxen were introduced to the Arctic National Wildlife Refuge in 1969 and 1970 after being extirpated in the late 1800s; subsequently the introduced herds spread west and east. Sign of muskoxen was observed in the western Kuparuk Oilfield in the 1980s. We first saw large numbers in the uplands east of the Itkillik River in May 1993 , and the population has grown since then to 99 muskoxen including 19 calves in 1997, although we have not conducted comprehensive surveys. Muskoxen in the uplands typically move during summer to areas along rivers and streams; in 1997, we repeatedly observed groups of mixed sex muskoxen (24 total) and small groups of bulls on the lower Kachemach River through the latter part of August. In July 1997, a cow and calf were seen on an island in the delta, and solitary bulls have been seen on the delta in the past.

Spotted Seal—Spotted seals in Alaska range north from Bristol Bay to the Chukchi Sea and east to the Beaufort Sea. They whelp, breed, and molt on the pack-ice front from March through April and disperse to nearshore waters during summer. They commonly haul-out on islands, sand spits, and shoals from mid-summer to late fall. On four of eight surveys in 1997, we saw one to five spotted seals in two locations in the East Channel.

Other Mammals—Three species of mammals were seen during surveys in 1997 that we had not seen during five previous years in the Colville area. We found the hindquarters of a snowshoe hare that was being eaten by a snowy owl in the Facility Area. Snowshoe hares are common upstream on the Colville River near Umiat but are rare along the lower river. We observed moose on three occasions: a pair north of the Transportation Corridor, one on an island in the eastern delta, and one in the southwestern corner of the Transportation Corridor. Moose, like snowshoe hares, are more common upstream than on the lower Colville. On 29 July, we saw a gray wolf on the Kachemach River that pursued a caribou unsuccessfully. In 1995, other researchers saw a gray wolf on the Miluveach River. The wolf population in the area has been increasing in recent years as indicated by increased sightings and harvest by residents of Nuiqsut.

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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 fishes 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 occurred intermittently for several decades, only recently have plans to develop the area commercially proceeded beyond the exploration phase. ARCO Alaska, Inc. (hereafter, ARCO) and its partner Anadarko Petroleum Corporation received Federal permits for the Alpine Development Project on the central delta on 13 February 1998. As part of the planning process, and in recognition of the regional and local importance of the Colville Delta to a variety of interested parties, ARCO initiated studies in 1992 to examine the biological, physical, and cultural resources of the delta. In this annual report on the 1997 field season, we present the results from our sixth year of study of the wildlife resources on the Colville Delta.

The Colville River drains a watershed of ~53,000 km^2, or ~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 lakes, wetlands, and terrestrial habitats. The delta supports a wide array of wildlife and is known to be a regionally important nesting area for Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders (Rothe et al. 1983, North et al. 1984, Meehan and Jennings 1988; see Appendix Table A for scientific names). The delta also provides breeding habitat for passerines, shorebirds, gulls, and predatory birds such as jaegers and owls. In spring, the delta provides some of the earliest open water and snow-free areas on the Arctic Coastal Plain for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for feeding and staging. In addition to use by birds, the delta is used seasonally by caribou for insect-relief habitat, by arctic and red foxes for denning, and by spotted seals for fishing and for haul-out sites (Seaman et al. 1981). In recent years, the delta and adjacent areas have been visited increasingly by muskoxen and brown bears, and the delta occasionally is used for denning by both brown and polar bears (see reviews in Johnson et al. 1997).

The primary goal of the Colville wildlife studies always 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, although the focal species that were examined and the exact boundaries of study areas varied over the six years of study (as better information on the location of the oil reservoir became available). During a meeting with the U.S. Fish and Wildlife Service (USFWS) in spring 1992, we agreed to focus on particular species, based primarily on the following criteria: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, or 3) special concern of regulatory agencies. Accordingly, Yellow-billed Loons, Tundra Swans, Brant, Spectacled Eiders, King Eiders, caribou, and arctic foxes were chosen for investigation (Smith et al. 1993). Species that were not the focus of surveys in 1992 but were monitored opportunistically included Red-throated Loons, Pacific Loons, Greater White-fronted Geese (hereafter, White-fronted Geese), muskoxen, and red foxes. In 1993, we studied the same focal species but expanded the study area for all species to the entire delta region (Smith et al. 1994). In 1994, we surveyed the delta only for eiders (Johnson 1995). In 1995, we expanded our studies again to monitor the distribution and abundance of the same suite of species investigated in 1992 and 1993, and we added an investigation of habitat use by the focal species (Johnson et al. 1996). We continued with similar surveys in 1996 and 1997, adding surveys for spotted seals and post-breeding geese.

The overall goal of the 1997 studies was to continue to collect baseline data on 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. monitor the distribution, abundance, and habitat use of selected waterbird species during the pre-nesting, nesting, brood-rearing, and fall-staging seasons;

2. monitor the distribution and abundance of caribou during the calving and post-calving seasons;
3. locate fox dens and describe their habitat associations;
4. locate haulouts of spotted seals; and
5. monitor the distribution of other large mammals in the study area.

STUDY AREA

The development scenario proposed by ARCO includes a gravel airstrip (~1.8 km long) and two gravel pads (Alpine Pad 1, a drill site and processing facility, and Alpine Pad 2, a drill site), all connected by ~3 km of gravel road (Figure 1). The total area projected to be covered with gravel fill is ~39 ha. A sales-quality pipeline to the Kuparuk Oilfield would connect this development to existing infrastructure. No all-season road is planned to access the Alpine facilities from the Kuparuk Oilfield; materials, equipment, and personnel will travel by air or, during winter, overland on ice roads.

The study area in 1997 essentially was unchanged from 1995–1996 and comprised several contiguous areas in which the distribution of wildlife was monitored. As defined in this report, the Colville Delta survey area encompasses 551 km^2 and refers to that area between the westernmost and easternmost distributary channels of the Colville River (Figure 1). The entire area within 1,000 m of the proposed airstrip and the processing facility and within 200 m of the separate drill sites and the connecting road is called the Facility Area (9.3 km^2 total). As a result of better delineation of the oil reservoir and identification of environmental and economic concerns, the location of proposed surface development (Facility Area and pipeline route) has been modified somewhat from the original 1995 proposal (Johnson et al. 1996: Figure 1) and a revised layout in 1996 (Johnson et al. 1997: Figure 1). 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 that portion of the delta west of the Nechelik Channel that is bounded by a flood-plain terrace adjacent to the westernmost 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 route.

The geographic extent of the wildlife investigations during 1992-1997 has varied because of changes in exploration plans and potential development scenarios. The boundaries of the wildlife study area in 1992 included several exploratory drill sites and extended from Kalubik Creek on the east to the Nechelik 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). That year we conducted intensive surveys for a variety of bird species on 6 plots ranging from 46 to 61 km^2 in size. 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 also 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, we surveyed for eiders only in a 478-km^2 area consisting of just the delta (Johnson 1995). In 1995–1997, ARCO proposed specific sites for facilities and infrastructure, so the wildlife study area encompassed those proposed sites, while the entire delta was maintained as the core area for evaluating regional-scale distributions of wildlife (Figure 1; Johnson et al. 1996, 1997).

The Colville River has two main distributaries: the Nechelik Channel and the East Channel. These two channels together carry ~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 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

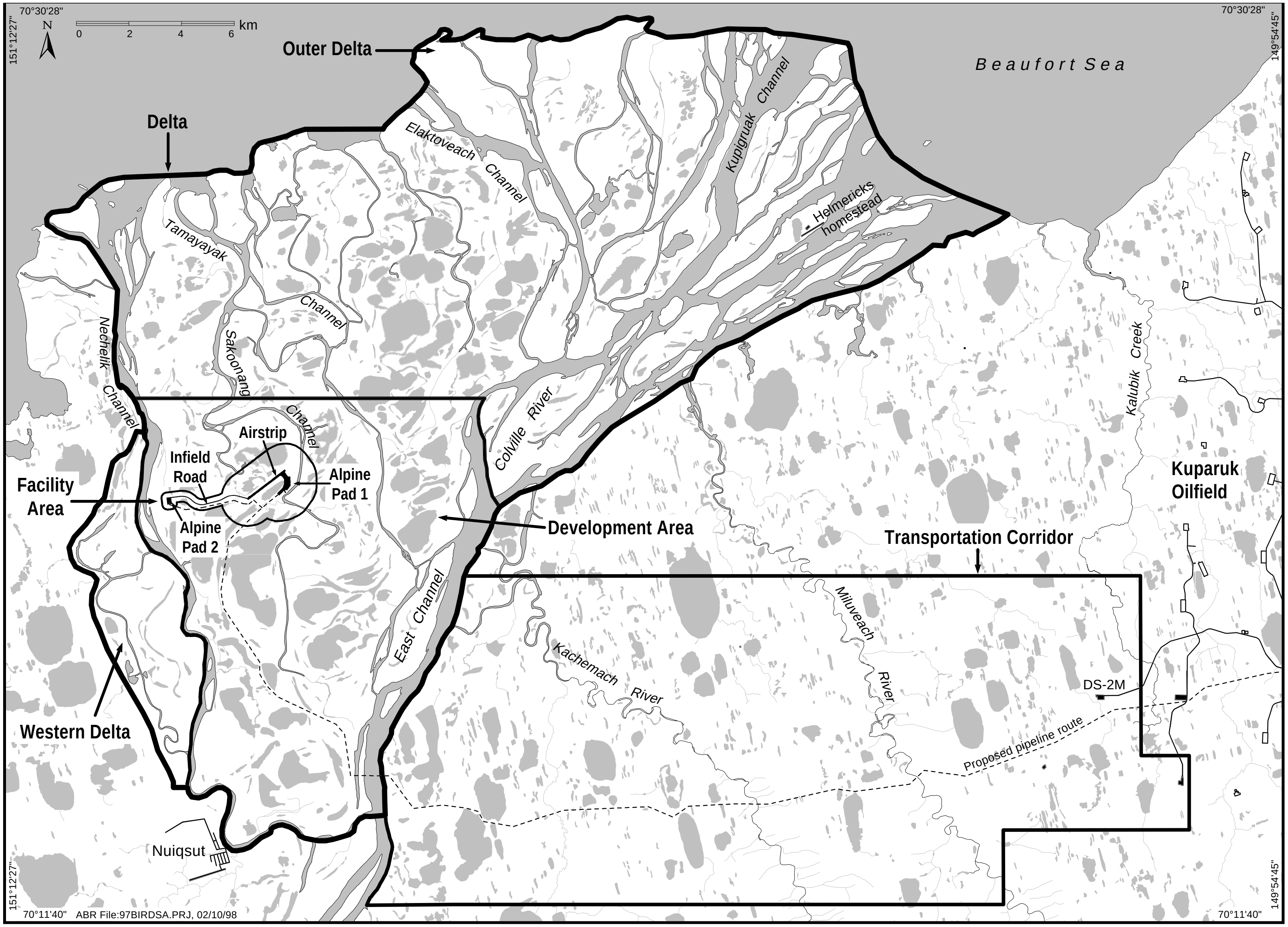

Figure 1. Survey area boundaries for the wildlife studies on the Colville River Delta and Transportation Corridor, Alaska, 1997. Mammal surveys were conducted over larger areas specific to each species.

in winter. Decreased river flow during winter results in an intrusion of salt water into the delta's channels, 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 extensive 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).

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 common 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 those large 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, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes, occur on the delta (Walker 1983).

Many lakes on the delta are "tapped" (Walker 1978), in that they are connected to the river by narrow channels that are caused by thermokarst decay of ice wedges between the river and adjacent lakes and by the migration of river channels (Walker 1978). Channel connections allow water levels in tapped lakes to fluctuate more dramatically than in untapped lakes, resulting in barren or partially vegetated shorelines and allowing salt water to intrude into some of these lakes. River sediments raise the bottom of these lakes near the channel, eventually exposing previously submerged areas and reducing the flow of riverine water to the most extreme flood events. 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).

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 delta has an arctic maritime climate (Walker and Morgan 1964). Winters last ~8 months and are cold and windy. 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 floodwaters are at maximal levels. Water levels subsequently decrease in the delta throughout the summer, with the lowest levels occurring in late summer and fall, just before freeze-up (Walker 1983). 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 that 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).

METHODS

In 1997, we conducted surveys for selected wildlife species to assess their distribution, abundance, and use of specific sites proposed for development. In addition, we conducted habitat studies to investigate what landforms and vegetation types were most important seasonally to wildlife on the Colville Delta and in the adjacent Transportation Corridor. Habitat studies consisted of analyses of habitat selection by a subset of wildlife species; habitat classification and mapping of the Colville Delta and Transportation Corridor were initiated in 1995 (Johnson et al. 1996) and completed in 1996 (Jorgenson et al. 1997). We have included data from previous years in our assessments of distribution, abundance, and habitat use, when such inclusion was appropriate.

HABITAT CLASSIFICATION AND MAPPING

The development of a wildlife habitat classification was a three-step process: 1) field surveys of vegetation/soil/hydrology relationships; 2) development of an ecological land classification (ELC) that delineated terrain units, surface-forms, and vegetation across the study area; and 3) derivation of a reduced set of wildlife-oriented habitat classes by combining ELC types. Detailed methods for the mapping and classification were presented by Johnson et al. (1996). In 1996, the accuracy of the habitat map was assessed by Jorgenson et al. (1997).

The habitat classification was based on those landscape properties that we considered to be 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, we combined dissimilar vegetation types because selected wildlife species either did not use them or used them to similar extents. Conversely, wildlife use may differ between habitats with similar vegetation based on relief, soil characteristics, associated fauna, or other factors not reflected by 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 (Johnson et al. 1996: Appendix Table A8) illustrated some of the differences among various systems. In our study, we concentrated on breeding waterbirds that use waterbody and wet- and moist-tundra types and on mammals and upland birds that use shrubland and dry-tundra habitats.

We collapsed 195 ELC class combinations into an initial set of 49 wildlife habitat types that were based on a hierarchical classification of wildlife habitats (Table 1) used in several bird-habitat studies in the nearby Prudhoe Bay Oilfield (Murphy et al. 1989, Johnson et al. 1990, Anderson et al. 1991, Murphy and Anderson 1993). Included were several new habitat types (e.g., Aquatic Sedge with Deep Polygons, Deep Open Water with Polygonized Margins, and various Tapped Lake classes) we added to the original system to recognize habitats unique to the Colville Delta region. We further reduced the initial 49 wildlife habitat types by eliminating types that had both extremely small areas (<0.5% of the total area) and low levels of wildlife use and by combining similar types that apparently had similar levels of use. Combining habitat types was somewhat 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 from 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, we evaluated habitat selection with detailed analyses for selected wildlife species. We based the quantitative analyses of habitat selection by these species on the locations of bird groups, bird nests, and fox dens observed during aerial surveys (and ground surveys for fox dens only). For each species, we calculated habitat use for applicable combinations of season (e.g., pre-nesting, nesting, and brood-rearing), year of survey (different years, depending on the species), and area surveyed (Delta or Transportation Corridor). For each combination, we calculated:

1. numbers of adults, nests, young, or dens for each habitat;
2. percent use of each habitat;
3. percent availability of each habitat;
4. selection index; and
5. the probability that use was not proportional to availability.

We calculated percent use as the percentage of the total number of groups of birds, nests, nesting-colony locations, broods, or dens that were observed in each habitat. Use was calculated from group locations for birds that were in flocks or broods, because the assumption of independence of selection among individuals in the group was not reasonable. For Brant colonies and fox dens (active and inactive combined), both of which generally are static in location, we used the cumulative number of locations in the analyses. For all other species, the parameters were calculated for each year of survey. The availability of each habitat was the percentage of that habitat in the total area surveyed. Except where noted, we considered all habitats within a survey area

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

- **MARINE WATER**
  - Inshore Water
  - Offshore Water
  - Sea Ice
- **COASTAL ZONE**
  - Nearshore Water
    - Open Nearshore Water (marine)
    - Brackish Water
      - Deep
        - without Islands
        - with Islands
        - with Polygonized Margins
      - Shallow
    - Tapped Lake (deltas only)
      - Deep
        - with low-water Connection
        - with high-water Connection
      - Shallow
        - with low-water Connection
        - with high-water Connection
  - Coastal Wetland Complex
    - Salt Marsh
      - Halophytic Sedge
      - Halophytic Grass
      - Halophytic Herb
      - Halophytic Dwarf Willow Scrub
  - Barren
    - Coastal Island
    - Coastal Beach
      - Cobble/gravel
      - Sand
    - Coastal Rocky Shore
      - Low
      - Cliffs
    - Tidal Flat
    - Salt-killed Tundra
    - Causeway
- **FRESH WATER**
  - Open Water
    - Deep Open Water
      - Isolated
        - without Islands
        - with Islands
        - with Polygonized Margins
      - Connected
    - Shallow Open Water
      - without Islands
      - with Islands
      - with Polygonized Margins
  - River or Stream
    - Tidal
    - Lower Perennial
    - Upper Perennial
      - Deep Pools
      - Shallow
      - Riffles
      - Falls
    - Intermittent
  - Water with Emergents (shallow, isolated, or connected)
    - Aquatic Sedge Marsh
      - without Islands
      - with Islands
      - with Deep Polygons
    - Aquatic Grass Marsh
      - without Islands
      - with Islands
    - Aquatic Herb
      - without Islands
      - with Islands
- **BASIN WETLAND COMPLEX**
  - Young (ice-poor)
  - Old (ice-rich)
- **MEADOW**
  - Wet Meadows
    - Nonpatterned
      - Sedge (*Carex, Eriophorum*)
      - Sedge–Grass (*Carex, Dupontia*)
    - Low-relief
    - High-relief (sedge–willow)
  - Moist Meadows
    - Low-relief
      - Sedge–Dwarf Shrub Tundra
      - Tussock Tundra
      - Herb
    - High-relief
      - Sedge–Dwarf Shrub Tundra
      - Tussock Tundra
  - Dry Meadows
    - Grass
    - Herb
- **SHRUBLAND**
  - Riverine Shrub
    - Riverine Low Shrub
      - Willow
      - Birch
      - Alder
    - Riverine Dwarf Shrub
  - Upland Shrub
    - Upland Low Shrub
      - Mixed Shrub Tundra
      - Willow
      - Alder
    - Upland Dwarf Shrub
      - *Dryas*
      - Ericaceous
  - Shrub Bogs
    - Low Shrub Bog
    - Dwarf Shrub Bog
- **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
  - Cliff (rocky)
  - Bluff (unconsolidated)
    - Barren
    - Partially Vegetated
  - Burned Area (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
    - Impoundment
      - Drainage Impoundment
      - Effluent Reservoir
    - Gravel
      - Barren or Partially Vegetated
      - Vegetated
  - Structure or Debris

to be available. However, where the survey areas differed among species, years, and/or seasons, the availability of habitats also differed.

We used Ivlev's E ([% use – % availability] / [% use + % availability]; Ivlev 1961) as an index of selection because it generates a value bounded between –1 and +1. Values near 0 indicate that relative use equals relative availability, and values near –1 and +1 indicate use is less than availability and use is greater than availability, respectively. We calculated measures of multi-year selection by first pooling the data for all years under consideration, then recalculating Ivlev's E with those pooled data. Separate analyses were calculated for the Delta and Transportation Corridor survey areas for each species except Yellow-billed Loons and Brant, for which we had too few observations in the Transportation Corridor to conduct the analyses. In addition to calculating habitat use and selection, we measured the distance from each location to the nearest waterbody habitat on the digital map to evaluate the affinity of each species for waterbodies.

We tested for significant habitat selection (i.e., use ≠ availability) by conducting Monte Carlo simulations (Haefner 1996) on multi-year data for each species. Each simulation used random numbers (range = 0–100) to choose a habitat from the cumulative frequency distribution of the percent availability of habitat. The number of "random choices" in a simulation was equal to the number of nests, dens, or groups of birds from which percent use was calculated. We conducted 1,000 simulations for each species and summarized the frequency distribution by percentiles. We defined habitat preference (i.e., use > availability) to occur when the observed use by a species was greater than the 97.5 percentile of simulated random use. Conversely, we defined habitat avoidance (i.e., use < availability) to occur when the observed use was less than the 2.5 percentile of simulated random use. These percentiles were chosen to achieve an alpha level (Type I error) of 5% for a two-tailed test. Habitats with nonsignificant selection (i.e., observed use ≥2.5 and ≤97.5 percentiles) were deemed to have been used approximately in proportion to their availability. The simulations and calculations of percentiles were conducted in a Microsoft® Excel spreadsheet on a personal computer.

WILDLIFE SURVEYS

For the 1997 wildlife studies, we used both fixed-wing aircraft and helicopters to fly aerial surveys over the Colville Delta and the Transportation Corridor for selected avian and mammalian species (Table 2). We also conducted several ground surveys near the proposed Facility Area. As in previous years, the 1997 avian studies focused on the distribution and abundance of Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, Brant, and (added in 1996) Greater White-fronted Geese during different seasons (detailed in the methods for each species). During surveys, we collected additional information opportunistically on other waterbirds, such as Canada Geese, Snow Geese, and Pacific and Red-throated loons. We concentrated our surveys for mammals on caribou, arctic foxes, and spotted seals, but we incidentally collected information on other species, such as brown bears, moose, and muskoxen.

NEST AND BROOD SEARCHES

We conducted nest searches on the ground using the same techniques as in 1996; however, the 1997 survey area was restricted to the vicinity of the proposed facilities (Figure 1) and to several areas on the outer delta where nesting eiders have been observed in the past. Within each search area, we searched on foot the shorelines (≤10 m) of all waterbodies, and in all intervening habitat we searched with ~10-m spacing between observers. Although we primarily searched for Spectacled Eider nests, we also searched for nests of King Eider, Tundra Swan, goose, loon, and other waterbirds. For each nest, we recorded the species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. We revisited nest sites of waterbirds in the ground-search area after hatch to determine their fate. Nests were classified as successful if egg membranes were detached from the eggshells. During brood-rearing, two to three observers conducted the ground survey for all waterbirds and inspected all waterbodies in the Facility Area. We mapped all nest, brood, and non-breeder locations on 1:18,000-scale color aerial photographs and added the locations found in 1997 to the existing GIS database containing locations identified in 1992–1996. For

Table 2. Descriptions of wildlife surveys conducted on the Colville River Delta and adjacent areas, Alaska, 1997.

Species	Survey Type	Phenological Season	Dates	Aircraft[b]	Transect[a] Width (km)	Transect[a] Spacing (km)	Aircraft Altitude (m)	Area Surveyed
BIRDS								
Eiders	Aerial	Pre-nesting	12, 13, 16, 20 June	C185	0.4	0.4	30–35	Delta
			12, 13 June	C185	0.4	0.4	30–35	Transportation Corridor
	Ground	Nesting	18–22, 25, 29, 30 June	-	-	-	-	Facility Area and Outer Delta
	Ground	Brood-rearing	15–17 July	-	-	-	-	Facility Area
Tundra Swans	Aerial	Nesting	20–22 June	C185	1.6	1.6	150	Delta and Transportation Corridor
		Brood-rearing	19–21 Aug.	C185	1.6	1.6	150	Delta and Transportation Corridor
		Fall staging	28 Sep.	C185	n/a	n/a	150	Delta and Transportation Corridor
Loons	Aerial	Nesting	27–28 June	PA18	n/a	n/a	30–40	Delta and Transportation Corridor
		Brood-rearing	16–18 Aug.	206L	n/a	n/a	30–70	Delta and Transportation Corridor
	Ground	Nesting	18–25 June	-	-	-	-	Facility Area
		Brood-rearing	15–17 July, 14–16 Aug.	-	-	-	-	Facility Area
Brant	Aerial	Nesting	18 June	PA18	n/a	n/a	50–80[c]	Portions of the Delta and Transportation Corridor
		Fall staging	22 Aug.	C185	n/a	n/a	90	Delta
Other geese	Aerial	Brood-rearing	26, 27 July	PA18	0.4	1.6	90	Delta and Transportation Corridor
	Aerial	Fall staging	21, 22 Aug.	C185	0.4	1.6	90	Delta and Transportation Corridor
Other breeding birds	Ground	Nesting	25, 26 June	-	-	-	-	Facility Area
MAMMALS								
Caribou	Aerial	Calving	1 June	C185	0.8	3.2	90	Colville Delta survey area
			1, 2 June	C185	0.8	1.6	90	Colville East survey area
			2 June	C185	0.8	1.6	90	Kuparuk South survey area
			12, 13 June	206L	0.8	1.6	90	Kuparuk South survey area
			10–12 June	206L	0.8	1.6	90	Colville East survey area
			12, 13, 16, 20 June[d]	C185	0.4	0.4	30–35	Colville Delta survey area
		Insect	28 June–31 July, 22 Aug.	PA18 or 206L	1.6	1.6, 3.2	150	Development Area and Transportation Corridor (transect surveys & general reconnaissance)
Foxes	Aerial & ground	Denning	23–25 June, 9–17 July	206L	1.6	1.6	90	Delta and Transportation Corridor (helicopter survey with stops at dens to assess activity)
	Ground	Denning	6–20 July	-	-	-	-	Delta and Transportation Corridor (evaluation of pup production)
Spotted Seals	Aerial	Late-summer	23, 26, 29 July, 2, 19, 21, 22 Aug. 28 Sep.	C185	n/a	n/a	450	Colville River East Channel and distributaries south to Itkillik River

[a] n/a = not applicable.
[b] C185 = Cessna 185 fixed-wing airplane; PA18 = Piper “Super Cub” fixed-wing airplane; 206L = Bell “Long Ranger” helicopter.
[c] Colonies were inspected from the lower altitudes.
[d] Survey on the delta was conducted concurrently with the eider survey on these dates.

nests of waterbirds in or near the gravel footprint of the facility, we recorded their exact locations with a differential GPS.

EIDERS

In 1997, we flew aerial surveys during the pre-nesting period and conducted ground searches for eider nests and broods (Table 2). For the pre-nesting survey, we used the same methods as in previous years (1992–1996), although the survey areas differed in extent. In 1997, we flew surveys over the entire delta and Transportation Corridor. 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, and the pilot searched forward to observe birds that would be directly under the aircraft, thereby covering 100% of the survey areas. The strip width for this and other transect surveys was delimited visually by tape marks on the windows and wing struts or skids of the aircraft (Pennycuick and Western 1972). We recorded the locations of eiders on 1:63,360-scale USGS maps, except in 1997, when we used a 1:63,000-scale habitat map. We used audio tapes to record numbers, species, and sexes of eiders and their perpendicular distances from the flight line. Later, these locations were entered manually into a GIS database for mapping and analysis.

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 the USFWS (1987b) protocol, the total indicated number of birds was calculated by first doubling the number of males not in flocks (flocks are defined >4 males or a mixed-sex group of >3 birds that can not be separated into singles or pairs), then adding this product to the number of birds in flocks. The indicated number of pairs was the number of males. Numbers and densities were not adjusted with a visibility correction factor.

Habitat selection was analyzed for locations of groups (singles, pairs, or flocks) of non-flying eiders during pre-nesting and brood-rearing in the Delta and during pre-nesting in the Transportation Corridor. For analysis of selection during the pre-nesting season, we used locations from aerial surveys in 1993-1997. The pre-nesting survey in 1993 and portions of the brood-rearing survey in 1995 were flown at 50% coverage; all other surveys were flown at 100% coverage. For those surveys flown at 50% coverage, we calculated habitat availability only on those strips that were surveyed. Habitat selection by broods could be calculated only for 1995, the only year we flew aerial surveys during brood-rearing. For all other surveys conducted with coverage that was not representative of the delta or Transportation Corridor (e.g., nesting, when ground searches were done only in selected areas), we summarized the percent use of each habitat but did not calculate selection indices.

TUNDRA SWAN

In 1997, we flew aerial surveys for Tundra Swans during the nesting, brood-rearing, and fall-staging seasons (Table 2). During nesting and brood-rearing, we conducted aerial surveys over the entire delta and Transportation Corridor in accordance with USFWS protocols (USFWS 1987a, 1991). We flew east-west transects spaced at 1.6-km intervals in a fixed-wing airplane that was navigated with the aid of a GPS receiver. 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. The same methods were used for nesting and brood-rearing surveys on the delta in 1993, 1995, and 1996, and in the Transportation Corridor in 1988-1993, 1995, and 1996 (Smith et al. 1994, Johnson et al. 1997). Beginning in 1995, we photographed each nest with a 35-mm camera for site verification. From 1988 to 1993, surveys in the Transportation Corridor were conducted as part of swan studies in the Kuparuk River Unit (see Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993, 1994). During nesting in 1992, the survey on the delta differed from those of other years, in that it was flown along east-west survey lines spaced 2.4 km apart (Smith et al. 1993). During brood-rearing in 1992, parallel lines oriented northeast-southwest were flown at ~2.4-km intervals.

The fall-staging surveys departed from the standard USFWS protocol in that we flew fewer flight lines (spaced 4.8 km apart) and flew at a higher altitude (~215 m agl) than is specified in the protocol. We frequently diverged from those lines to count swans seen in the distance; we also revisited locations where we had seen swans during previous staging surveys. In 1997, additional information on swan staging was gathered by helicopter-based surveys of locations favored by flocks of swans in previous years. These surveys were opportunistic and were flown in inclement weather; systematic flight lines or set flight altitudes could not be adhered to during those surveys.

We summarized observed numbers of swans, nests, and broods and calculated densities for each survey area and season. No corrections were made for sightability. Nesting success was estimated from the ratio of broods to nests counted during aerial surveys. The accuracy of these estimates of nesting success can be affected by a number of factors. First, swan broods are less likely than swan nests to be missed by observers during aerial surveys (see Stickney et al. 1992), thus inflating the estimated nesting success. Second, some broods probably are lost to predation between hatching and the aerial survey, thus deflating estimated nesting success. Finally, swan broods are mobile and can move into or out of a survey area prior to the survey, thus biasing the estimated nesting success in either direction. However, immigration and emigration of broods are less of a problem for estimating nesting success in large, well-defined areas, such as the Delta survey area. Accordingly, we calculated estimates of nesting success only for the delta, and these should be considered only relative indices of annual nesting success.

Habitat selection was calculated for Tundra Swan nests and broods for each year surveyed. Each survey was flown at 100% coverage, so we used the entire Delta and Transportation Corridor survey areas for calculating available habitats. We calculated the selection indices from the locations of each nest or brood. Although some nest sites were used in multiple years, we were not able to distinguish these sites objectively from others where nests were close, but not in exactly the same location, in consecutive years. None of the nest sites were used in all the years that surveys were conducted. Hawkins (1983) found 21% of the swan nests on a portion of the Colville Delta were on mounds used the previous year. Monda et al. (1994) found that 49% of the nests in the Arctic National Wildlife Refuge were on mounds used previously and that nest sites reused from previous years were slightly more successful than new nest sites. Therefore, to delete multi-year nest sites from the habitat analysis could bias the results toward habitats selected by less experienced and less successful pairs. To avoid potential bias, we have chosen to include all nest sites, while recognizing that some locations may not be annually independent.

LOONS

In 1997, we used a fixed-wing aircraft to survey for nesting loons and a helicopter to survey for brood-rearing loons (Table 2). We used the same methods in 1995 and 1996 (Johnson et al. 1996, 1997), whereas we flew both the nesting and brood-rearing surveys in 1992 and 1993 in a fixed-wing aircraft (Smith et al. 1993, 1994). We flew all surveys in a lake-to-lake pattern, concentrating on lakes ~10 ha or larger in size and adjacent smaller lakes; we excluded coastal lakes and tapped lakes with low-water connections to river channels, where Yellow-billed Loons have not been observed to nest (North 1986, Johnson et al. 1997). We used the 10-ha-size criterion in 1995–1997 to concentrate our efforts on Yellow-billed Loons, which typically nest and rear their broods on lakes ≥10 ha (Sjolander and Agren 1976, North and Ryan 1989). Aerial surveys conducted in the Transportation Corridor in 1993 indicated that this area was used minimally by Yellow-billed Loons during the breeding season (Smith et al. 1994). Consequently, in 1995–1997, we surveyed only large lakes with suitable nesting habitat and areas where Yellow-billed Loons had been seen previously. During the nesting season in 1996 and 1997, we revisited with a helicopter those lakes in the Delta and Transportation Corridor survey areas where Yellow-billed Loons had been seen but nests were not found on the initial aerial survey, to determine whether nesting was occurring. We also recorded locations of nesting and brood-rearing Pacific and Red-throated loons during all surveys. However, surveys for these two species were not thorough, because we did not systematically search small lakes (<10 ha), which primarily are used by these species for nesting and brood-rearing (Bergman and Derksen 1977). We recorded all loon locations on 1:63,630-scale USGS maps.

In the Facility Area in 1997, we conducted intensive searches by helicopter (2 July, 18 August) and on foot of all waterbodies for nesting and brood-rearing loons (Table 2). We recorded locations of nests and broods of all three loon species on 1:63,360-scale USGS maps or on copies of 1:18,000-scale color aerial photographs. The ground searches in 1997 were conducted similarly to those in 1995 and 1996 (Johnson et al. 1996, 1997).

We calculated the total number of adults, nests, broods, and young by season for all three species of loons. We calculated density (number/km^2) only for Yellow-billed Loons because our survey coverage for Pacific and Red-throated loons was inadequate for estimating density. For the Outer Delta, we analyzed data from only that portion of the total area that was surveyed in both the nesting and brood-rearing seasons for 1993, 1995–1997. Habitat selection by nesting and brood-rearing Yellow-billed Loons was analyzed only for the Delta survey area; the sample size in the Transportation Corridor was too small for analysis. We calculated selection indices based on nests found in 1993, 1995–1997 and on broods found in 1995–1997.

BRANT AND OTHER GEESE

In 1997, we flew aerial surveys for Brant during nesting and fall staging (Table 2). Methods for the nesting and staging surveys were similar to those used since 1989 for surveys of Brant between the Colville and Sagavanirktok rivers (Ritchie et al. 1990, Anderson et al. 1997). The survey area extended up to 15 km inland from the coast on the delta (nesting and staging periods) and up to 20 km inland in the Transportation Corridor (nesting period only).

Nesting surveys were flown lake-to-lake along a predetermined path that included known colony sites and lakes with numerous islands (i.e., potential colony sites). We did not survey the Anachlik Colony-complex (nesting colonies at the mouth of the East Channel), specifically to avoid disturbing the large number of nesting birds there (>950 nests; Martin and Nelson 1996). We recorded a nest wherever we saw either a down-filled bowl or an adult in incubation posture, and mapped all observations on 1:63,360-scale USGS maps. Our aerial counts of Brant and their nests should be considered minimal numbers 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.

During brood-rearing, we collected information on Brant during a systematic survey for all geese (Table 2), rather than during a coastal survey, as was done in previous years. This systematic survey was flown at 90 m agl on east-west flight lines that were 1.6 km apart. Two observers searched a 400-m wide strip on the either side of the plane, thereby achieving 50% coverage of the survey area. As during other surveys, we recorded species, numbers, and locations on 1:63,360 scale USGS maps.

During fall staging, we flew a systematic delta-wide survey and a non-systematic coastal survey (Table 2). The systematic survey encompassed all staging geese, including Brant, and followed the same protocol as that used during brood-rearing. The non-systematic coastal survey followed the shorelines of bays, deltaic islands, and river channels, extending ~10 km inland, and was flown at 90 m agl and also with two observers.

We tallied the number of Brant observed during all surveys and compared those totals to numbers observed in previous years. No corrections were made for sightability. The annual nest counts do not include the Anachlik Colony complex. All locations were added to the GIS database for the Delta and Transportation Corridor.

We calculated habitat selection values only for that portion of the Outer Delta that was surveyed annually. Because Brant tend to nest in the same colony locations each year, we based habitat selection on the cumulative number of nesting colony (≥1 nest) locations observed for all years surveyed (1992, 1993, and 1995–1997). We used the number of nesting colonies in each habitat in our analysis rather than the number of nests in each colony (although we report the number of nests), because individual nest locations within colonies are unlikely to be independent of each other. We did not analyze habitat selection by brood-rearing Brant because a comparable coastal survey was not flown in 1997;

however, the previous analysis was repeated with 1,000 iterations (increased from 500 iterations in 1996) in the Monte Carlo simulation.

In 1997, we continued a systematic brood-rearing survey for geese in late July that was developed originally in 1996 to count White-fronted Geese, although we also counted Brant, and Canada and Snow geese. The methods followed those described above for Brant systematic surveys. Coverage in 1996 was equivalent to 25% of the study area (one observer), whereas coverage in 1997 was 50% (two observers). During a similar systematic survey for fall-staging geese, we again doubled our coverage in 1997 (50%) over that in 1996 by using two observers. In addition to these surveys, we opportunistically collected information on geese during surveys for eiders, swans, and loons.

OTHER BIRDS

During the 1997 aerial and ground surveys, we opportunistically collected data on birds other than the focal species. Special emphasis was placed on gathering information in the Facility Area. During various surveys for focal species, we recorded locations of nesting, brood-rearing, molting, and staging ducks, jaegers, gulls, terns, and ptarmigan, and noted the occurrence of nesting shorebirds and passerines. We recorded locations of nests and birds from all surveys on 1:18,000-scale color aerial photographs.

On 25–26 June 1997, we conducted an intensive breeding-bird survey of all species at the proposed locations for the airstrip, drill pads, and infield road. We used digitized maps of the proposed footprints overlaid on a satellite image of the area to define the boundaries of our search areas. The intensive survey required 3–7 researchers to search the footprint area by walking in a zig-zag path while spaced ~10 m apart. We recorded all species encountered on the ground or in flight but did not concentrate on finding nests of shorebirds or passerines, because most nests either had hatched or were in the latter stages of incubation at that time.

CARIBOU

Calving Season

During the 1997 calving season (late May–mid-June), we conducted aerial surveys in three contiguous, non-overlapping survey areas that encompassed the Colville Delta, the Transportation Corridor, other areas north and south of the Transportation Corridor, and the area south of the Kuparuk Oilfield. The Kuparuk Oilfield also was surveyed (Lawhead et al. 1998), and those data are included in this report. The survey objectives were to monitor the distribution and abundance of caribou near the peak and end of the calving season.

We flew calving surveys during 1–3 June and 10–15 June (Table 2). The first round of surveys, scheduled to coincide with the expected peak of calving activity, covered the Colville Delta, Colville East (as expanded in 1995), and Kuparuk South (called Kuparuk Inland by Johnson et al. [1996]) survey areas, as well as the Kuparuk Field (Figure 30). The second round of surveys was scheduled near the end of calving, coinciding with the timing of comparable surveys by the Alaska Department of Fish and Game (ADFG) in previous years. The Colville Delta survey area was not surveyed separately in the second survey period because caribou were recorded during the pre-nesting survey for eiders, which was conducted at the same time, using a lower altitude and closer transect spacing (therefore constituting a census) than the usual calving surveys.

As in previous years, we surveyed systematically spaced strip transects during the calving season. A pilot and two observers in a fixed-wing aircraft (first survey) or helicopter (second survey) followed north-south-oriented transect lines. 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 and Kuparuk South survey areas and at 3.2 km in the Colville Delta survey area. The two observers viewed 400-m-wide strips on opposite sides of the aircraft, resulting in approximately 50% coverage of the survey area at 1.6-km spacing and 25% coverage at 3.2-km spacing. Transect lines followed section lines on USGS topographic maps, and we tallied the number of caribou observed in 3.2-km-long transect segments. Caribou were classified either as “large” animals (adults and yearlings) or as calves.

We estimated snow cover visually as an index to survey conditions. As spring snow melt occurs during the calving season, the complex, 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 compensate for counts made during poor viewing conditions is to estimate sightability by conducting duplicate surveys in a portion of the study area using different survey methods, and then to apply a sightability correction factor (SCF) to adjust the raw counts for the entire area (Gasaway et al. 1986). Smith et al. (1994) calculated an SCF in the Colville East survey area by comparing fixed-wing and helicopter counts made during conditions of intermediate snow cover (20–70%). In 1997, late snowmelt resulted in patchy snow cover during our second round of surveys, so we applied the SCF to adjust our population estimates. Only the counts of large caribou could be adjusted, however, because Smith et al. (1994) were unable to develop an SCF for calves. The SCF was not applied to the counts for 1–3 June because the snow cover had not yet begun to melt and sightability was much higher.

We estimated population numbers for large caribou (cows + yearlings + bulls), calves, and total caribou in the survey areas using standard errors derived by Smith et al. (1994: Appendix C) and formulas adapted from Gasaway et al. (1986). The counts of total caribou and calves from each survey were extrapolated (using the ratio of the entire survey area to the actual area surveyed on transects) to estimate the “observable” population (i.e., the population for the entire survey area, unadjusted for sightability). In text, estimates are followed by the 80% confidence interval (CI); for example, an observable population estimate of 70 ± 30 means that the 80% CI ranges from 40 to 100 caribou. The observable population estimate for the second survey period was multiplied by the SCF to calculate the adjusted population estimate, which is an estimate of the number of large caribou in the entire area surveyed, assuming sightability of 100%.

During the calving season, we also sampled the sex and age composition (cows, calves, yearlings, and bulls) of caribou groups in the southern portion of the Colville East and Kuparuk South survey areas (specifically, from 149° 28' to 150° 32' W and 69° 56' to 70° 06' N) on 13 June to estimate initial production of calves. Helicopter speed varied from 40 to 125 km/h (slowing frequently to observe groups closely), and altitude ranged from 30 to 50 m agl, with two observers viewing opposite sides of the helicopter. The six transect lines followed on the composition survey were oriented perpendicular (east–west) to those used for the calving distribution surveys, and lines were spaced at intervals of 2 minutes of latitude (approximately 3.5 km) to avoid duplicate counts of caribou among adjacent transects. Deviations from transects were made only when it was necessary to examine groups closely.

Insect Season

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 Delta (primarily the Development Area and Western Delta) and Transportation Corridor (including the adjacent area extending 5 km [3 mi] south of it) survey areas. Distribution and movements were monitored by an observer stationed at ARCO’s Kuparuk facility from 28 June to 31 July; additional observations were provided by biologists surveying other species or working on other projects in the study areas. Daily observations recorded weather conditions, levels of insect harassment, and caribou movements, which were tracked primarily by aerial surveys. Supplemental observations from a truck were used to monitor the general movements of caribou in the vicinity of the oilfield road system.

Insect-season surveys employed a combination of systematic strip-transect surveys specifically for caribou and nonsystematic reconnaissance surveys or observations during other wildlife surveys (e.g., for fox dens and waterbird broods). Depending on aircraft availability, the systematic transect surveys used either a helicopter (Bell 206L) or a fixed-wing airplane (Piper PA-18, Table 2). We surveyed 1.6-km-wide, east–west-oriented strip transects and viewed out to 0.8 km on each side of the aircraft to achieve complete coverage of the transect strip. This broad strip width (1.6 km) was sufficient for detecting most groups of caribou, but some single animals and very small groups (<5 animals) probably were missed. Survey intensity varied among surveys, depending on the prior distribution and movements of caribou in the study area; daily observations allowed us to keep close track of caribou movements. We recorded the location and number of caribou groups on USGS topographic maps. We recorded group type (cow/calf-dominated, bull-dominated, mixed sex/age) and, when possible, 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 in 1997 with both aerial and ground-based surveys (Table 2). No systematic surveys to locate fox dens were conducted in 1997. Instead, we checked dens found in previous years and made note of dens sighted incidentally during waterbird surveys, particularly eider prenesting surveys. Additional observations during 23–25 June and 6–10 July employed a helicopter to check the status of known dens and to search for other dens along drainages, banks of drained lake basins, and on mounds and pingos. We landed at each den site to determine its status and returned later to observe active dens to evaluate pup production.

During ground visits, we evaluated evidence of use by foxes and confirmed the species using the den. Fox sign used to assess den status included the presence or absence of adult and pup foxes; presence and appearance of droppings, diggings, and tracks; trampled vegetation; shed fur; prey remains; and predator sign (e.g., pup remains; following Garrott 1980). We classified dens into three categories (following Burgess et al. 1993):

1. natal dens—sites at which young were whelped, characterized by abundant adult and pup sign early in the current season;
2. secondary dens—sites not used for whelping, but used by litters moved from natal dens later in the season (determination made from sequential visits or from amount and age of pup sign); and
3. inactive dens—sites with either no indication of use in the current season or those showing evidence of limited use for resting or loafing by adults, but not inhabited by pups.

Because foxes commonly move pups from natal dens to secondary dens, repeated observations during the denning season are needed to classify den status with confidence. As in 1996, we expended more effort than in previous years to determine den status. Based on our initial assessment of den activity, den observations during 6–20 July were devoted to counting pups at as many active dens as possible. Observers were dropped off by helicopter at suitable vantage points several hundred meters from den sites, from which they conducted observations with binoculars and spotting scopes over periods of 3–5 hours; observations usually were conducted early and late in the day, to correspond with active periods of foxes.

Habitat selection indices for foxes were calculated by using the total number of dens located for both arctic and red foxes during 1992–1997. Our measure of habitat availability was the total area of all terrestrial habitats; waterbodies were omitted because they cannot be used for fox dens. In the selection analysis, no distinction was made between active (natal or secondary) and inactive dens, because den status can change annually. Only sites that we had visited, confirmed, and mapped on aerial photographs were included in the habitat selection analysis.

SPOTTED SEAL

We flew eight aerial surveys on the Colville Delta from late July through late September 1997 to search for spotted seals (Table 2). We flew the surveys in a fixed-wing aircraft at 450 m agl. A pilot and one or two observers scanned ahead and to the sides of the aircraft, looking for seals in the water or hauled out on river bars and islands in the major channels of the Colville River. The flight path followed the course of the channels, remaining to one side of a given channel to optimize visibility. We flew multiple passes over wider portions of channels to ensure complete coverage of the area surveyed. The observer used binoculars to scan more distant objects on spits, sandbars, or in the water.

When we observed seals (or seal-like objects), we circled over the area until an identification and a count were made.

The area surveyed consisted of the eastern channel of the delta, including the Elaktoveach, Kupigruak, and Colville (main) channels, from the confluence of the Itkillik River downstream to the sea. In addition, we surveyed the Jones Islands and Pingok Island on 29 July.

OTHER MAMMALS

Incidental observations of grizzly bears and muskoxen were recorded during aerial and ground-based surveys for waterbirds, caribou, and fox dens. On 4 June 1997, we flew a reconnaissance (nonsystematic) survey specifically for muskoxen in the uplands east of the Itkillik River with a fixed-wing airplane. Grizzly and polar bear den locations were obtained from agency biologists (R. Shideler, ADFG, Fairbanks, AK; S. Schliebe, USFWS Marine Mammals Management, Anchorage, AK; and S. Amstrup, USGS Biological Resources Division, Anchorage, AK) and from existing literature.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

We aggregated the 195 classes (terrain unit, surface-form, and vegetation combinations; see Johnson et al. 1996) identified by the ecological land classification into a set of 24 wildlife habitat types for the Delta and Transportation Corridor survey areas (Figure 2, Table 3). This aggregation resulted in 12 waterbody, 10 terrestrial, and 2 wetland-complex types. The habitats are described in Appendix Table B, and a list of plant taxa found within them are reported in Johnson et al. (1996).

The large differences in availability of particular habitats between the Delta and the Transportation Corridor survey areas reflected differences in marine and riverine processes between the two areas (Figure 2, Table 3). On the delta, the most abundant habitats were Wet Sedge-Willow Meadow (19% of the total area), River or Stream (15%), Barrens (14%), and Tidal Flat (10%). Other habitats that were less common but were unique to the delta included Brackish Water (1%), Tapped Lake with Low-water Connections (4%), Salt Marsh (3%), Salt-killed Tundra (5%), and Aquatic Sedge with Deep Polygons (2%). The most abundant habitats in the Transportation Corridor were Moist Tussock Tundra (28% of the total area), Moist Sedge–Shrub Meadow (25%), Old Basin Wetland Complex (10%), and Deep Open Water without Islands (9%).

Basin Wetland Complexes were particularly important features of the Transportation Corridor, where they were composed of a variety of moist, wet, and aquatic habitats. These complexes were rare on the delta. In our usage, Basin Wetland Complexes are portions of thaw-lake basins that delineate areas containing a complex mosaic of habitat patches, the components of which were below the scale of mappable units (<0.25 ha for waterbody habitats and <0.5 ha for terrestrial habitats). 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, so the areas calculated for these complexes represent 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 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 a wide variety of stages occur in thaw-basin evolution that could confound analyses of habitat use.

Because of our interest in reducing the number of habitats to facilitate analyses and their presentation, some habitats may include some rather dissimilar ecological land classes. For example, theRiverine and Upland Shrub class combined tall willows on the floodplains with *Dryas* tundra on upland ridges, because the *Dryas* tundra covered such a small percentage (0.1%) of the total area. Similarly, we combined several ELC classes with different surface-forms into one habitat type (e.g., Wet Sedge–Willow Meadow combined areas of high- and low-density polygons). A cross-reference between our habitat classes and other wildlife habitat classifications that have been used on the Arctic Coastal Plain was presented by Johnson et al. (1996).

Figure 2. Habitat map of the Delta and Transportation Corridor survey areas, colville River Delta, Alaska.

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

	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	16.35	3.0	0	0
Tidal Flat	56.05	10.2	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	5.15	0.9	6.52	1.9
Shallow Open Water w/o Islands	2.30	0.4	10.84	3.2
Shallow Open Water w/Islands or Polygonized Margins	0.55	0.1	7.37	2.1
River or Stream	81.76	14.8	2.31	0.7
Aquatic Sedge Marsh	0	0	0.97	0.3
Aquatic Sedge w/Deep Polygons	13.60	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	35.60	10.4
Nonpatterned Wet Meadow	41.92	7.6	24.47	7.1
Wet Sedge–Willow Meadow	102.36	18.6	19.87	5.8
Moist Sedge–Shrub Meadow	13.36	2.4	84.67	24.7
Moist Tussock Tundra	2.52	0.5	94.62	27.6
Riverine or Upland Shrub	27.40	5.0	7.74	2.3
Barrens (riverine, eolian, lacustrine)	78.90	14.3	1.93	0.6
Artificial (water, fill, peat road)	0.02	<0.1	0.47	0.1
Total	551.29	100	343.16	100

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, where they tend to concentrate around large river deltas (Johnson and Herter 1989). Derksen et al. (1981) described them as common breeders in the National Petroleum Reserve–Alaska (NPR–A) but uncommon east of there at Storkersen Point. Spectacled Eiders arrive on the Colville Delta in early June, and nest-initiation dates in different years and areas have ranged 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 and nesting areas after incubation begins (Gabrielson and Lincoln 1959, Kistchinski and Flint 1974, TERA 1995). The latest record of this species on the Colville Delta is 28 August (Gerhardt et al. 1988).

King Eiders nest in high densities in the Prudhoe Bay area (Troy 1988) and near Storkersen Point (Bergman et al. 1977), but densities appear to decline west of the Colville River (Derksen et al. 1981). On the Colville Delta, they are common (i.e., occur in all or nearly all proper habitats, but some suitable habitat not occupied) visitors but uncommon or rare (i.e., occur regularly but in small numbers) nesters (Simpson et al. 1982, North et al. 1984, Johnson 1995). King Eiders occur frequently in flocks on open channels and waterbodies in early June, after Spectacled Eiders have dispersed to nesting habitats (Johnson 1995); thus, King Eiders possibly arrive on the delta slightly later than Spectacled Eiders and/or they use the delta as a staging 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, Johnson et al. 1997), 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, Boise State University, pers. comm.).

DISTRIBUTION AND ABUNDANCE

Pre-nesting

The distributions of both Spectacled and King eiders in 1997 were similar to those recorded on surveys flown in 1993-1996 (Figures 3 and 4). Spectacled Eiders were more numerous in the Delta survey area than in the Transportation Corridor, whereas the reverse was true for King Eiders. In five years of aerial surveys, we recorded only one pair of Common Eiders, a pair seen on the coastline of the delta in 1992.

We conducted our pre-nesting survey later (12–20 June) in 1997 than in the past (10-14 June). Snow and ice cover was extensive on 10 June, with many of the shallow lakes that normally were used by eiders remaining frozen. Therefore, we delayed our survey until open water appeared in shallow lakes and wetland complexes. Patchy snow and ice made eiders difficult to detect from the air. Nonetheless, the timing of the survey appeared to be good with regard to the movement of eiders into breeding areas. Only 12% of the Spectacled Eiders were in groups of >1 pair, suggesting that most birds seen were pairs that had dispersed to breeding habitat. On previous pre-nesting surveys, the proportion of groups of Spectacled Eiders that were either single birds or pairs ranged from 73% to 100% (Johnson et al. 1997). In 1997, as in previous years, we found a higher percentage of single birds and pairs of Spectacled Eiders than of King Eiders. The percentage of King Eiders that were single birds or pairs was 65% in 1997 and has ranged from 54% to 71% on past surveys.

The late snowmelt in 1997 was in stark contrast to the early snowmelt in 1996. Snow cover was essentially gone (0–5%) by the first week of June in 1996, whereas it still ranged from 25% to 30% in the second week of June 1997 (also see Caribou section of this report). Although we did not monitor nest initiation dates, the delayed snowmelt and thawing of lakes probably resulted in a relatively late nesting season compared to the last five years.

Delta—Spectacled and King eiders on the Colville Delta were primarily associated with coastal areas in all years (Figures 3 and 4). During pre-nesting in 1997, we found groups (singles, pairs, or flocks) of Spectacled Eiders no farther than 13.7 km from the coastline, and the average distance was 3.7 km (n = 43 groups). From 1993 to 1997, the farthest inland Spectacled Eiders were seen during pre-nesting was 14.0 km, and the average distance was 4.1 km (n = 141 groups). Derksen et al. (1981) reported that Spectacled Eiders in the NPR-A were attracted to coastal areas, and Kistchinski and Flint (1974) found the highest numbers of Spectacled Eiders in the maritime area on the Indigirka delta, although they estimated that area extended 40-50 km inland. King Eiders on the Colville Delta had a similar affinity for the coast: the maximal distance a group was found from the coast between 1993 and 1997 was 14.2 km, and the mean was 5.7 km (n = 88 groups).

In 1997, Spectacled Eiders were the numerically dominant eider species during pre-nesting surveys on the delta; we counted 59 Spectacled Eiders (54%), 49 King Eiders (45%), and 1 (1%) unidentified eider (Table 4). The relative species composition on the delta in 1997 was similar to that in 1994 and 1995, when Spectacled Eiders composed the majority of eiders seen (Johnson 1995, Johnson et al. 1996). In 1993 and 1996, however, Spectacled Eiders were the minority species, representing only 44% and 39%, respectively, of all eiders seen (Smith et al. 1994, Johnson et al. 1997).

Densities of Spectacled Eiders in 1997 returned to the levels observed in 1993–1995 (Figure 5). In 1997, 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 4). Because of changes in study area boundaries over the years, that

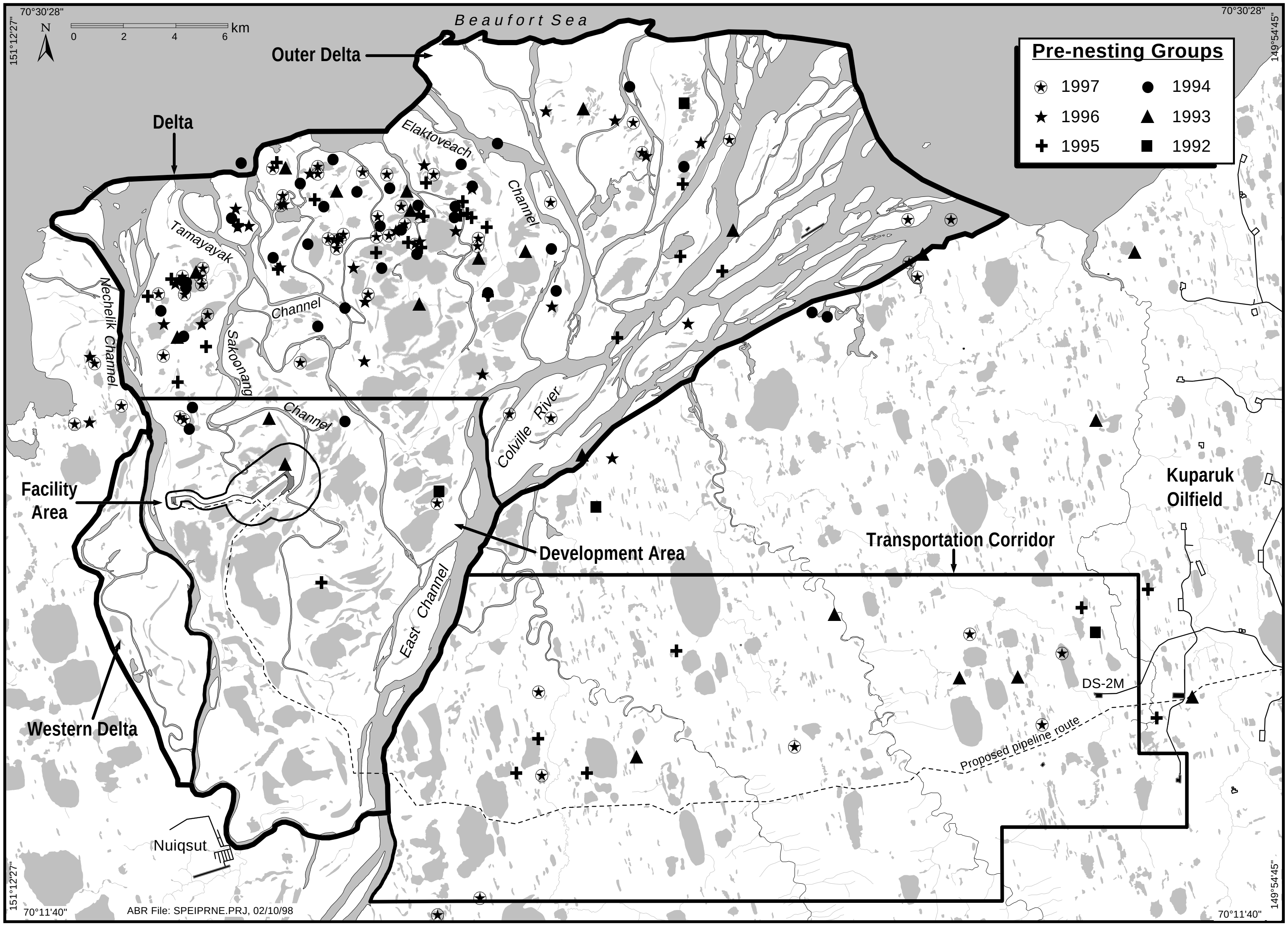

Figure 3. Distribution of Spectacled Eider groups observed during pre-nesting aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1997.

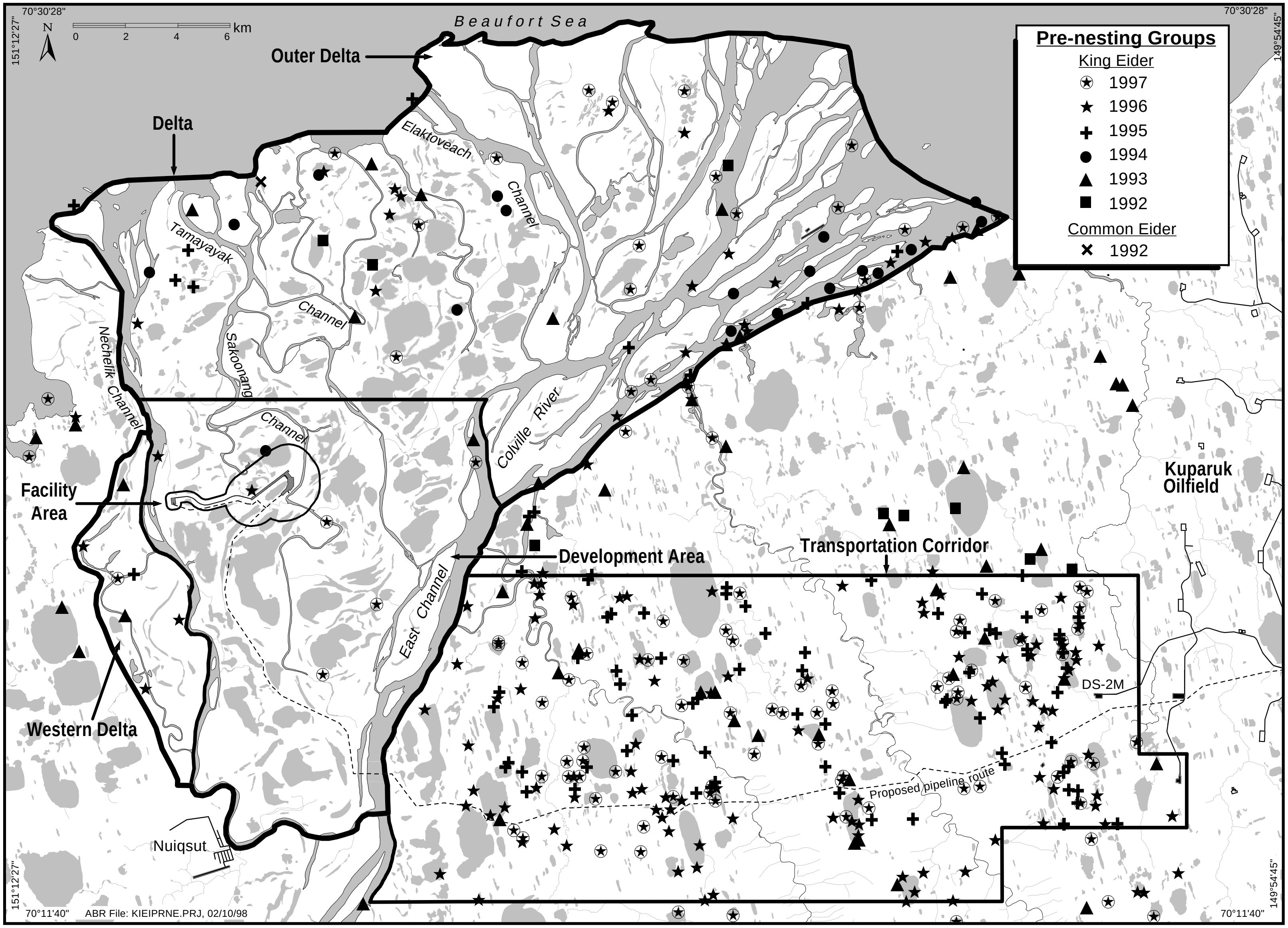

Figure 4. Distribution of King and Common eider groups observed during pre-nesting surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1997.

Table 4. Numbers and densities (uncorrected for sightability) of eiders seen during aerial surveys (100% coverage) of the Delta survey area (523 km^2), Colville River Delta, Alaska, 12–20 June 1997.

	Numbers					Density (birds or pairs/km^2)		
	Observed			Indicated		Observed	Indicated	
Species	Males	Females	Total	Total[a]	Pairs[b]	Total	Total[a]	Pairs[b]
NON-FLYING BIRDS								
Spectacled Eider	29	11	40	59	29	0.08	0.11	0.06
King Eider	27	15	42	54	27	0.08	0.10	0.05
Unidentified eider	0	0	0	0	0	0	0	0
FLYING BIRDS								
Spectacled Eider	15	4	19	30	15	0.04	0.06	0.03
King Eider	4	3	7	8	4	0.01	0.02	0.01
Unidentified eider	0	1	1	0	0	<0.01	0	0
NON-FLYING + FLYING BIRDS								
Spectacled Eider	44	15	59	89	44	0.11	0.17	0.08
King Eider	31	18	49	62	31	0.09	0.12	0.06
Unidentified eider	0	1	1	0	0	<0.01	0	0

[a] Total indicated = (number of males not in groups × 2) + number of birds in groups (see USFWS 1987b).
[b] Pairs indicated = number of males.

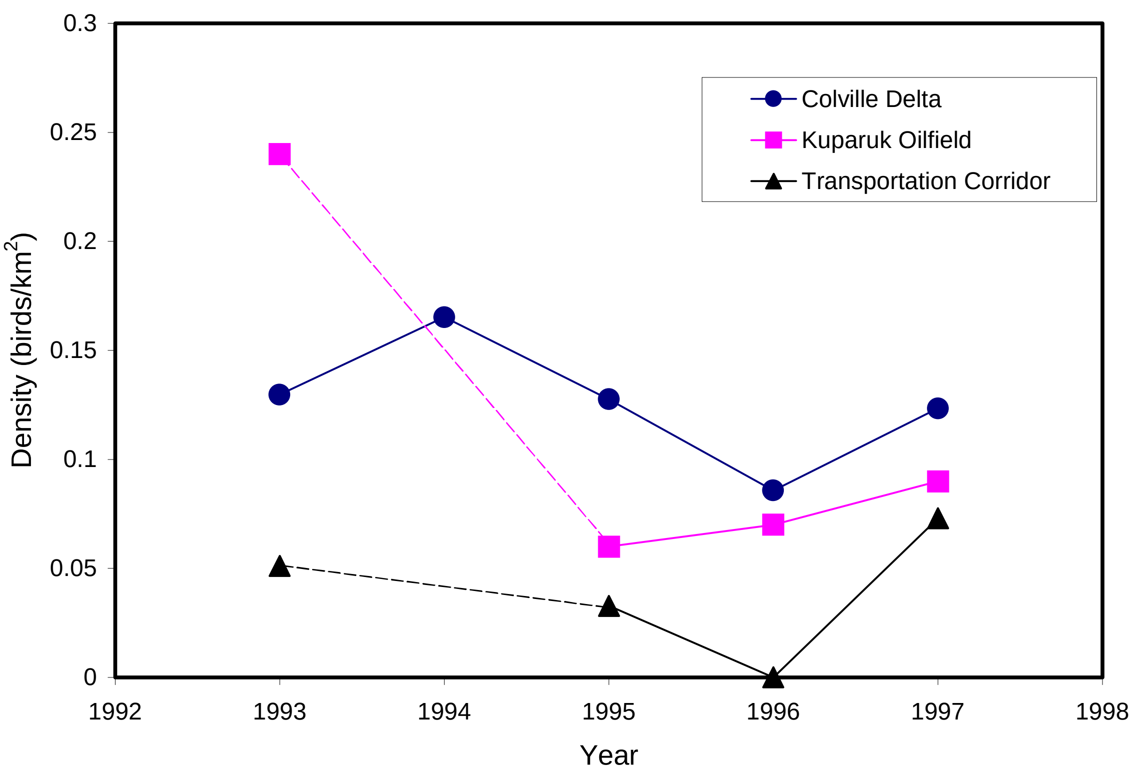

Figure 5. Trend in densities of Spectacled Eiders counted on aerial surveys during pre-nesting on the Colville River Delta, in the Transportation Corridor, and in the Kuparuk Oilfield, Alaska, 1993–1997. Data are from Anderson et al. (1998a) and this study.

density is not strictly comparable to the densities reported for 1993-1995 (Smith et al. 1994, Johnson 1995, Johnson et al. 1996). Recalculating these densities for an area surveyed in 1994 (478 km^2) that was common to all five years of study resulted in a density of 0.12 birds/km^2 in 1997, similar to the density that was calculated in 1993 and 1995 (Table 5). No trend was apparent in Spectacled Eider densities during the last five pre-nesting seasons (Figure 5). The lowest density on the delta (0.09 birds/km^2) was observed in 1996, but that year's survey appeared to be biased by the relatively early departure of males from the breeding grounds (Johnson et al. 1997). Densities on the delta were higher than those in the nearby Transportation Corridor and Kuparuk Oilfield with the exception of 1993 in the Kuparuk Oilfield, when an unusually high density was recorded.

The density of King Eiders in 1997 (0.10 birds/km^2) in the common survey area (478 km^2) was the second lowest observed since 1993 (Table 5). As with Spectacled Eiders, no annual trend was apparent, but densities on the delta were dramatically below those in the Transportation

Table 5. Numbers and densities of eiders during pre-nesting in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1993–1997. Counts were made from fixed-wing aircraft in early June (Johnson et al. 1997, this study). Survey areas varied in size among years but are adjusted here to the area common to all four years; therefore, numbers and densities may differ from those reported for the original survey areas. See Figure 1 for survey areas.

		1997		1996		1995		1994		1993[a]	
Area	Species	No.	Birds/km^2	No.	Birds/km^2	No.	Birds/km^2	No.	Birds/km^2	No.	Birds/km^2
Delta (478 km^2)[b]											
	Spectacled Eider	59	0.12	41	0.09	61	0.13	79	0.17	31	0.13
	King Eider	49	0.10	53	0.11	30	0.06	58	0.12	34	0.14
	Unidentified eider	1	<0.01	4	0.01	15	0.03	4	0.01	3	0.01
Development Area (126 km^2)											
	Spectacled Eider	4	0.03	0	0	2	0.02	4	0.03	4	0.06
	King Eider	8	0.06	4	0.03	0	0	1	0.01	5	0.08
	Unidentified eider	0	0	0	0	2	0.02	0	0	1	0.02
Facility Area (9 km^2)											
	Spectacled Eider	0	0	0	0	0	0	0	0	2	0.47
	King Eider	0	0	2	0.23	0	0	0	0	0	0
	Unidentified eider	0	0	0	0	0	0	0	0	0	0
Outer Delta (352 km^2)											
	Spectacled Eider	55	0.16	41	0.12	59	0.17	75	0.21	27	0.15
	King Eider	39	0.11	49	0.14	30	0.09	57	0.16	29	0.16
	Unidentified eider	0	0	4	0.01	13	0.04	4	0.01	2	0.01
Western Delta (31 km^2)											
	Spectacled Eider	0	0	0	0	0	0	-	-	0	0
	King Eider	2	0.07	6	0.20	4	0.13	-	-	5	0.16
	Unidentified eider	0	0	0	0	0	0	-	-	0	0
Transportation Corridor (274 km^2)[c]											
	Spectacled Eider	20	0.07	0	0	9	0.03	-	-	7	0.05
	King Eider	212	0.77	162	0.59	240	0.88	-	-	31	0.23
	Unidentified eider	0	0	1	<0.01	0	0	-	-	1	0.01

[a] Coverage of survey areas in 1993 was 50% of that in 1994–1997.
[b] Although the delta encompassed 551 km^2, only 478 km^2 were common to five years of surveys.
[c] Although the Transportation Corridor encompassed 343 km^2, only 274 km^2 were common to four years of surveys.

Corridor and Kuparuk Oilfield in all years but 1993 (Figure 6).

Within the Delta survey area, neither the Development Area nor the Facility Area appears to be important to breeding eiders (Figures 3 and 4). During pre-nesting surveys in 1997, we saw only four Spectacled Eiders and eight King Eiders in the Development Area, and no eiders in the Facility Area (Table 5). On aerial surveys in previous years, we saw no more than four Spectacled Eiders and five King Eiders in the Development Area. Only one pair of Spectacled Eiders (in 1993) and one pair of King Eiders (in 1996) have been seen in the Facility Area during pre-nesting aerial surveys.

Of the areas surveyed on the delta, the Outer Delta consistently contained the highest density of both Spectacled and King eiders (Table 5). In 1997, the density of Spectacled Eiders in this area (0.16 birds/km^2) was the second highest since 1993. In contrast, the density of King Eiders in 1997 (0.11 birds/km^2) was the second lowest since that date.

The overall distribution of eiders on the delta was consistent annually. However, abundance and relative species composition varied among years, with survey timing relative to arrival and nest initiation contributing to this variation. Except for a decline in density of King Eiders from 1994 to 1995, annual changes were relatively minor.

Transportation Corridor—Spectacled Eiders were scattered throughout the Transportation Corridor, but occurred in lower numbers and farther inland than in the Delta survey area (Figure 3). In 1997, we saw 20 Spectacled Eiders, the highest number in 4 years of surveys (the Transportation Corridor was not surveyed in 1994; Table 5). Spectacled Eiders occurred in lower numbers in 1993 and 1995 (7 and 9 birds, respectively) and were not seen during the 1996 survey. Spectacled Eiders in the Transportation Corridor were found a maximal distance of 24.3 km from the coast, which was 10.3 km farther inland than they were on the delta.

King Eiders also were distributed widely throughout the Transportation Corridor, but, unlike Spectacled Eiders, they were abundant (Figure 4). In 1997, we counted 220 King Eiders in the

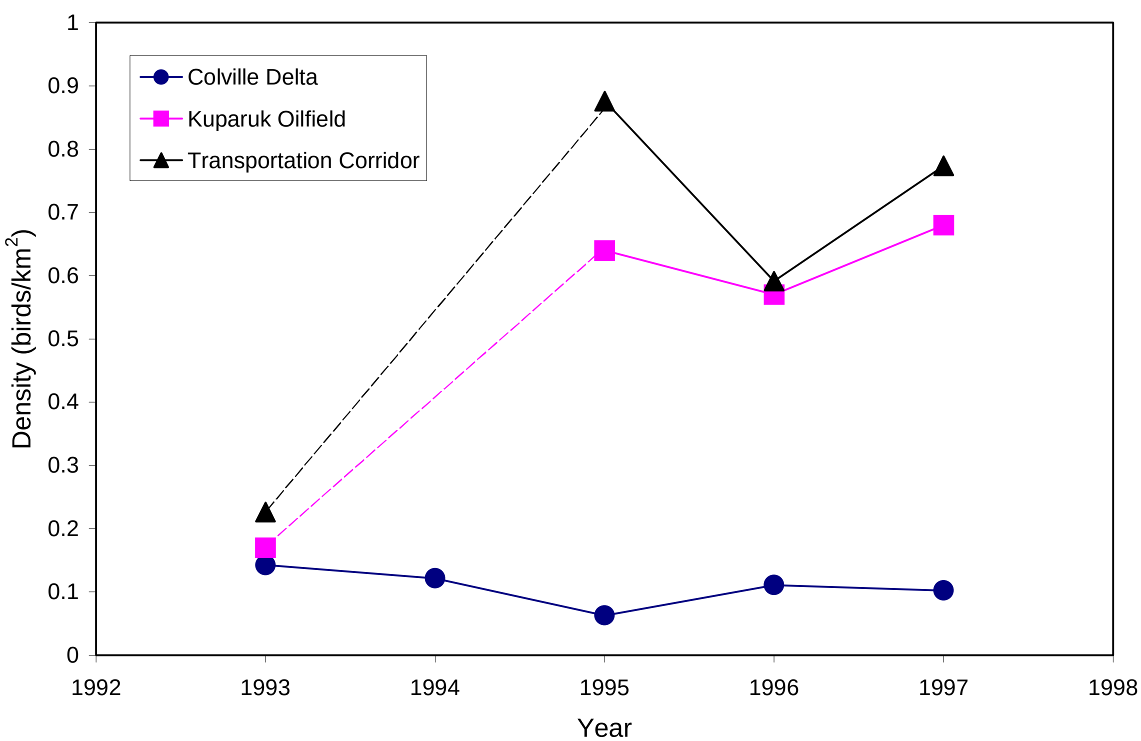

Figure 6. Trend in densities of King Eiders counted on aerial surveys during pre-nesting on the Colville River Delta, in the Transportation Corridor, and in the Kuparuk Oilfield, Alaska, 1993–1997. Data are from Anderson et al. (1998a) and this study.

Transportation Corridor (Table 6). Densities increased from 1993 to 1995, declined in 1996, and increased again in 1997 (Figure 6). The maximal distance from the coast pre-nesting King Eiders were seen in the Transportation Corridor was 28.1 km, or 13.9 km farther from the coast than on the delta..

Nesting

Delta—The northern portion of the delta, where eiders tended to concentrate during pre-nesting (Figures 3 and 4), also is where eiders appear to nest most commonly. We have not found any documented nest locations that were farther than 13 km from the coast (Figure 7), although we must emphasize that coverage during nest searching has never been complete on the delta. For three years (1995–1997), we searched near the Facility Area and found no Spectacled Eider nests and only one probable King Eider nest, found in 1996 (identification based on color patterns of contour feathers in the nest; Anderson and Cooper [1994]). We also searched eight areas on the Outer Delta in 1997 where Spectacled Eider nests had been found in the past and found three Spectacled Eider nests (one identified by contour feathers) and two unidentified eider nests. Nest searches in some of those areas in 1994 produced 17 Spectacled Eider nests, 3 King Eider nests, and 1 Common Eider nest (Johnson 1995). Smith et al. (1994) had fewer historic nesting locations to search and found seven Spectacled Eider nests (five identified by contour feathers) and one unidentified eider nest in 1993. In 1992, when nest searches were restricted to two 10-ha study plots (one on the Outer Delta and one in the Development Area), only one Spectacled Eider nest was found, 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); however, we were able to obtain the location of only four of these nests (M. North, unpubl. data). The earliest records we have found for nest locations are two Spectacled Eider nests on the Outer Delta in 1958 and four in 1959 (T. Myres, unpubl. data). Four nests were found in 1993 and 1994 on the same lakes as the nests from these earliest records (Figure 7).

The low number of nests found in 1997 may have been a result of few nests initiated or of high failure rate prior to the nest searches. We suspect that nest initiation may have been lower in 1997, due to a delayed breakup of ice on lakes. Nesting by both Tundra Swans and Yellow-billed Loons also declined in 1997 from previous years, and the late thawing of lakes in 1997 was the most obvious difference we could detect during nest initiation.

Table 6. Numbers and densities (uncorrected for sightability) of eiders seen during aerial surveys (100% coverage) of the Transportation Corridor survey area (343 km^2), Colville River Delta, Alaska, 12–13 June 1997.

	Numbers					Density (birds or pairs/km^2)		
	Observed			Indicated		Observed	Indicated	
Species	Males	Females	Total	Total[a]	Pairs[b]	Total	Total[a]	Pairs[b]
NON-FLYING BIRDS								
Spectacled Eider	10	8	18	19	10	0.05	0.06	0.03
King Eider	80	70	150	159	80	0.44	0.47	0.23
FLYING BIRDS								
Spectacled Eider	2	2	4	4	2	0.01	0.01	0.01
King Eider	36	34	70	72	36	0.20	0.21	0.10
NON-FLYING + FLYING BIRDS								
Spectacled Eider	12	10	22	23	12	0.06	0.07	0.03
King Eider	116	104	220	231	116	0.64	0.67	0.34

[a] Total indicated = (number of males not in groups × 2) + number of birds in groups (see USFWS 1987b).
[b] Pairs indicated = number of males.

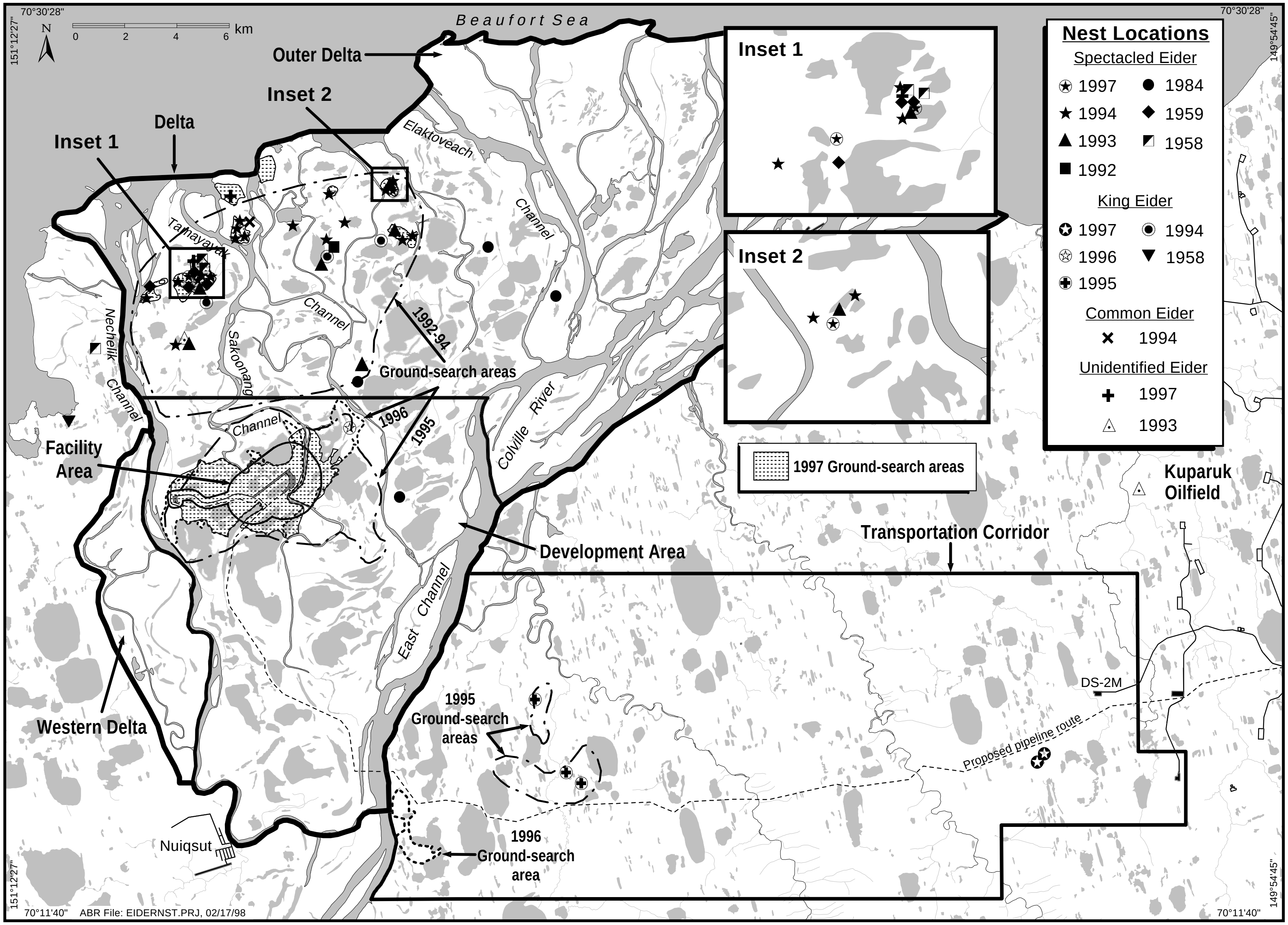

Figure 7. Distribution of eider nests located during ground searches in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–1997. Locations are from T. Myres (1958, 1959, unpubl. data), M. North (1984, unpubl. data), Smith et al. (1993, 1994), Johnson et al. (1997), and this study. Nest locations and search areas do not represent all nesting areas for eiders.

Possibly because we focused the nest searches on Spectacled Eiders, we found few nests of other eider species on the delta. More probable, however, is that the delta does not support much nesting by other eider species. The same search techniques were used in the Kuparuk Oilfield, where 51% of the 146 nests found in five years belonged to King Eiders (Anderson et al. 1998a). In six years of nest searching on the delta, only 17% of 36 nests belonged to species other than Spectacled Eiders: one Common Eider nest, and four King Eider nests (two identified by contour feathers). An additional three nests (8% of 36) belonged to unidentified eiders.

Transportation Corridor—In 1997, we did not search for nests in the Transportation Corridor. Anderson et al. (1998b), however, searched for eider nests along the road corridor to the proposed Tarn drill sites in the eastern portion of the Transportation Corridor and found two King Eider nests. In 1996, we searched for eider nests in the Transportation Corridor only at the ASRC Gravel Mine site and found none (Johnson et al. 1997). During searches for Spectacled Eider nests in 1995, we found three King Eider nests, in areas where nest searches were conducted for the first time (Figure 7). However, many more King Eiders undoubtedly nest in the Transportation Corridor, because we saw >150 birds annually on the pre-nesting surveys in 1995–1997 (Table 5). Furthermore, our nest searches in 1995–1997 were conducted in only small portions of the Transportation Corridor that were not where King Eiders were concentrated during pre-nesting nor where we would expect high numbers of nests (Figure 4).

Brood-rearing

Delta—In 1997 and 1996, we saw no broods of Spectacled or King eiders during helicopter or foot surveys of the Facility Area; however, no other areas were searched specifically for eider broods on the delta. We saw one brood of unidentified eiders at the northern border of the Development Area during an aerial survey for loon broods (Figure 8). Over all years, the distribution of broods was similar to the distribution of eiders during pre-nesting and nesting surveys (Figures 3, 4, and 7), in that all broods were seen 13 km from the coast. In 1995, we saw only one Spectacled Eider brood and one King Eider brood during a systematic helicopter survey of the delta, and no eider broods in the Development Area, where survey coverage was 100%. (Coverage was 50% for the other survey areas.) The density of Spectacled Eider broods in 1995 was 0.004 and 0.006 broods/km^2 on the Delta and Outer Delta survey areas, respectively. The number of broods undoubtedly was undercounted because of the cryptic coloration and furtive behavior of female eiders and their young. Densities based on helicopter surveys in the Prudhoe Bay area ranged from 0.008 to 0.05 broods/km^2 for 1991-1993 (TERA 1995). No brood survey was conducted on the delta in 1994 (Johnson 1995). During ground searches for broods in 1993, we found 11 Spectacled Eider broods with 42 young (Smith et al. 1994). One brood with 3 young occurred in the Facility Area, and the remaining 10 broods occurred on the Outer Delta.

Transportation Corridor—In 1997, we did not survey the Transportation Corridor for eider broods; however, we saw one brood (8 young, Figure 8) and three groups of adults (range = 15–30 adults) of unidentified eiders during other surveys. In 1996, we searched only the ASRC Gravel Mine site (on the ground) for eider broods and found none (Johnson et al. 1997). During helicopter surveys conducted in 1995 in the Transportation Corridor (at 50% coverage), we found 1 Spectacled Eider brood with 1 young and 51 King Eider broods with 156 young. Those 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 in the corridor was 3.1 young (n = 51 broods, based on number of females).

HABITAT SELECTION

Both Spectacled and King eiders strongly preferred waterbodies during all portions of the breeding season, but habitat preferences differed between the two major survey areas because of differences in habitat availability. On the delta, Spectacled Eiders preferred habitats that occurred near the coast, whereas King Eiders preferred river and stream areas. Those habitats were absent or rare in the Transportation Corridor; we detected no preferences among the few Spectacled Eiders

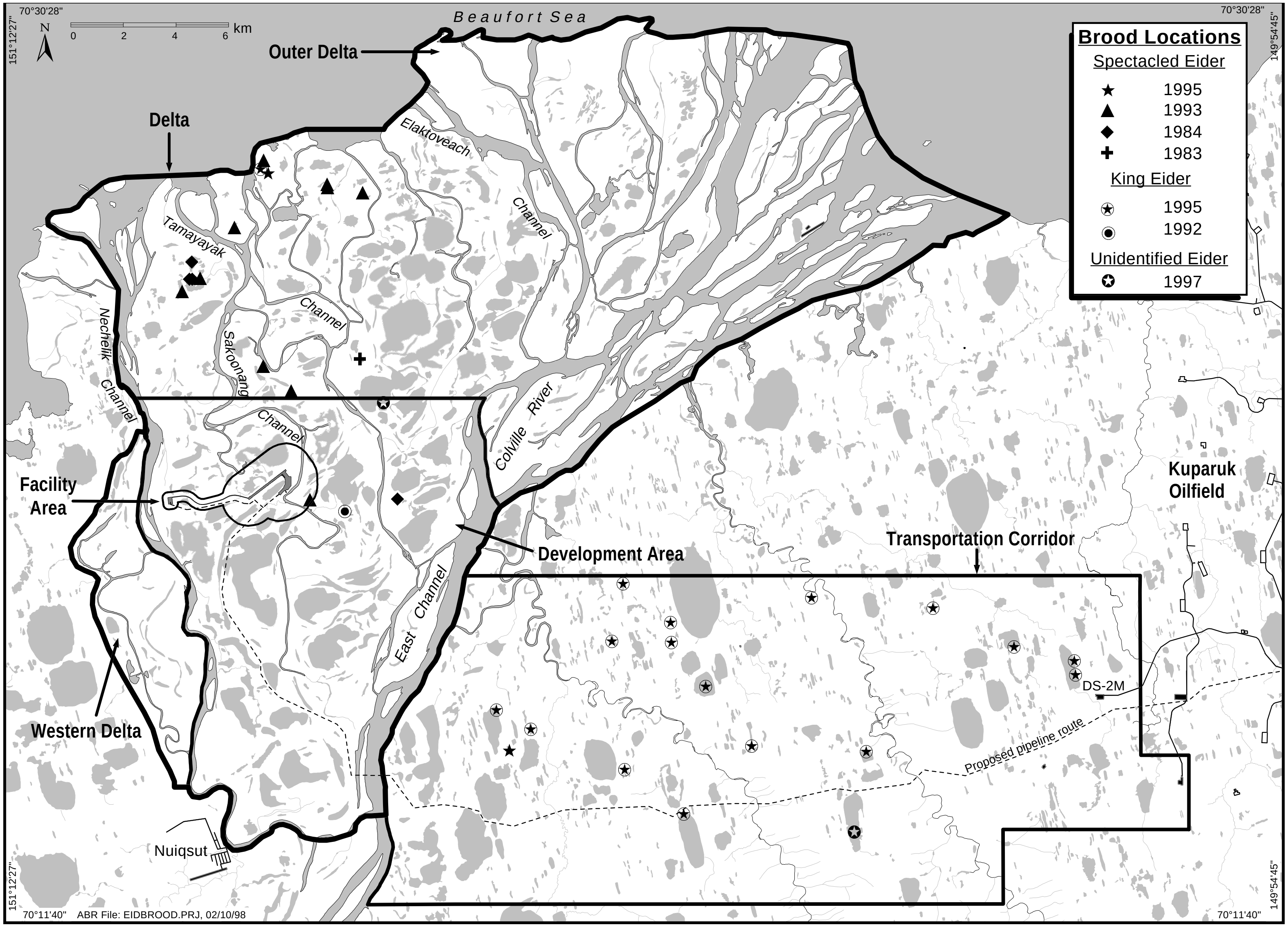

Figure 8. Distribution of Spectacled, King, and unidentified eider broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1983, 1984, 1992, 1993, 1995, and 1997. Locations are from M. North (1983, 1984, unpubl. data), Smith et al. (1993, 1994), Johnson et al. (1997), and this study.

observed there, and King Eiders preferred freshwater lakes in addition to streams.

Pre-nesting

Delta—Based on five years (1993-1997) of aerial surveys on the delta, pre-nesting Spectacled Eiders preferred (i.e., use was significantly greater than availability as determined by Monte Carlo simulation) 6 of 23 habitats that were available, whereas King Eiders preferred only 1 habitat (Tables 7 and 8). Measures of habitat selection for Spectacled and King eiders in 1997 are reported in Appendix Tables C1–C2, and those for previous years were presented in Johnson et al. (1996, 1997). On the delta, Spectacled Eiders preferred Brackish Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Aquatic Grass Marsh (Table 7). All of the preferred habitats, except Shallow Open Water with Islands or Polygonized Margins and Aquatic Grass Marsh, were more coastal in distribution (Figure 2). Shallow Open Water with Islands or Polygonized Margins and Aquatic Grass Marsh were preferred, despite each being used by only two groups of Spectacled Eiders. The significant preference for these habitats, however, reflected their rarity on the delta (totaling 0.3% of the area).

The greatest use (in terms of number of groups) by Spectacled Eiders during pre-nesting was of Aquatic Sedge with Deep Polygons (24 groups), Brackish Water (12 groups), and Salt-killed Tundra

Table 7. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1993–1997 (from Johnson et al. 1997, this study). See Appendix C1 for 1997 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	0	0	1.8	-1.00	ns
Brackish Water	31	12	12.6	1.3	0.82	prefer
Tapped Lake w/Low-water Connection	14	5	5.3	4.1	0.13	ns
Tapped Lake w/High-water Connection	8	5	5.3	3.8	0.17	ns
Salt Marsh	16	8	8.4	3.2	0.45	prefer
Tidal Flat	0	0	0	9.2	-1.00	avoid
Salt-killed Tundra	18	10	10.5	4.9	0.36	prefer
Deep Open Water w/o Islands	3	2	2.1	4.2	-0.34	ns
Deep Open Water w/Islands or Polygonized Margins	4	2	2.1	1.0	0.37	ns
Shallow Open Water w/o Islands	2	1	1.1	0.4	0.41	ns
Shallow Open Water w/Islands or Polygonized Margins	2	2	2.1	0.1	0.91	prefer
River or Stream	6	3	3.2	14.7	-0.65	avoid
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	43	24	25.3	2.6	0.81	prefer
Aquatic Grass Marsh	2	2	2.1	0.2	0.79	prefer
Young Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	16	9	9.5	7.9	0.09	ns
Wet Sedge–Willow Meadow	25	9	9.5	18.3	-0.32	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.3	-1.00	ns
Moist Tussock Tundra	0	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	0	0	0	4.7	-1.00	avoid
Barrens (riverine, eolian, lacustrine)	2	1	1.1	14.8	-0.87	avoid
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	ns
Total	192	95	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Table 8. Habitat selection (pooled among years) by King Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1993–1997 (Johnson et al. 1997, this study). See Appendix C1 for 1997 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10	2	3.6	1.8	0.34	ns
Brackish Water	3	2	3.6	1.3	0.48	ns
Tapped Lake w/Low-water Connection	6	3	5.4	4.1	0.13	ns
Tapped Lake w/High-water Connection	4	2	3.6	3.8	-0.03	ns
Salt Marsh	0	0	0	3.2	-1.00	ns
Tidal Flat	2	1	1.8	9.2	-0.67	avoid
Salt-killed Tundra	5	3	5.4	4.9	0.04	ns
Deep Open Water w/o Islands	0	0	0	4.2	-1.00	ns
Deep Open Water w/Islands or Polygonized Margins	0	0	0	1.0	-1.00	ns
Shallow Open Water w/o Islands	0	0	0	0.4	-1.00	ns
Shallow Open Water w/Islands or Polygonized Margins	0	0	0	0.1	-1.00	ns
River or Stream	113	33	58.9	14.7	0.60	prefer
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	2	1	1.8	2.6	-0.19	ns
Aquatic Grass Marsh	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	1	1	1.8	7.9	-0.63	avoid
Wet Sedge–Willow Meadow	10	6	10.7	18.3	-0.26	ns
Moist Sedge–Shrub Meadow	0	0	0	2.3	-1.00	ns
Moist Tussock Tundra	0	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	2	1	1.8	4.7	-0.45	ns
Barrens (riverine, eolian, lacustrine)	1	1	1.8	14.8	-0.78	avoid
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	ns
Total	159	56	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

(10 groups). Five habitats were avoided (i.e., use was significantly less than availability), but, of those habitats, only Tidal Flat and Riverine or Upland Shrub were not used by Spectacled Eiders (Table 7). Among the unused habitats, only the most abundant types were classified as significantly avoided. Conversely, Wet Sedge–Willow Meadow was used by nine groups (9.5% of the total) of Spectacled Eiders, yet was avoided according to the Monte Carlo analysis, because its abundance (at 18% of the area, it was the most abundant habitat on the delta) was so much greater than its use.

Elsewhere, studies have emphasized the importance of emergent vegetation in waterbodies for eiders. In the NPR–A, Spectacled Eiders were found in shallow *Arctophila* ponds and deep open lakes in June, with shallow *Carex* ponds becoming more important through the summer (Derksen et al. 1981). In the Kuparuk Oilfield, most pre-nesting Spectacled Eiders were found in basin wetland complex, aquatic grass (*Arctophila)*, and aquatic sedge (*Carex*) habitats (Anderson et al. 1998a). Bergman et al. (1977) found most Spectacled Eiders at Storkersen Point in deep *Arctophila* wetlands. In Prudhoe Bay, pre-nesting Spectacled Eiders used flooded terrestrial habitats, but preferred impoundments and ponds with emergent vegetation (both *Arctophila* and *Carex*; Warnock and Troy 1992). Lakes with emergents are not abundant on the Colville Delta; however, Aquatic Sedge with Deep Polygons and Aquatic Grass Marsh, which are analogous to the *Carex* and *Arctophila* ponds described elsewhere, were significantly preferred by Spectacled Eiders on the delta (Table 7).

King Eiders used 12 of 23 available habitats on the delta during pre-nesting, but only one habitat was used by large numbers of birds (Table 8). River or Stream was the only preferred habitat, which was used by 33 groups (59% of the total) containing 113 King Eiders. Three relatively abundant habitats on the delta were significantly avoided, despite each being used by one group of King Eiders: Tidal Flat, Nonpatterned Wet Meadow, and Barrens. The high use of River or Stream, low use of typical nesting habitat (i.e., lakes and meadows), and the prevalence of flocks rather than pairs (see Distribution and Abundance) suggested that King Eiders had not yet dispersed into breeding areas during the pre-nesting survey. Furthermore, the low number of nests found on nest searches indicates that the Colville River Delta may be more important as a stopover for King Eiders breeding elsewhere than as a nesting area. At Storkersen Point, where King Eiders nest in relatively high densities, they preferred shallow and deep *Arctophila* wetlands, basin complexes, and coastal wetlands during pre-nesting and nearly the same habitats during nesting (Bergman et al. 1977). Nest densities also are high at Prudhoe Bay, where pre-nesting King Eiders used almost all habitats but preferred wet, aquatic nonpatterned tundra, aquatic strangmoor, and water with and without emergents (Warnock and Troy 1992).

Transportation Corridor—In four years of pre-nesting surveys in the Transportation Corridor (1993 and 1995–1997), we saw only 29 Spectacled Eiders (11 groups), suggesting that this area is less important than is the delta for breeding. Six of 18 habitats were used, but none was preferred by Spectacled Eiders (Table 9). Although the habitats used by Spectacled Eiders here were similar to those used for nesting elsewhere on the Arctic Coastal Plain, a larger sample of Spectacled Eiders will be needed to clarify habitat preferences in the Transportation Corridor.

Unlike Spectacled Eiders, we saw large numbers of King Eiders (532 adults in 166 groups on the ground) in the Transportation Corridor. In four years of surveys (1993 and 1995–1997), King Eiders used 14, and preferred 4 of 18, available habitats (Table 10). Deep Open Water without Islands, both types of Shallow Open Water, and River or Stream were significantly preferred and, except for River or Stream, were the three most used habitats. All three habitats that were significantly avoided by King Eiders—Moist Sedge–Shrub Meadow, Moist Tussock Tundra, and Wet Sedge–Willow Meadow—did receive some use, but were used less than expected given their availability.

Bergman et al. (1977) found that pre-nesting King Eiders preferred different habitats shallow and deep *Arctophila*, basin complexes, and coastal wetlands from those in our study, but this may be explained by differences both in study area and in scale between the two classifications. For example, coastal wetlands were absent and Aquatic Grass Marsh was rare in the Transportation Corridor. Moreover, we delineated multiple types (0.25 ha in size) where they occurred in one waterbody, whereas Bergman et al. (1977) classified whole waterbodies. For example, the Deep Open Water and Shallow Open Water types where we found the most King Eiders could have *Arctophila* margins that were delineated separately if 0.25 ha. Waterbodies containing these combinations of habitats would be classified as the deep and shallow *Arctophila* or basin complexes in the classification system of Bergman et al. (1977).

Nesting

Delta—We conducted nesting surveys on the ground because of the difficulty in finding eider nests from the air. Consequently, complete surveys of extensive habitats 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 (1993, 1994, and 1997) or that included proposed development sites (1995–1997). Thus, we did not search a representative sample of habitats from which selection could be calculated; instead, we used the nesting data to summarize habitat associations.

Nesting Spectacled Eiders used many of the same habitats that were preferred during pre-nesting. Between 1992 and 1997, 7 (25%) of 28 nests (total includes 6 nests identified by contour feathers) on the delta were found in Aquatic Sedge with Deep Polygons (Table 11). Other important nesting habitats were Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra, which together contained 54% of all nests. We did not find eiders nesting on water, but nests on islands could be

Table 9. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 and 1995–1997 (Johnson et al. 1997, this study). No Spectacled Eiders were seen in 1996. See Appendix C2 for 1997 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[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	ns
Salt Marsh	-	-	-	0	-	-
Tidal Flat	-	-	-	0	-	-
Salt-killed Tundra	-	-	-	0	-	-
Deep Open Water w/o Islands	6	3	27.3	9.1	0.50	ns
Deep Open Water w/Islands or Polygonized Margins	0	0	0	1.8	-1.00	ns
Shallow Open Water w/o Islands	7	2	18.2	3.2	0.70	ns
Shallow Open Water w/Islands or Polygonized Margins	1	1	9.1	2.3	0.60	ns
River or Stream	0	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0	0	0	0.3	-1.00	ns
Aquatic Sedge w/Deep Polygons	0	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	3	2	18.2	4.4	0.61	ns
Old Basin Wetland Complex	0	0	0	10.6	-1.00	ns
Nonpatterned Wet Meadow	10	2	18.2	7.3	0.43	ns
Wet Sedge–Willow Meadow	0	0	0	5.8	-1.00	ns
Moist Sedge–Shrub Meadow	2	1	9.1	24.2	-0.45	ns
Moist Tussock Tundra	0	0	0	27.0	-1.00	ns
Riverine or Upland Shrub	0	0	0	2.3	-1.00	ns
Barrens (riverine, eolian, lacustrine)	0	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0	0	0	0.1	-1.00	ns
Total	29	11	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.

[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

classified as in a waterbody at the scale of our habitat map (i.e., small islands and islands ≤5 m from shore were not mapped). Spectacled Eider nests were strongly associated with waterbodies in all habitats in which they occurred, averaging 1.0 m (range = 0.1–10 m; $n = 28$) from permanent water (Smith et al. 1994, Johnson et al. 1997). Brackish Water was the nearest waterbody class to 46% of the nests, and Deep Open Water without Islands was the nearest to 21% of the nests (Table 11). We found no Spectacled Eider nests in 1995 or 1996, when searching was concentrated near the Facility Area (Figure 7).

Similar habitat associations were reported for other locations. Nests on the Yukon-Kuskokwim Delta averaged 2.1 m from water (Dau 1974). Annual mean distances of Spectacled Eider nests to water in the Kuparuk Oilfield ranged from 0.6 to 5.4 m over 5 years, and the waterbodies closest to nests were primarily basin wetland complexes, shallow and deep open lakes, and water with both *Carex* and *Arctophila* emergents (Anderson et al. 1998a). In the Kuparuk Oilfield, the most common nesting habitats were basin wetland complexes, aquatic grass with islands, low-relief wet meadows, and nonpatterned wet meadows. Spectacled Eiders at Storkersen Point preferred the same habitat (deep *Arctophila*) for nesting as they did during pre-nesting (Bergman et al. 1977). In the NPR–A, Spectacled Eiders used shallow *Carex* ponds during summer (Derksen et al. 1981). In Prudhoe Bay, nests were found in both *Carex* ponds and wet, nonpatterned

Table 10. Habitat selection (pooled among years) by King Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993 and 1995–1997 (Johnson et al. 1997, this study). See Appendix C2 for 1997 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[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	ns
Salt Marsh	-	-	-	0	-	-
Tidal Flat	-	-	-	0	-	-
Salt-killed Tundra	-	-	-	0	-	-
Deep Open Water w/o Islands	168	40	24.1	9.1	0.45	prefer
Deep Open Water w/Islands or Polygonized Margins	15	6	3.6	1.8	0.33	ns
Shallow Open Water w/o Islands	101	34	20.5	3.2	0.73	prefer
Shallow Open Water w/Islands or Polygonized Margins	62	19	11.4	2.2	0.67	prefer
River or Stream	10	6	3.6	0.7	0.68	prefer
Aquatic Sedge Marsh	2	1	0.6	0.3	0.34	ns
Aquatic Sedge w/Deep Polygons	0	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	37	9	5.4	4.3	0.11	ns
Old Basin Wetland Complex	43	15	9.0	10.5	-0.08	ns
Nonpatterned Wet Meadow	50	18	10.8	7.3	0.20	ns
Wet Sedge–Willow Meadow	4	2	1.2	5.8	-0.66	avoid
Moist Sedge–Shrub Meadow	30	9	5.4	24.3	-0.64	avoid
Moist Tussock Tundra	8	5	3.0	27.2	-0.80	avoid
Riverine or Upland Shrub	1	1	0.6	2.3	-0.58	ns
Barrens (riverine, eolian, lacustrine)	1	1	0.6	0.6	0.02	ns
Artificial (water, fill, peat road)	0	0	0	0.1	-1.00	ns
Total	532	166	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

tundra (Warnock and Troy 1992). As mentioned earlier, waterbodies with emergent vegetation, except for ponds in Aquatic Sedge with Deep Polygons, are not abundant on the Colville Delta; therefore, nesting habitat on the delta differs somewhat from areas with abundant *Carex* and *Arctophila* waterbodies.

We found only four King Eider nests (two were identified by contour feathers) during six years of nest searches on the delta. Three of these nests were in Aquatic Sedge with Deep Polygons, and the other was in Salt-killed Tundra (Table 12). The distance from permanent water was greater and more variable ($\bar{x}$ = 20 m; range = 0.5-80 m) than for Spectacled Eider nests. The nearest waterbodies were both types of Tapped Lakes, Deep Open Water without Islands, and Shallow Open Water without Islands. Anderson et al. (1997) found King Eiders in the Kuparuk Oilfield nesting near basin wetland complexes, aquatic grass, shallow open water, and aquatic sedge. At Storkersen Point, nesting King Eiders preferred shallow and deep *Arctophila* and coastal wetlands (Bergman et al. 1977). Farther east, in Prudhoe Bay, King Eiders used a wider array of non-aquatic habitats than did Spectacled Eiders and preferred moist, wet low-centered polygons and wet strangmoor (Warnock and Troy 1992).

Transportation Corridor—We found no Spectacled Eider nests in the Transportation Corridor in 1995 or 1996, which were the only years small portions of that survey area (locations where Spectacled Eiders were seen on pre-nesting aerial surveys) were searched for nests. Three nests of King Eiders were found in 1995, and two nests were found in 1997. Those nests occurred in both types of Basin Wetland Complexes, Nonpatterned Wet Meadow, and Moist

Table 11. Habitat use by Spectacled Eiders during nesting in the Delta survey area, Colville River Delta, Alaska, 1992–1994 and 1997 (Johnson et al. 1997, this study). Nests were found during ground searches of selected portions of the study area. No nests were found in 1995 and 1996.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Brackish Water	5	17.9
Tapped Lake w/High-water Connection	1	3.6
Salt Marsh	1	3.6
Salt-killed Tundra	4	14.3
Deep Open Water w/o Islands	1	3.6
Shallow Open Water w/o Islands	1	3.6
Aquatic Sedge w/Deep Polygons	7	25.0
Nonpatterned Wet Meadow	6	21.4
Wet Sedge–Willow Meadow	2	7.1
Total	28	100
NEAREST WATERBODY HABITAT [a]		
Brackish Water	13	46.4
Tapped Lake w/High-water Connection	4	14.3
Deep Open Water w/o Islands	6	21.4
Deep Open Water w/Islands or Polygonized Margins	2	7.1
Shallow Open Water w/o Islands	1	3.6
Shallow Open Water w/Islands or Polygonized Margins	2	7.1
Total	28	100

[a] Nearest waterbody (≥ 0.25 ha in size) was measured from the digital map.

Tussock Tundra (Table 12). The nests were an average of 1 m (range = 0.5–3.0 m) from permanent water. The nearest waterbodies were both types of Basin Wetland Complexes and Shallow Open Water without Islands, which were some of the waterbody types that King Eiders most often nested near in the adjacent Kuparuk Oilfield (Anderson et al. 1997).

Brood-rearing

Delta—We only conducted aerial surveys for eider broods in 1995; however, we saw one unidentified eider brood in Deep Open Water without Islands in 1997, during an aerial survey for loons. We conducted ground surveys for eider broods in the Facility Area from 1995 to 1997 and in various other areas in 1992 and 1993. Only eleven Spectacled Eider broods have been seen since 1993 (Table 13), and only one was seen during a systematic survey. Most of the broods were found in Salt-killed Tundra (36% of all locations) and Brackish Water (27%), suggesting a strong attraction to coastal habitats. A similar attraction was exhibited by broods for coastal lakes; we saw most broods (64%) nearest to Brackish Water ($\bar{x}$ = 0.03 km; n = 7). In NPR-A, Spectacled Eider broods primarily used shallow *Carex* ponds, deep open lakes, and deep *Arctophila* (Derksen et al. 1981). Post-nesting adults without broods at Storkersen Point also preferred deep *Arctophila* (Bergman et al. 1977).

Only two King Eider broods have been seen on the delta since studies began in 1992. We saw one King Eider brood in 1995 in Aquatic Sedge with Deep Polygons ~0.02 km from Brackish Water. In 1992, we found the other brood in Wet Sedge–Willow Meadow ~0.07 km from Deep Open Water without Islands.

Transportation Corridor—The Transportation Corridor was searched specifically for eider broods only in 1995. In 1997, we saw one unidentified eider brood in Deep Open Water without Islands during a loon survey. One Spectacled Eider brood was in Shallow Open Water with Islands or Polygonized Margins during a systematic aerial survey of the Transportation Corridor in 1995. On the same survey, 16 King Eider brood groups were found in 6

Table 12. Habitat use by King Eiders during nesting in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1994–1997 (Johnson et al. 1997, this study). Nests were found during ground searches of selected portions of the study area.

Area/Habitat	No. of Nests	Use (%)
DELTA		
HABITAT USED		
Salt-killed Tundra	1	25
Aquatic Sedge w/Deep Polygons	3	75
Total	4	100
NEAREST WATERBODY HABITAT [a]		
Tapped Lake w/Low-water Connection	1	25
Tapped Lake w/High-water Connection	1	25
Deep Open Water w/o Islands	1	25
Shallow Open Water w/o Islands	1	25
Total	4	100
TRANSPORTATION CORRIDOR		
HABITAT USED		
Young Basin Wetland Complex	1	20
Old Basin Wetland Complex	2	40
Nonpatterned Wet Meadow	1	20
Moist Tussock Tundra	1	20
Total	5	100
NEAREST WATERBODY HABITAT [a]		
Shallow Open Water w/o Islands	2	40
Young Basin Wetland Complex	2	40
Old Basin Wetland Complex	1	20
Total	5	100

[a] Nearest waterbody (≥0.25 ha in size) was measured from the digital map.

habitats, 3 of which were preferred: Deep Open Water without Islands and both types of Shallow Open Water (Table 14). These three habitats also were used by the largest numbers of brood groups. Moist Sedge–Shrub Meadow and Moist Tussock Tundra were unused by King Eiders and were used significantly less than their availability. King Eider broods at Storkersen Point preferred shallow *Carex* (equivalent to Aquatic Sedge Marsh) and deep *Arctophila* (Bergman et al. 1977).

TUNDRA SWAN

BACKGROUND

Tundra Swans arrive on the Colville Delta in mid- to late May (Simpson et al. 1982, Hawkins 1983). Swans occupy breeding territories and initiate nests soon after arrival, although they can be delayed by late snowmelt (Lensink 1973, McLaren and McLaren 1984). Preferred nesting habitat is characterized by numerous lakes and associated wetlands (King and Hodges 1980, Monda et al. 1994). Tundra Swans are traditional in their selection of nesting territories and often may use the same nest mounds in successive years (Palmer 1976, Monda et al. 1994). 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 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). Freezing temperatures and snow in early autumn can hasten their departure and cause mortality of young swans (Lensink 1973, Monda and Ratti 1990).

Table 13. 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 (Johnson et al. 1996). Broods were located during both aerial and ground surveys.

Habitat	No. of Brood-rearing Groups	No. of Young	Use[a] (%)	Mean Distance to Waterbody[b] (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	2	7	18.2	
Total	11	47	100	
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
Aquatic Grass Marsh	1	4	9.1	0
Total	11	47	100	0.05

[a] Use is calculated from number of brood-rearing groups.
[b] Distance was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—With minor exceptions, the distribution of Tundra Swan nests on the delta has been relatively consistent among years (Figure 9). We located 32 Tundra Swan nests during systematic aerial surveys of the delta in 1997, a sharp decline from the 45 nests located in 1996 (Table 15). In 1997, we found four additional nests opportunistically during intensive aerial surveys for eiders, and five more nests during ground searches. Although nesting effort was greatly reduced in 1997, we counted more swans on the delta (749) than in any previous year (Table 16). Factors that could account for this increase in swan numbers include the occupation of the delta by flocks of failed breeders from surrounding regions or the presence of returning non-breeding swans (either subadults or non-breeding adults) from previous successful breeding seasons. During the aerial survey on 20 June, we observed a flock of ~200 swans on the Outer Delta in the Kupigruak Channel; the following day, we found 4 flocks ranging in number from 57 to 110 on the delta. Because of the large number of nonbreeders present, only 7% of the total swans on the delta were associated with nests in 1997 (Table 16).

From 1996 to 1997, swan nesting also decreased between the Kuparuk and Colville rivers; in the Kuparuk Oilfield, nesting effort declined by 37% from that in 1996, and 7% fewer swans were present than in the previous five-year mean (Anderson et al. 1998a). The decline in nests probably was due to the late snowmelt and thawing of waterbodies that occurred in the region in spring 1997 (Anderson et al. 1998a; also see Eider and Caribou sections of this report).

Although nesting on the delta declined in 1997, nest density (0.06 nests/km^2), determined from aerial surveys, remained within the range of values we have observed over the previous four years of surveys (0.03–0.08 nests/km^2; Table 15). Higher densities of nests have been found on the delta during intensive ground searches, however. In 1982, for example, 48 nests were found on the northern 80% of the delta (Simpson et al. 1982), and in 1981, 32 swan nests were found on ~80% of the delta (Rothe et al. 1983). Nest densities determined from aerial surveys of other areas on the coastal plain were similar to those for the Colville Delta: 0.04–0.06 nests/km^2 on the

Table 14. Habitat selection by King Eiders during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1995 (Johnson et al. 1996).

Habitat	Area (km^2)	No. of Brood-rearing Groups	No. of Young	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[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	0.09	0	0	0	<0.1	-1.00	ns
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	15.21	5	76	31.3	9.2	0.55	prefer
Deep Open Water w/Islands or Polygonized Margins	3.10	1	6	6.3	1.9	0.54	ns
Shallow Open Water w/o Islands	5.16	4	23	25.0	3.1	0.78	prefer
Shallow Open Water w/Islands or Polygonized Margins	3.60	3	41	18.8	2.2	0.79	prefer
River or Stream	1.09	0	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0.49	1	4	6.3	0.3	0.91	ns
Aquatic Sedge w/Deep Polygons	0.03	0	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0.23	0	0	0	0.1	-1.00	ns
Young Basin Wetland Complex	7.03	2	6	12.5	4.2	0.49	ns
Old Basin Wetland Complex	16.90	0	0	0	10.2	-1.00	ns
Nonpatterned Wet Meadow	11.97	0	0	0	7.2	-1.00	ns
Wet Sedge–Willow Meadow	9.66	0	0	0	5.8	-1.00	ns
Moist Sedge–Shrub Meadow	40.06	0	0	0	24.1	-1.00	avoid
Moist Tussock Tundra	46.31	0	0	0	27.9	-1.00	avoid
Riverine or Upland Shrub	3.92	0	0	0	2.4	-1.00	ns
Barrens (riverine, eolian, lacustrine)	0.98	0	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0.26	0	0	0	0.2	-1.00	ns
Total	166.09	16	156	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated for groups.
[b] Significance calculated from 1.000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km^2 in the Kuparuk Oilfield and adjacent areas (Anderson et al. 1998a).

In 1997, the density of nests within the Development Area (0.06 nests/km^2) was the same as that estimated for the entire Delta survey area (Table 15). Ten (31%) of the 32 nests located during aerial surveys on the delta occurred in the Development Area. Ground observers found another four nests, resulting in a combined count of 14 nests for the Development Area (0.08 nests/km^2). In previous years, we found 5–17 nests during aerial surveys in the Development Area, and nest density was the same as that for the entire delta (except in 1996; see Table 15), suggesting that the Development Area and the Outer Delta are used equally by nesting swans.

In the Facility Area in 1997, we found two swan nests, one by aerial survey and one by ground survey (Figure 10). In previous years, we found 0–3 swan nests during aerial surveys of the Facility Area (Table 15). Prior to 1995, however, we conducted only aerial surveys in the Facility Area. In the larger area (14 km^2) searched on foot around the Facility Area, we found seven swan nests (0.49 nests/km^2). Two of these nests were located on both the aerial and ground surveys, one nest by aerial survey only, and the remaining four nests were found only by ground searchers. Of six nests within the ground-search area that we revisited after hatch, five nests (83%) were successful, and the sixth nest failed.

The aerial survey failed to detect four of seven nests (57%) in the ground-search area suggesting that sightability of swan nests in the Facility Area was low. A larger sample of nests is necessary to estimate sightability for the delta, but it appears that swan nest sightability varies with habitat, density, and the presence of snow or ice. Using an intensive aerial survey designed to measure sightability of nests in the nearby Kuparuk Oilfield, Stickney et al. (1992)

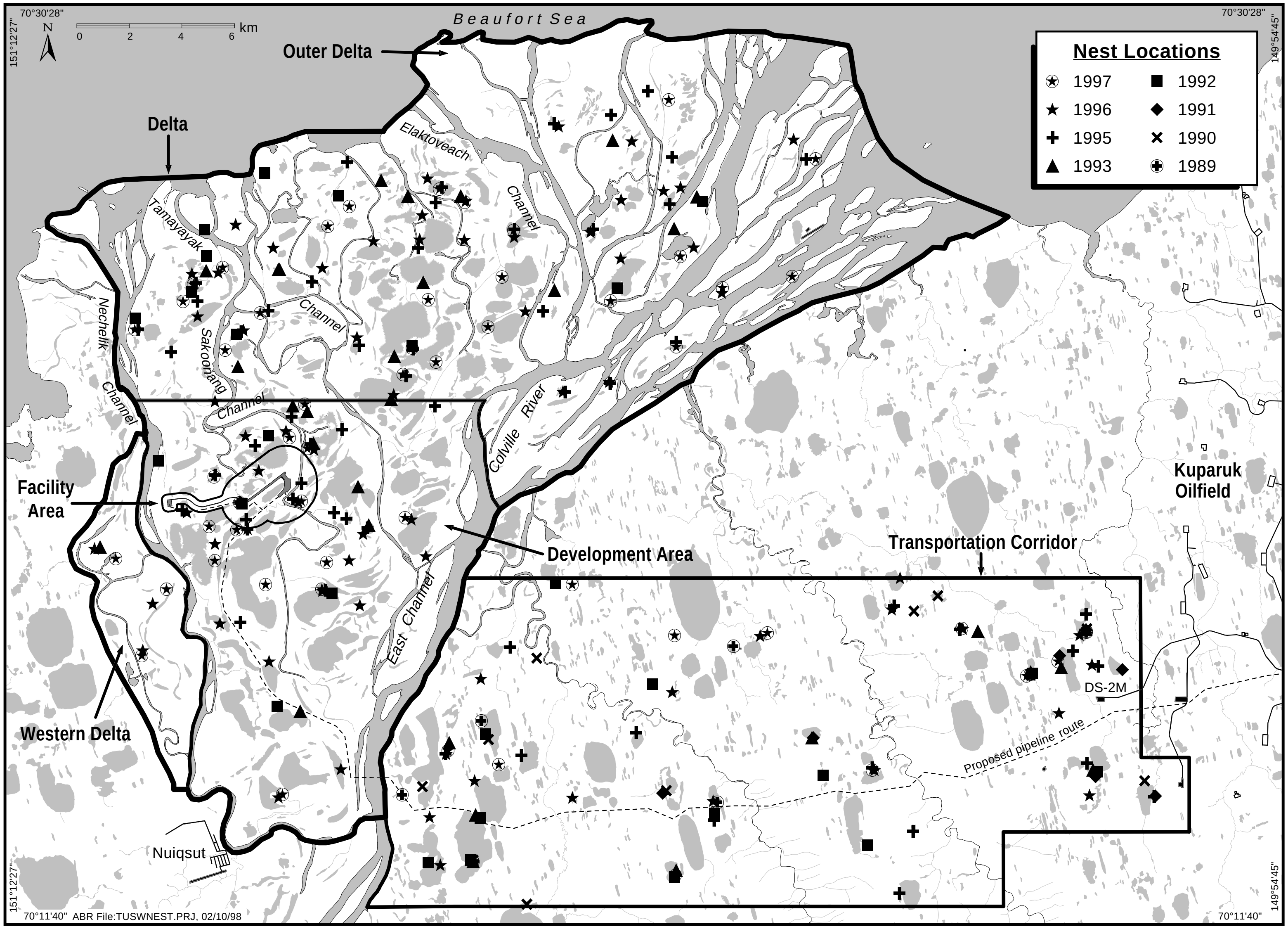

Figure 9. Distribution of Tundra Swan nests observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995–1997. In 1989–1991, only the Transportation Corridor was surveyed. Locations are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), Smith et al. (1993, 1994), Johnson et al. (1997), and this study.

Table 15. Numbers and densities of Tundra Swan nests and broods counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995–1997 (Johnson et al. 1997, this study).

		Nests		Broods		
Area	Year	No.	No./km^2	No.	No./km^2	Mean Brood Size
Delta (551km^2)	1997	32	0.06	24	0.04	2.5
	1996	45	0.08	32	0.06	3.4
	1995	38	0.07	25	0.05	3.7
	1993	20	0.04	14	0.03	2.6
	1992	14	0.03	16	0.03	2.4
Development Area (169 km^2)	1997	10	0.06	8	0.05	2.4
	1996	17	0.10	14	0.08	3.5
	1995	12	0.07	6	0.04	3.7
	1993	6	0.04	3	0.02	2.0
	1992	5	0.03	6	0.04	1.8
Facility Area (9 km^2)	1997	1	0.11	1	0.11	3.0
	1996	1	0.12	3	0.35	3.7
	1995	3	0.35	0	0	0
	1993	0	0	0	0	0
	1992	1	0.12	1	0.12	1.0
Outer Delta (352 km^2)	1997	19	0.05	15	0.04	2.6
	1996	25	0.07	16	0.05	3.3
	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
Western Delta (31 km^2)	1997	3	0.10	1	0.03	3.0
	1996	3	0.10	2	0.06	3.0
	1995	0	0	2	0.06	3.0
	1993	1	0.03	1	0.03	4.0
	1992	0	0	1	0.03	5.0
Transportation Corridor (343	1997	11	0.03	11	0.03	2.4
	1996	19	0.06	16	0.05	3.0
	1995	18	0.05	10	0.03	2.7
	1993	10	0.03	10	0.03	2.3
	1992	12	0.03	15	0.04	2.2
	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

estimated that 27% of swan nests were missed on the standard nesting survey. Using a similar sightability comparison on the Alaska Peninsula, Wilk (1988) estimated that standard aerial nesting surveys missed ~31% of the swan nests present.

On the Outer Delta, we located 19 swan nests during aerial surveys for swans in 1997 (Table 15); four additional nests were located during other aerial surveys; and one additional nest was located on ground searches (S. Earnst, Boise State Univ., Boise, ID, pers. comm.). The number and density of nests seen on aerial surveys were lower than those in 1995 and 1996. On the Western Delta in 1997, we located three swan nests during aerial surveys (Figure 9). We also found three nests there in 1996, but no more than one nest in any other year.

Transportation Corridor—In 1997, we located 11 swan nests (0.03 nests/km^2) in the Transportation Corridor during systematic swan aerial surveys (Figure 9). Observers on eider surveys located one additional nest. During the previous seven years,

Table 16. Numbers of Tundra Swans counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995–1997 (Johnson et al. 1997, this study).

		Nesting		Brood-rearing					Fall Staging
Area	Year	Total Swans	Swans with Nests (%)	Total Swans	No. of Adults	No. of Young	Adults with Broods (%)	Young (%)	Total Swans
Delta									
	1997	749	7	348	287	61	14	18	286
	1996	579	12	358	250	108	25	30	355
	1995	208	31	261	169	92	29	35	64[a]
	1993	240	12	237	200	37	13	16	295
	1992	249	7	297	259	38	13	13	0
Transportation Corridor									
	1997	37	49	107	81	26	21	24	0
	1996	52	67	105	57	48	53	46	no data
	1995	87	40	93	66	27	30	29	5
	1993	50	32	83	60	23	33	28	no data
	1992	46	48	105	72	33	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	69	63	6	6	8	no data

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

numbers of nests located in the Transportation Corridor ranged from 6 to 19 (Table 15). Since 1989, the number of nests in the Transportation Corridor has fluctuated, but the general trend has been an increase in nesting.

The number of swans counted in the Transportation Corridor during the nesting season grew steadily from 1989 to 1995; however, during 1996 and 1997, numbers declined (Table 16). Although the proportion of swans associated with nests has increased slightly over the previous seven years, this trend has not been consistent each successive year.

Brood-rearing

Delta—Tundra Swan broods were distributed throughout the Colville Delta (Figure 11). Brood counts on the delta in mid-August 1997 indicated that ~75% of the 32 nests (seen on aerial survey) were successful (Table 15). Similar nesting success rates were estimated from nest and brood surveys in 1996 (71%) and 1993 (70%), whereas we counted more broods than nests in 1992 (success = 114%). Clearly, we undercounted nests and/or some broods may have immigrated to the delta in 1992. In 1997, average brood size was 2.5 young/brood (range = 1–5), or the second lowest we have recorded, and the density was 0.04 broods/km^2. Mean nesting success (calculated from aerial survey results only) on the delta was 74.5 % (n = 5 years). Two earlier studies on the delta, both employing intensive ground surveys, provide comparative data. Rothe et al. (1983) reported a nesting success rate of 91% (n = 32 nests) and a mean of 2.1 young/brood for the Colville Delta in late July 1981. In 1982, nesting success was 71% (n = 48 nests), and average brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). In a three-year study (1988–1990) of swans nesting on the Canning and Kongakut river deltas, the overall nesting success was 76% (n = 110 nests, Monda et al. 1994).

Productivity (as indicated by nesting success, brood density, and average brood size) on the delta during the five years that we conducted aerial surveys was similar to or greater than values reported in other studies of swans on the Arctic Coastal Plain. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995–1997) recorded average brood sizes of 2.1–2.8 young/brood and densities of 0.02–0.04 broods/km^2 (Ritchie et al. 1990, 1991;

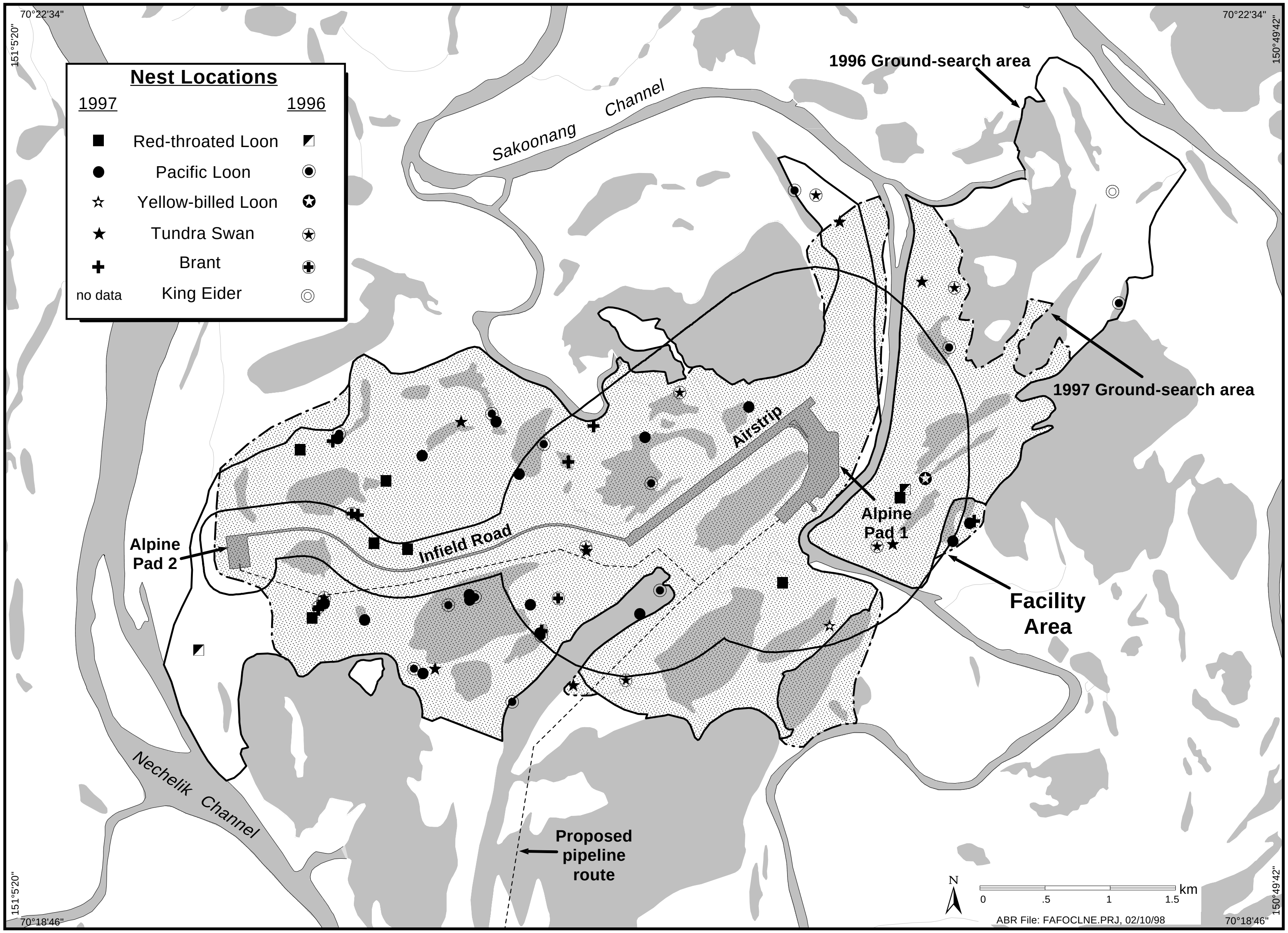

Figure 10. Nest locations of Red-throated, Pacific, and Yellow-billed loons, Tundra Swans, Brant, and King Eiders observed during aerial and ground surveys in June and July near the Facility Area, Colville River Delta, Alaska, 1996 and 1997.

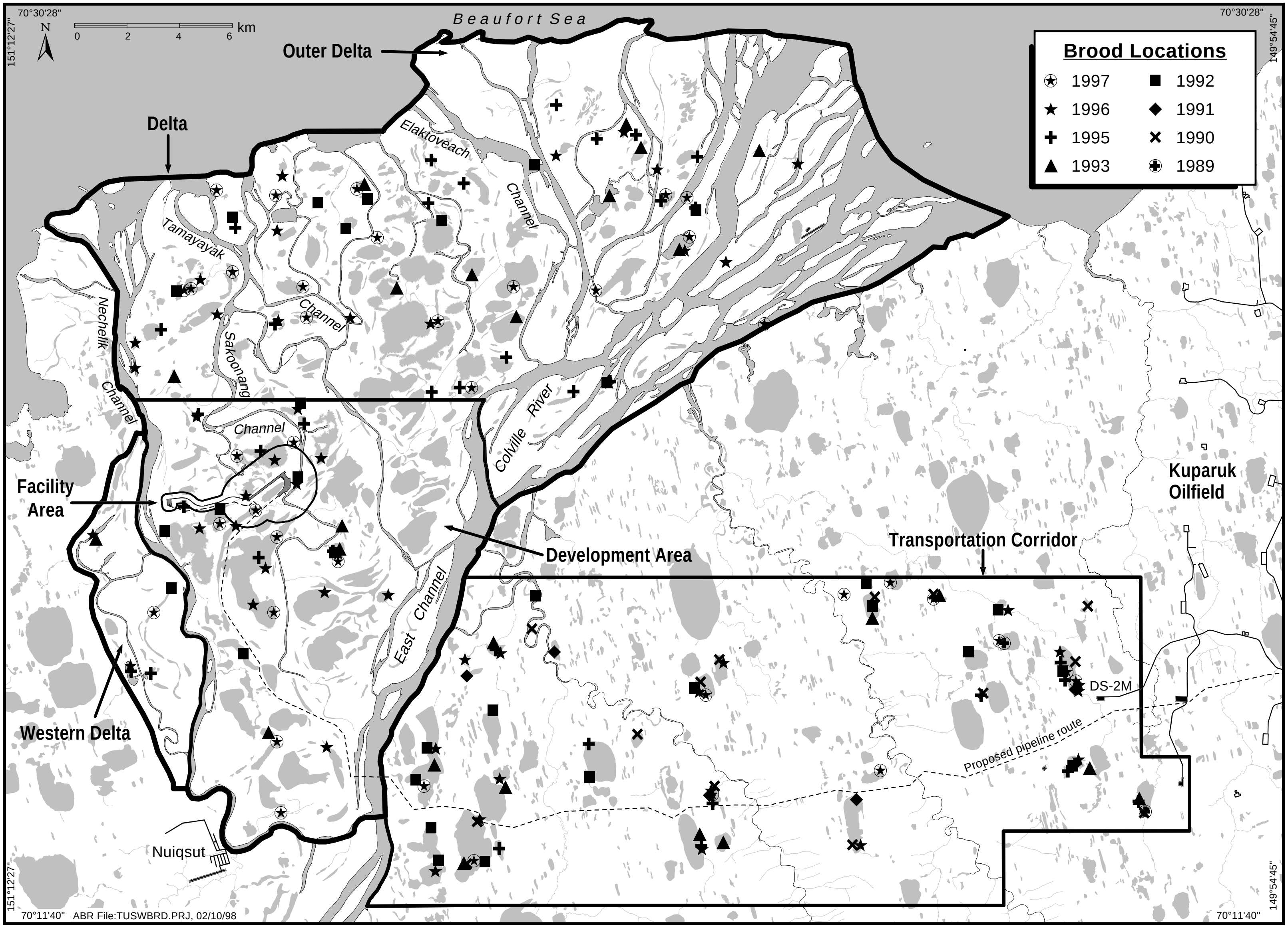

Figure 11. Distribution of Tundra Swan broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995–1997. In 1989–1991, only the Transportation Corridor was surveyed.

Stickney et al. 1992, 1993; Anderson et al. 1996, 1997, 1998a). Platte and Brackney (1987) estimated 63–85% nesting success, 0.04 broods/km^2, and 2.5 young/brood on portions of the Arctic Coastal Plain during 1982–1985.

The smaller number of nests and broods found on the delta in 1997 resulted in young swans representing only 18% of all swans present in August (Table 16). The number of adult swans counted on the delta during the brood-rearing survey was greater than in any of the previous years of this study. The percentage of young swans on the delta has ranged from 13 to 35% over the 5 years of study (Table C4). In 1982, the percentage of young swans on the delta was 26% (Simpson et al. 1982). In the adjacent Kuparuk Oilfield, the percentage of young swans has ranged from 21 to 34% since 1988 (Anderson et al. 1998a).

In the Development Area, we found eight broods during the aerial survey in 1997, down sharply from the high count of 14 broods in 1996 (Table 15). Nonetheless, the 1997 brood count is the second highest since our surveys began. We found one brood in the Facility Area in 1997 during the aerial survey (Figure 12). However, as many as three broods were seen there during ground surveys. In 1996, we saw three broods in the Facility Area during an aerial survey.

The annual trend in the density of swan broods between the Development Area and the Outer Delta was similar to that found for nests; that is, the two areas had equivalent densities in all years except 1996, when densities of broods and nests were higher in the Development Area (Table 15). On the Outer Delta, we found 15 broods on an aerial survey in 1997, similar to the count in 1996. An additional three broods located incidentally during other aerial surveys of the Outer Delta were not included in totals used for interannual comparisons.

Transportation Corridor—The range of densities of Tundra Swan broods in the Transportation Corridor during eight years of surveys (0.01–0.05 broods/km^2) was nearly the same as that for the delta (0.03–0.06 broods/km^2; Table 15). In 1997, we found 11 broods, which approximated the average number of broods ($\bar{x}$ = 10.5; *n* = 8 years) found there since we began our surveys in this area in 1989. Nesting success for 1997 was 100%, and mean nesting success calculated for all survey years was 89% (*n* = 8 years).

As on the delta, fewer Tundra Swan young were counted in the Transportation Corridor in 1997 than in 1996 or 1995 (Table 16). However, the total number of adult swans counted in the Transportation Corridor during the brood survey was greater than in any previous year. In 1997, we counted 81 adults and 26 young, and 21% of all adult swans were with broods. In only one previous year (1991) was the percentage of adults with broods smaller than that in 1997. Overall, swans using the Transportation Corridor and the adjacent Kuparuk Oilfield have exhibited considerable annual variation in nesting effort, nesting success, and mean brood size (Anderson et al. 1998a). Regionally, 1997 was a much less productive year for Tundra Swans than either 1995 or 1996. Fewer nests and young swans were counted on the coastal plain between the Kuparuk and Colville rivers (an area that includes the Transportation Corridor) in 1997 than in 1995 or 1996, and mean brood size (2.2 young/ brood) was the second-lowest in that area since surveys began in 1988 (Anderson et al. 1998a).

Fall Staging

Delta—Tundra Swans have been widely distributed on the delta during our fall-staging surveys. However, most generally occur in several large flocks that occupy river channels on the Outer Delta (Figure 13). Wetlands immediately east of the delta, between the Miluveach River and Kalubik Creek, have had the largest aggregations of Tundra Swans on the Arctic Coastal Plain of Alaska during fall staging (Seaman et al. 1981), and we have observed large numbers there as well (Figure 13). We made several attempts to survey the entire Delta and Transportation Corridor areas during the fall-staging period in 1997, but inclement weather through much of September prevented the completion of all but one survey (28 September). Two flocks (127 swans and 77 swans) comprised the majority of the 286 swans on the delta at that time (Table 16).

We recorded variable departure times from the delta. For example, on 19 September 1995, we counted only 64 swans, most of which were in discrete family groups distributed throughout the delta. Although weather at that time was

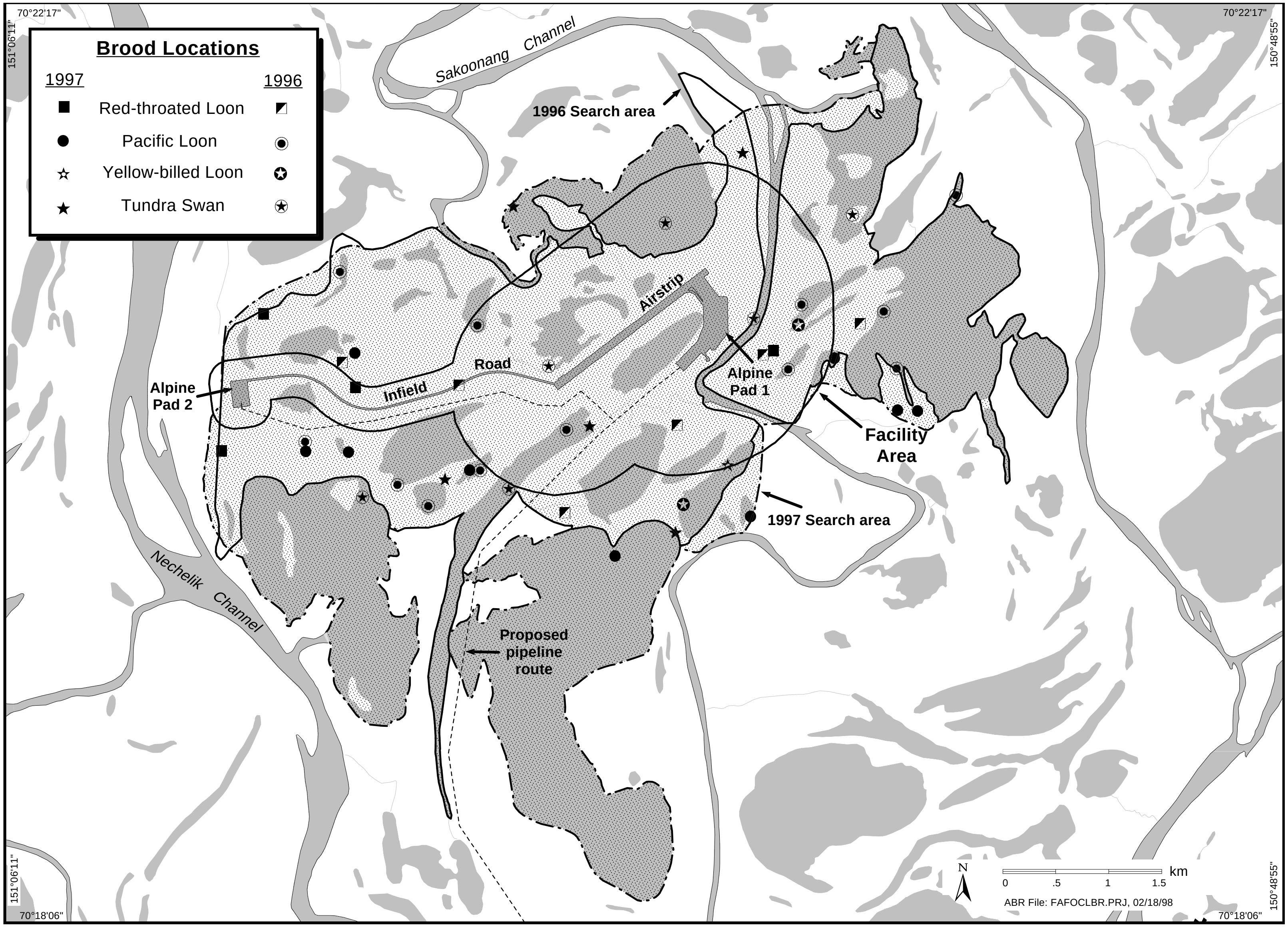

Figure 12. Brood locations of Red-throated, Pacific, and Yellow-billed loons, and Tundra Swans observed during aerial and ground surveys in July and August near the Facility Area, Colville River Delta, Alaska, 1996 and 1997.

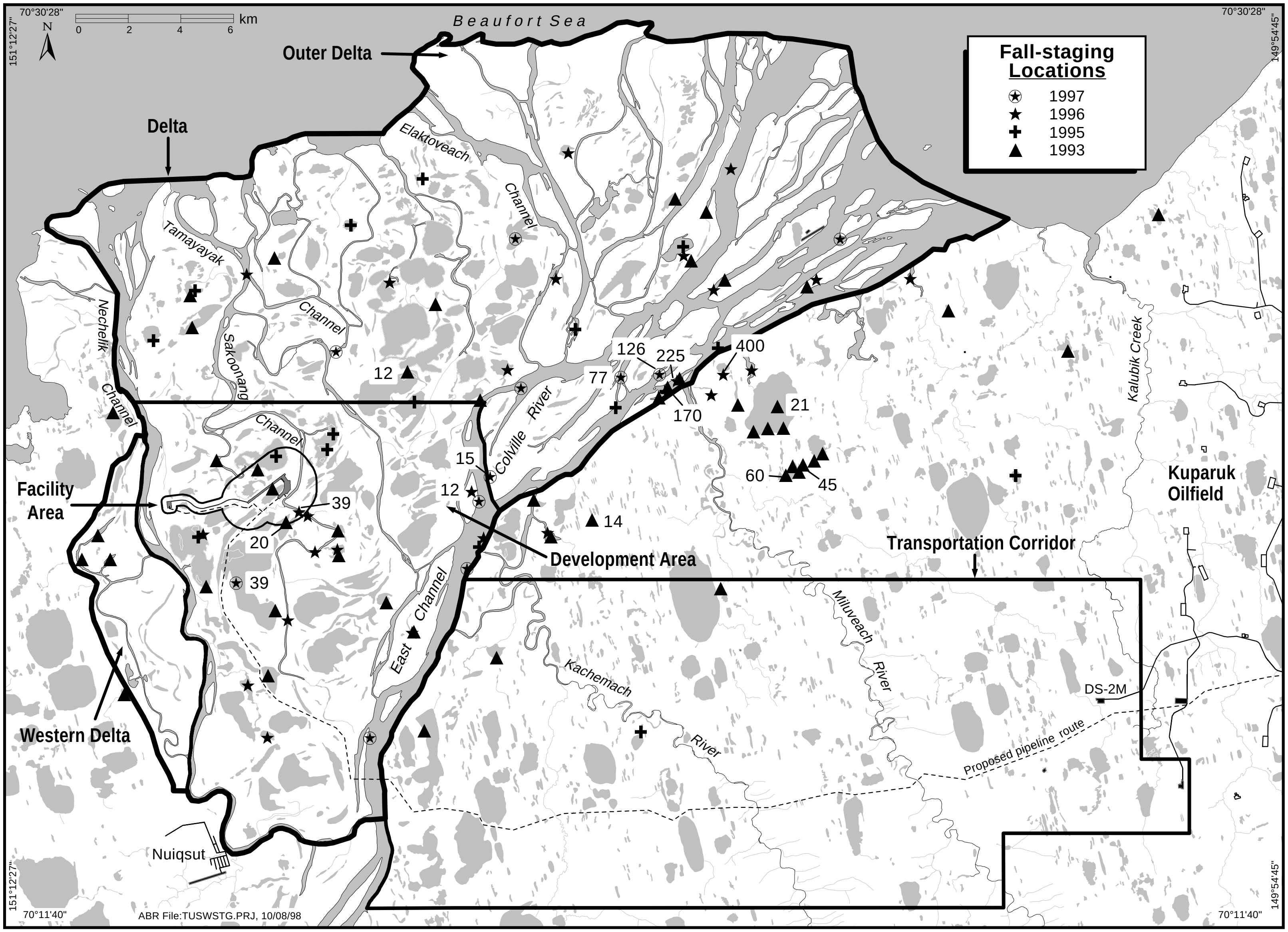

Figure 13. Distribution of Tundra Swan fall-staging groups observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1993 and 1995–1997.

exceptionally mild, three days of subzero temperatures two weeks earlier had caused lakes to freeze (J. Helmericks, Golden Plover, Prudhoe Bay, AK, pers. comm.) and may have induced most swans to leave. Similarly, in 1992, subzero temperatures after 8 September caused an early freeze, and swans vacated the delta by the time of our fall-staging survey (17 September, Smith et al. 1993). In contrast, temperatures in 1993 remained above freezing until after a staging survey on 15 September, when we saw 295 swans (Table 16). In 1996, we also saw large numbers of swans (355) on the staging survey, but it was conducted on 6 September, before the first freezing temperatures of the month; we have no data on when the swans departed. These few observations suggest that the departure of most swans from the delta can be triggered before the middle of September by cold temperatures and freeze-up of waterbodies, but large numbers of swans can remain on the delta much later when temperatures remain above freezing. Surveys in three (1993, 1996, 1997) of the five years considered here documented staging by large numbers of swans prior to migration, an event also reported by Campbell et al. (1988).

Although the Colville Delta and nearby wetlands have been identified as important fall-staging areas for swans, the origins of the birds staging there remain unclear. Swans nest in moderate to high densities from the delta northwest to Teshekpuk Lake (Derksen et al. 1981) and from the delta east to the Kuparuk River (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1995, 1996, 1997). Although swans from surrounding nesting areas may be staging on the delta, our total counts of swans during staging surveys have not indicated an increase over the total during the brood-rearing period (Table 16). To understand more clearly the importance of the delta and adjacent wetlands for swan staging, information on swan residency time and origin of swans is needed. That information would require marking swans from other areas on the Arctic Coastal Plain and locating them on multiple surveys throughout the fall-staging period.

Transportation Corridor— We flew one complete staging survey (28 September) over the Transportation Corridor in 1997 and observed no swans. We surveyed portions of the area on 23 and 24 September by helicopter during poor weather, but saw no swans at that time either. Although complete, systematic staging surveys have not been flown over the Transportation Corridor annually, we suspect that this area is of limited importance to staging swans.

HABITAT SELECTION

Nesting

Delta—Tundra Swans on the delta used a wide range of habitats for nesting. During five years of surveys, swan nests were located in 15 of 23 available habitats (Table 17). Five habitat types were preferred, and four were avoided. We found 118 nests (79% of the total) in preferred habitats; together these habitats covered 36% of the Delta survey area. Annual measurements of habitat selection for previous years can be found in Johnson et al. (1996, 1997); habitat selection for 1997 is presented in Appendix Table C3 and C4.

Most nests (61; 41% of the total) were located in Wet Sedge–Willow Meadow, a preferred habitat that also was the most widely available (19%) habitat in the Delta survey area (Table 17). The second-highest number of nests (21) occurred in Nonpatterned Wet Meadow, another preferred habitat. No other habitat type in the Delta survey area contained >20 nests. Salt-killed Tundra, Aquatic Sedge with Deep Polygons, and Moist Sedge–Shrub Meadow also were preferred. Nesting swans avoided Tidal Flat, River or Stream, Riverine or Upland Shrub, and Barrens, which together composed 44% of the Delta survey area.

Swans on the delta appeared to be attracted to nest sites near lakes and ponds. The mean distance of swan nests to the nearest waterbody was 0.1 km (Table 18). In decreasing order of use, swan nests were most closely associated with three waterbody types on the delta: Deep Open Water without Islands, Tapped Lake with Low-water Connections, and Brackish Water.

Transportation Corridor—Swans used a wide array of habitats during the eight years of surveys in the Transportation Corridor; nests were found in 13 of the 18 habitats available (Table 19). Three habitats were preferred, and three were avoided. Thirty-one nests (33% of the total) occurred in preferred habitats: Deep Open Water with Islands or

Table 17. Habitat selection (pooled among years) by nesting Tundra Swans in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, and 1995–1997 (Johnson et al. 1997, this study). See Appendix C3 for 1997 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	ns
Brackish Water	6.50	0	0	1.2	-1.00	ns
Tapped Lake w/Low-water Connection	21.42	2	1.3	3.9	-0.49	ns
Tapped Lake w/High-water Connection	20.36	3	2.0	3.7	-0.29	ns
Salt Marsh	16.35	8	5.4	3.0	0.29	ns
Tidal Flat	56.05	2	1.3	10.2	-0.77	avoid
Salt-killed Tundra	25.63	16	10.7	4.6	0.40	prefer
Deep Open Water w/o Islands	23.31	4	2.7	4.2	-0.22	ns
Deep Open Water w/Islands or Polygonized Margins	5.15	3	2.0	0.9	0.37	ns
Shallow Open Water w/o Islands	2.30	0	0	0.4	-1.00	ns
Shallow Open Water w/Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	ns
River or Stream	81.76	0	0	14.8	-1.00	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	13.60	10	6.7	2.5	0.46	prefer
Aquatic Grass Marsh	1.37	2	1.3	0.2	0.69	ns
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	41.92	21	14.1	7.6	0.30	prefer
Wet Sedge–Willow Meadow	102.36	61	40.9	18.6	0.38	prefer
Moist Sedge–Shrub Meadow	13.36	10	6.7	2.4	0.47	prefer
Moist Tussock Tundra	2.52	1	0.7	0.5	0.19	ns
Riverine or Upland Shrub	27.40	1	0.7	5.0	-0.76	avoid
Barrens (riverine, eolian, lacustrine)	78.90	5	3.4	14.3	-0.62	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	551.29	149	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Polygonized Margins, Aquatic Sedge Marsh, and Young Basin Wetland Complex. These preferred habitats, however, composed only 6% of the area in the Transportation Corridor. The three avoided habitats—Moist Sedge–Shrub Meadow, Moist Tussock Tundra, and Deep Open Water without Islands—together occupied 61% of the survey area but contained only 28% of the nests.

Although swan nests were found in most of the available habitats in the Transportation Corridor that also were used on the delta, habitat preferences did not overlap between the two areas. Two of the habitats preferred in the Transportation Corridor are either absent or rare on the delta (Aquatic Sedge Marsh and Young Basin Wetland Complex). Likewise, two habitats preferred on the delta (Salt-killed Tundra and Aquatic Sedge with Deep Polygons) were absent or rare in the Transportation Corridor. Among the habitats that were preferred on the delta and common in both areas, only Wet Sedge–Willow Meadow and Moist Sedge–Shrub Meadow were used less than their availability in the Transportation Corridor. Moist Sedge–Shrub Meadow occupied a large percentage of the Transportation Corridor (25%), but contained a relatively small percentage of the nests (11%). The difference in selection for Wet Sedge–Willow Meadow between the two areas may relate to its distribution: on the delta, this habitat is widespread and borders many of the waterbodies near which swans tend to nest, whereas in the Transportation Corridor, it appears to occur in isolated patches, which occupy a small proportion of the shorelines of lakes (Figure 2).

Table 18. Distance to the nearest waterbody of Tundra Swan nests detected on aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995–1997 (Johnson et al. 1997, this study).

	Delta			Transportation Corridor		
Nearest Waterbody Habitat	No. of Nests	Use (%)	Mean Distance[a] (km)	No. of Nests	Use (%)	Mean Distance[a] (km)
Brackish Water	23	13.4	0.10	0	0	-
Tapped Lake w/Low-water Connection	27	15.7	0.09	0	0	-
Tapped Lake w/High-water Connection	18	10.5	0.09	0	0	-
Deep Open Water w/o Islands	48	27.9	0.09	20	21.1	0.05
Deep Open Water w/Islands or Polygonized Margins	12	7.0	0.05	14	14.7	0.01
Shallow Open Water w/o Islands	13	7.6	0.14	6	6.3	0.02
Shallow Open Water w/Islands or Polygonized Margins	2	1.2	0.04	11	11.6	0.05
River or Stream	18	10.5	0.14	0	0	-
Aquatic Sedge Marsh	0	0	-	6	6.3	<0.01
Aquatic Grass Marsh	11	6.4	0.05	4	4.2	0.08
Young Basin Wetland Complex	0	0	-	17	17.9	<0.01
Old Basin Wetland Complex	0	0	-	17	17.9	0.02
Total	172	100	0.10	95	100	0.03

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

Swan nests in the Transportation Corridor were found close to waterbodies: the mean distance of nests to the nearest waterbody was 0.03 km (Table 18). Deep Open Water without Islands was the nearest waterbody to most nests. Other waterbody types that were closest to >10 nests were Old Basin Wetland Complex, Young Basin Wetland Complex, Shallow Open Water with Islands or Polygonized Margins and Deep Open Water with Islands or Polygonized Margins.

Tundra Swans breeding on the Canning and Kongakut river deltas in northeastern Alaska selected marsh habitats and nested near either large lakes or coastal lagoons (Monda et al. 1994). Because only seven habitats were classified for these deltas and because the habitats differed in availability from those on the Colville Delta, the habitat use reported by Monda et al. (1994) was not directly comparable with our findings. Similar to our comparison of swan nesting habitat on the Colville Delta and Transportation Corridor, Monda et al. (1994) found differences between their two study sites that reflected differences in habitat availability. On the Kongakut delta, 89% of the 36 nests were <1 km from a coastal lagoon, 42% of the nests were in areas classified as saline graminoid-shrub (probably equivalent to our Salt Marsh), and 36% of the nests were ≤10 m from waterbodies. On the Canning delta, 22% of 54 nests were <1 km from a coastal lagoon, 52% of the nests were in graminoid-marsh (probably equivalent to Aquatic Grass and Sedge Marshes), 26% were in graminoid-shrub-water sedge (probably equivalent to our Wet SedgeWillow Meadow), and 63% were ≤10 m from waterbodies.

Brood-rearing

Delta—As was observed during nesting, Tundra Swans with broods used the majority of the habitats on the delta; broods occurred in 18 of 23 available habitats (Table 20). Four habitats were preferred, and three were avoided. Forty broods occurred in preferred habitats, and 11 broods occurred in avoided habitats. Brood-rearing swans used waterbodies for foraging and escape habitat and preferred them to terrestrial habitats. Swan broods preferred Brackish Water, Tapped Lake with Low-water Connections, and both Deep Open Water types, all of which together occupy 10% of the delta. The most broods (16% of the total) were in Wet Sedge–Willow Meadow, but it was not preferred because it occupies the most area (19%) on the delta. Broods avoided

Table 19. Habitat selection (pooled among years) by nesting Tundra Swans in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989–1993 and 1995–1997 (Johnson et al. 1997, this study). See Appendix C4 for 1997 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[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	ns
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	3	3.2	9.0	-0.47	avoid
Deep Open Water w/Islands or Polygonized Margins	6.52	11	11.7	1.9	0.72	prefer
Shallow Open Water w/o Islands	10.84	4	4.3	3.2	0.15	ns
Shallow Open Water w/Islands or Polygonized Margins	7.37	4	4.3	2.1	0.33	ns
River or Stream	2.31	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0.97	4	4.3	0.3	0.88	prefer
Aquatic Sedge w/Deep Polygons	0.03	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0.65	1	1.1	0.2	0.70	ns
Young Basin Wetland Complex	14.23	16	17.0	4.1	0.61	prefer
Old Basin Wetland Complex	35.60	10	10.6	10.4	0.01	ns
Nonpatterned Wet Meadow	24.47	12	12.8	7.1	0.28	ns
Wet Sedge–Willow Meadow	19.87	3	3.2	5.8	-0.29	ns
Moist Sedge–Shrub Meadow	84.67	10	10.6	24.7	-0.40	avoid
Moist Tussock Tundra	94.62	13	13.8	27.6	-0.33	avoid
Riverine or Upland Shrub	7.74	3	3.2	2.3	0.17	ns
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	ns
Total	343.16	94	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Tidal Flat, River or Stream, and Barrens, which together compose 39% of the delta.

The preference for salt-affected habitats (Brackish Water and Tapped Lake with Low-water Connection) by brood-rearing swans may reflect either a seasonal change in distribution or habitat preference, in that 37% of all swan broods on the delta were in salt-affected habitats, compared with only 19% of all nests. Swan broods ($\bar{x}$ = 6.6 km; n = 111) were only slightly closer to the coast, however, than were nests ($\bar{x}$ = 6.8 km; n = 149), suggesting that swans select different habitats in these two seasons without actually moving toward the coast.

All swan broods were near (and often swimming in) waterbodies, and most were associated with saline waterbodies (Table 21). The mean distance of broods to a waterbody was 0.03 km. The largest number of broods (28) was near Tapped Lakes with Low-water Connections, and most of the remaining broods were near either Brackish Water (25 broods), Deep Open Water without Islands (23 broods), or Tapped Lake with High-water Connections (17 broods).

Transportation Corridor—Unlike the delta, the Transportation Corridor contained little or no salt-affected habitat, resulting in differences in habitat use by swan broods. Swan broods used 13 of 18 habitats available in the Transportation Corridor (Table 22). Four habitats were preferred, and three were avoided. As on the delta, both types of Deep Open Water habitats were preferred, but two other habitats, Aquatic Sedge Marsh and Aquatic Grass

Table 20. Habitat selection (pooled among years) by Tundra Swans during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, and 1995–1997 (Johnson et al. 1997, this study). See Appendix C3 for 1997 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	ns
Brackish Water	6.50	8	7.2	1.2	0.72	prefer
Tapped Lake w/Low-water Connection	21.42	16	14.4	3.9	0.58	prefer
Tapped Lake w/High-water Connection	20.36	7	6.3	3.7	0.26	ns
Salt Marsh	16.35	7	6.3	3.0	0.36	ns
Tidal Flat	56.05	1	0.9	10.2	-0.84	avoid
Salt-killed Tundra	25.63	9	8.1	4.6	0.27	ns
Deep Open Water w/o Islands	23.31	11	9.9	4.2	0.40	prefer
Deep Open Water w/Islands or Polygonized Margins	5.15	5	4.5	0.9	0.66	prefer
Shallow Open Water w/o Islands	2.30	2	1.8	0.4	0.62	ns
Shallow Open Water w/Islands or Polygonized Margins	0.55	1	0.9	0.1	0.80	ns
River or Stream	81.76	5	4.5	14.8	-0.53	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	13.60	4	3.6	2.5	0.19	ns
Aquatic Grass Marsh	1.37	2	1.8	0.2	0.76	ns
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	41.92	7	6.3	7.6	-0.09	ns
Wet Sedge–Willow Meadow	102.36	18	16.2	18.6	-0.07	ns
Moist Sedge–Shrub Meadow	13.36	1	0.9	2.4	-0.46	ns
Moist Tussock Tundra	2.52	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	27.40	2	1.8	5.0	-0.47	ns
Barrens (riverine, eolian, lacustrine)	78.90	5	4.5	14.3	-0.52	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	551.29	111	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Marsh, also were preferred. In contrast, swan broods avoided Old Basin Wetland Complex, Moist Sedge–Shrub Meadow, and Moist Tussock Tundra. These habitats occupied 63% of the Transportation Corridor, whereas only 11% of the area was occupied by preferred habitats.

Most broods (56; 67% of the total) were found in Deep Open Water types (43 in Deep Open Water without Islands and 13 in Deep Open Water with Islands). No other preferred habitat was used by more than four broods.

The average distance of broods in the Transportation Corridor to the nearest waterbody was 0.01 km (Table 21). Sixty-six broods (78% of the total) were nearest both types of Deep Open Water and nine broods (11% of the total) were nearest to both types of Shallow Open Water.

Swan broods in northeastern Alaska used different habitats as the brood-rearing season progressed (Monda et al. 1994). Early in the brood-rearing season on the Kongakut River delta, grazing in saline graminoid marsh and aquatic-marsh habitats predominated. Later in the season, surface and sub-surface foraging concentrated more in aquatic-marsh habitat. Changes in habitat use and foraging methods may be related to nutritive quality of different plants or the ability of older, larger cygnets to feed on submerged vegetation (e.g., pondweeds [*Potamogeton* spp.]) in deeper water.

Spindler and Hall (1991) found swans feeding on various species of submergent pondweed in late August and September in brackish water environments of the Kobuk-Selawik Lowlands. On

Table 21. Mean distance to the nearest waterbody of Tundra Swan broods detected on aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993 and 1995–1997 (Johnson et al. 1997, this study).

	Delta			Transportation Corridor		
Nearest Waterbody Habitat	No. of Broods	Use (%)	Mean Distance[a] (km)	No. of Broods	Use (%)	Mean Distance[a] (km)
Brackish Water	25	20.8	0.03	0	0	-
Tapped Lake w/Low-water Connection	28	23.3	0.02	0	0	-
Tapped Lake w/High-water Connection	17	14.2	0.04	0	0	-
Deep Open Water w/o Islands	23	19.2	0.02	51	60.0	0.01
Deep Open Water w/Islands or Polygonized Margins	6	5.0	0	15	17.6	0.01
Shallow Open Water w/o Islands	5	4.2	0.03	5	5.9	<0.01
Shallow Open Water w/Islands or Polygonized Margins	1	0.8	0	4	4.7	0.01
River or Stream	13	10.8	0.07	1	1.2	0.08
Aquatic Sedge Marsh	0	0	-	4	4.7	0
Aquatic Grass Marsh	2	1.7	0	2	2.4	0
Young Basin Wetland Complex	0	0	-	2	2.4	0
Old Basin Wetland Complex	0	0	-	1	1.2	0
Total	120	100	0.03	85	100	0.01

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

the Colville Delta, swans also favored pond weed during the brood-rearing and molting periods (Johnson and Herter 1989). Wilk (1988) describes spring-staging swans feeding on abundant pondweeds in tidally influenced habitat in the Naknek River. Monda et al. (1994) also found that pondweeds were an important component of the diet of swans on the Kongakut and Canning river deltas; pondweeds, along with another important food, alkali grass (*Puccinellia phryganodes*), grow well in salt-affected environments. Although we did not collect data on the feeding habits of swans, the use of salt-affected and aquatic-marsh habitats by broods and fall-staging flocks on the Colville Delta and in the Transportation Corridor suggests that some of the same plants are being sought in our study area.

LOONS

BACKGROUND

On the Arctic Coastal Plain of Alaska, Yellow-billed Loons nest primarily between the Colville and Meade rivers, with the highest densities found south of Smith Bay (Brackney and King 1992). The Colville Delta also is an important nesting area for Yellow-billed Loons (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 in rivers, tapped lakes, and in the sea ice before nesting 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 nesting lake (Rothe et al. 1983); however, broods occasionally 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 of the Colville Delta in 1997, most Yellow-billed Loons (81%) and their nests (80%) were concentrated in the central part of the delta, between the Elaktoveach and Sakoonang channels (Figure 14). The few birds and nests found outside this area were located in previously recorded breeding territories of Yellow-billed Loons (North 1986, Johnson et al. 1997). This pattern of use is consistent with the distribution of loons and nests

Table 22. Habitat selection (pooled among years) by Tundra Swans during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989–1993 and 1995–1997 (Johnson et al. 1997, this study). See Appendix C4 for 1997 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[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	ns
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	43	51.2	9.0	0.70	prefer
Deep Open Water w/Islands or Polygonized Margins	6.52	13	15.5	1.9	0.78	prefer
Shallow Open Water w/o Islands	10.84	4	4.8	3.2	0.20	ns
Shallow Open Water w/Islands or Polygonized Margins	7.37	1	1.2	2.1	-0.29	ns
River or Stream	2.31	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0.97	4	4.8	0.3	0.89	prefer
Aquatic Sedge w/Deep Polygons	0.03	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0.65	2	2.4	0.2	0.85	prefer
Young Basin Wetland Complex	14.23	2	2.4	4.1	-0.27	ns
Old Basin Wetland Complex	35.60	1	1.2	10.4	-0.79	avoid
Nonpatterned Wet Meadow	24.47	2	2.4	7.1	-0.50	ns
Wet Sedge–Willow Meadow	19.87	2	2.4	5.8	-0.42	ns
Moist Sedge–Shrub Meadow	84.67	7	8.3	24.7	-0.50	avoid
Moist Tussock Tundra	94.62	2	2.4	27.6	-0.84	avoid
Riverine or Upland Shrub	7.74	1	1.2	2.3	-0.31	ns
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	ns
Total	343.16	84	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

documented for the delta during aerial surveys in 1993, 1995, and 1996 (Smith et al. 1994; Johnson et al. 1997), and during ground studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

In 1997, we counted 48 Yellow-billed Loons on the aerial nesting survey, 14 of which were associated with 10 nests. Numbers of loons and nests in 1997 were similar to counts made in other years when aerial surveys of the entire delta were conducted (1993, 1995, and 1996; Table 23). The similarity among years in the distribution and abundance (0.10 to 0.15 birds/km^2) of Yellow-billed Loons and their nests suggests that the breeding population on the delta has been relatively stable during at least the past five years. Similar densities have been reported for other Yellow-billed Loon nesting areas on the North Slope of Alaska: Square Lake in the National Petroleum Reserve–Alaska (0.14 birds/km^2; Derkson et al. 1981) and the Alaktak region south of Smith Bay (0.16 birds/km^2; McIntyre 1990).

In both 1997 and 1996, we revisited lakes where we had seen Yellow-billed Loon pairs but did not find nests on the initial aerial survey. During these second visits, we found an additional four nests in 1997 and an additional five nests in 1996 that either had been missed or were initiated after the first survey (Table 23). In 1997, we also found a Yellow-billed Loon nesting west of the Nechelik Channel, just north of the Western Delta area, during a survey for caribou (Figure 14). This area was not surveyed in previous years during our aerial surveys or by North et al. (1984) in 1983 and 1984. Our highest count of 19 nests (which includes two nests assumed

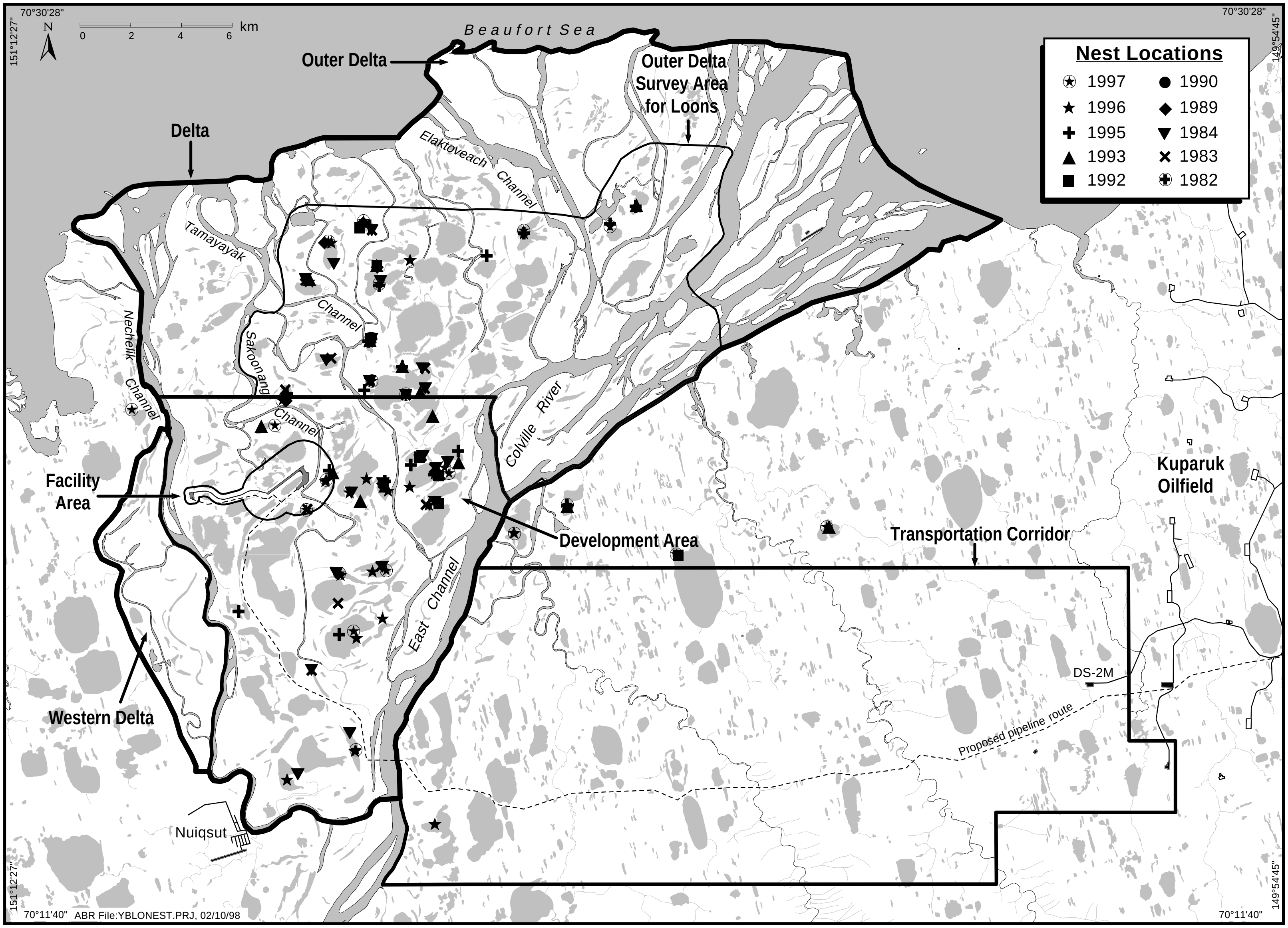

Figure 14. Distribution of Yellow-billed Loon nests observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1982–1984, 1989, 1990, 1992, 1993, and 1995–1997.

Table 23. Numbers and densities of loons and their nests counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, and 1995–1997 (Johnson et al. 1997, this study).

		Yellow-billed Loon				Pacific Loon[a]		Red-throated Loon[a]	
		Number		Number/km²		Number		Number	
Area	Year	Birds	Nests	Birds	Nests	Birds	Nests	Birds	Nests
Delta (324 km²)									
	1997	48	10 (14)[b]	0.15	0.03 (0.04)[b]	103	26	6	1
	1996	46	12 (17)[b]	0.14	0.04 (0.05)[b]	74	18	4	2
	1995	39	11	0.12	0.03	62	10	11	0
	1993	49	11	0.15	0.03	130	24	44	0
	1992[c]	12	2	0.10	0.02	5	3	2	0
Development Area (169 km²)									
	1997	29	6 (8)[b]	0.17	0.04 (0.05)[b]	61	14	0	0
	1996	30	8 (11)[b]	0.18	0.05 (0.07)[b]	59	13	1	0
	1995	24	5	0.14	0.03	33	4	8	0
	1993	28	7	0.17	0.04	81	17	12	0
	1992[c]	4	1	0.15	0.04	0	0	0	0
Facility Area (9 km²)									
	1997	2	0	0.22	0	2	0	0	0
	1996	3	1	0.32	0.11	4	1	0	0
	1995	2	1	0.22	0.11	0	0	0	0
	1993	2	1	0.22	0.11	10	1	0	0
	1992[c]	-	-	-	-	-	-	-	-
Outer Delta[d] (155 km²)									
	1997	19	4 (6)[b]	0.12	0.03 (0.04)[b]	42	12	6	1
	1996	15	4 (6)[b]	0.10	0.03 (0.04)[b]	15	5	3	2
	1995	15	6	0.10	0.04	29	6	3	0
	1993	21	4	0.14	0.03	49	7	32	0
	1992[c]	8	1	0.09	0.01	5	3	2	0
Transportation Corridor (343 km²)									
	1997	3	0	0.01	0	44	9	0	0
	1996	5	0 (1)[b]	0.01	0 (<0.01)[b]	31	14	0	0
	1995[e]	4	0	0.01	0	88	7	0	0
	1993	0	0	0	0	140	10	7	0
	1992[c]	-	-	-	-	-	-	-	-

[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] Number or density of nests found on initial survey and, in parentheses, cumulative number or density found after revisiting locations where loons, but no nests, were seen.

[c] In 1992, three plots were sampled; 119 km² were surveyed on the Delta, 93 km² were surveyed on the Outer Delta, 26 km² were surveyed in the Development Area, and the Transportation Corridor and the Facility Area were not surveyed.

[d] Portion of the Outer Delta described as the Loon Outer Delta survey area in Figure 14.

[e] In 1995, the Transportation Corridor was 274 km² in area.

from brood locations) for the delta occurred in 1996 and was similar to the 19 and 20 nests found during intensive ground surveys in 1983 and 1984, respectively (North and Ryan 1989).

In the Development Area, we counted 29 Yellow-billed Loons and 6 nests on the aerial nesting survey in 1997. Densities of both loons and their nests in the Development Area in 1992, 1993, and 1995–1997 varied little among years (Table 23). The addition of the nests that we found during revisits in 1996 and 1997 resulted in nests densities of 0.05 and 0.07 nests/km^2, respectively. We found the majority of nests in the north-central and northeastern part of the Development Area (Figure 14). In 1992, we found one nest in our survey plot that was in the northeastern part of the Development Area.

In the Facility Area in 1997, we saw one pair of Yellow-billed Loons but found no nests during the nesting survey conducted from a fixed-wing aircraft. In previous years, we counted a similar number of loons in the Facility Area during the nesting survey (Table 23). Five days after the aerial survey in 1997, we conducted an intensive helicopter survey of the Facility Area and found an adult on a nest (Figure 10). We also found this nest during the ground survey. The nest was later judged to be successful when young were seen nearby. In 1983, a nest was found on the same lake (North et al. 1983), and in 1996, a brood was seen on this lake, suggesting that nesting occurred that year. In 1993, 1995, and 1996, we found a Yellow-billed Loon nest on another lake in the Facility Area, east of the Sakoonang Channel (Figure 14). We did not see any loons or find a nest on that lake during aerial or ground surveys in 1997, although another ground crew found a nest on that lake (S. Earnst, unpubl. data). Reoccupation of territories on the Colville Delta by the same Yellow-billed Loons was suspected by North and Ryan (1988) in 1983 and 1984, when many pairs used the same nest bowl or nested in the same vicinities during those years (North and Ryan 1989).

The distribution and abundance of Yellow-billed Loons on the Outer Delta (i.e., Loon Outer Delta survey area, Figure 14) similar among years, especially 1996 and 1997, when the locations of four nests stayed the same. Most loons and nests found on aerial surveys in 1996 and 1997 were confined to the area between the Tamayayak and Elaktoveach channels (Figure 14). Two nest sites found in 1993 and 1995 were east of the Elaktoveach Channel. Other researchers on the delta in 1997 found a nest east of the Elaktoveach Channel in the same location as one nest from 1995 (S. Earnst, unpubl. data). Densities of Yellow-billed Loons on the Outer Delta ranged from 0.09 to 0.14 birds/km^2 for all years of our study. Nest densities were similar among years except for 1992, when only one nest was found in one of the two survey plots on the Outer Delta (Table 23).

Our loon surveys focused on Yellow-billed Loons, which tend to nest on large lakes (>10 ha). Consequently, the survey route flown did not provide complete coverage of smaller waterbodies, which are frequented by Pacific and Red-throated loons. Opportunistic counts of Pacific and Red-throated loons reflect their general distribution among areas but are not indicative of the relative abundance of these species (due to biases in species detectability) or annual changes in abundance (because of annual variation in survey intensity) (Figure 15, Table 23). Therefore, we have not calculated densities for these two species.

Pacific and Red-throated loons are more difficult to detect from aircraft than are Yellow-billed Loons because their smaller size and use of lakes with emergent vegetation decrease their detectability from aircraft. We flew the lake-to-lake survey pattern during the nesting season at a higher intensity (i.e., smaller lakes also were surveyed) in 1993 than in 1995–1997. This difference in survey intensity is reflected in the higher counts of Pacific and Red-throated loons in 1993. Although our counts are not adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon on the delta during each year of study and nesting was most common in the western and central part of the delta (Figure 15, Table 23). Summarizing ground surveys on the delta, Rothe et al. (1983) reported similar findings and suggested that Pacific and Red-throated loon densities on the Colville Delta were comparable to other areas in the Arctic Coastal Plain. Density estimates from sample plots in 1981 were 1.5 birds/km^2 for Pacific Loons and 0.6 birds/km^2 for Red-throated Loon (Rothe et al. 1983). Compared with these figures from the delta, Bergman and Derksen (1977) found similar Pacific Loon densities (1.6 birds/km^2) but higher Red-throated Loon densities (1.2–1.6 birds/km^2) during

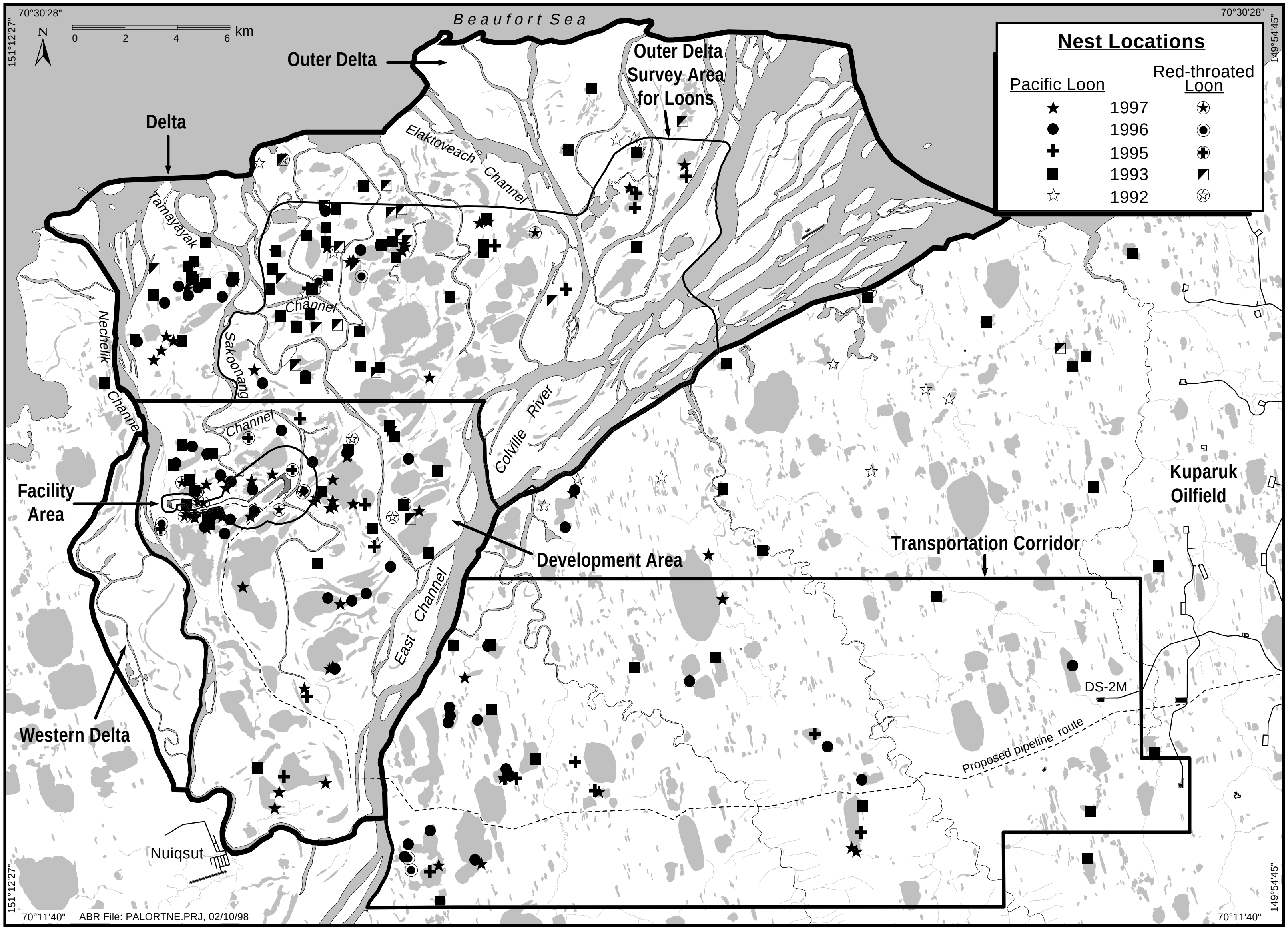

Figure 15. Distribution of Pacific and Red-throated loon nests observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, and 1995–1997

five years of study at Storkersen Point, 70 km east of the Colville Delta.

In 1996 and 1997, we surveyed the Facility Area (9 km^2) and the surrounding vicinity intensively during aerial and ground surveys and recorded nest locations for Pacific and Red-throated loons (Figure 10). In 1997, we found six Pacific and four Red-throated loon nests, up from four Pacific and one Red-throated loon nests in 1996. Within the larger ground-search area (14 km^2) in 1997, which includes the Facility Area, we found 16 Pacific Loon nests and 7 Red-throated Loon nests. Of the eight Pacific Loon nests that we revisited in 1997, we determined that five nests hatched successfully and three nests failed (62% success). Of the seven Red-throated Loon nests we revisited, three nests were successful, three were failed, and one had an unknown fate (43–50% success).

In 1996, in a ground-search area of similar size (17 km^2), we found 13 Pacific Loon nests and 2 Red-throated Loon nests, although we assumed from the number of broods seen in that area that 4 more Red-throated Loon nests were in the area. The nest density of Pacific and Red-throated loons in this area was 1.1 nests/km^2 and 0.5 nests/km^2, respectively, in 1997, and 0.8 nests/km^2 and 0.4 nests/km^2, respectively, in 1996. Similar densities were reported by Bergman and Derksen (1977) for Pacific Loons and Red-throated Loons at Storkersen Point. In 1993 and 1995, we also conducted both aerial and ground surveys of the Facility Area but not at the intensity of the 1996 and 1997 surveys. In 1993, we found one Pacific Loon nest on an aerial survey and in 1995, we found one Red-throated Loon nest during the ground survey.

Transportation Corridor—During the 1997 aerial nesting survey, we counted three Yellow-billed Loons in the Transportation Corridor, all in large lakes in the western part of the corridor (Table 23). We saw a similar number of loons in the Transportation Corridor in 1995 and 1996, and most were seen in the same area as the birds in 1997 (Figure 14). We saw no Yellow-billed Loons on the aerial survey in 1993, and we did not survey the Transportation Corridor in 1992. In 1996, we found a Yellow-billed Loon nest in the western part of the Transportation Corridor. That nest was the only nest we found in the Transportation Corridor during four years of surveys. In 1997, we also found four nests north of the Transportation Corridor (Figure 14). Each of these nest locations had been used by Yellow-billed Loons during one of the previous years of study (Johnson et al. 1997).

Pacific Loons and their nests were common in the Transportation Corridor in 1997, whereas Red-throated Loons were not seen on the aerial survey (Figure 15, Table 23). Survey intensity varied both among years and between the delta and the Transportation Corridor, therefore, we cannot compare the distribution and abundance of these loon species among years within the Transportation Corridor, nor can we compare between the delta and the Transportation Corridor. In 1995–1997, we selectively surveyed large lakes in the Transportation Corridor and consequently, we undercounted these species. In 1993, we included smaller lakes in the aerial survey and recorded 3× as many Pacific Loons as in 1997.

Brood-rearing

Delta—The distribution of brood-rearing Yellow-billed Loons on the Colville Delta in 1997 was similar to that during nesting (Figure 16). We counted 65 adult Yellow-billed Loons and 5 broods on the 1997 brood-rearing survey; all broods were associated with nesting lakes located during the nesting survey. Most nesting lakes where we did not find broods were still occupied by Yellow-billed Loon pairs. Adults with young remain on or near the nest lake during brood-rearing (North and Ryan 1989), while non-nesting and failed breeders maintain their territories throughout the summer (North and Ryan 1988). The density of Yellow-billed Loons on the delta during brood-rearing in 1995, 1996, and 1997 was nearly twice that in 1992 and 1993 (Table 24). In 1995–1997, we conducted intensive surveys that used a helicopter, rather than a fixed-wing aircraft, as the survey platform; this difference probably contributed to the higher bird count in those years.

Brood density on the delta was relatively stable during the five years of surveys, ranging from 0.01 to 0.03 broods/km^2 (Table 24). In 1993, 1996, and 1997, we counted five to seven broods. In 1992, we found only one brood during surveys of our three sample plots. The most productive year for brood-rearing was 1995, when we counted 11 broods during aerial surveys. This total was similar to the number

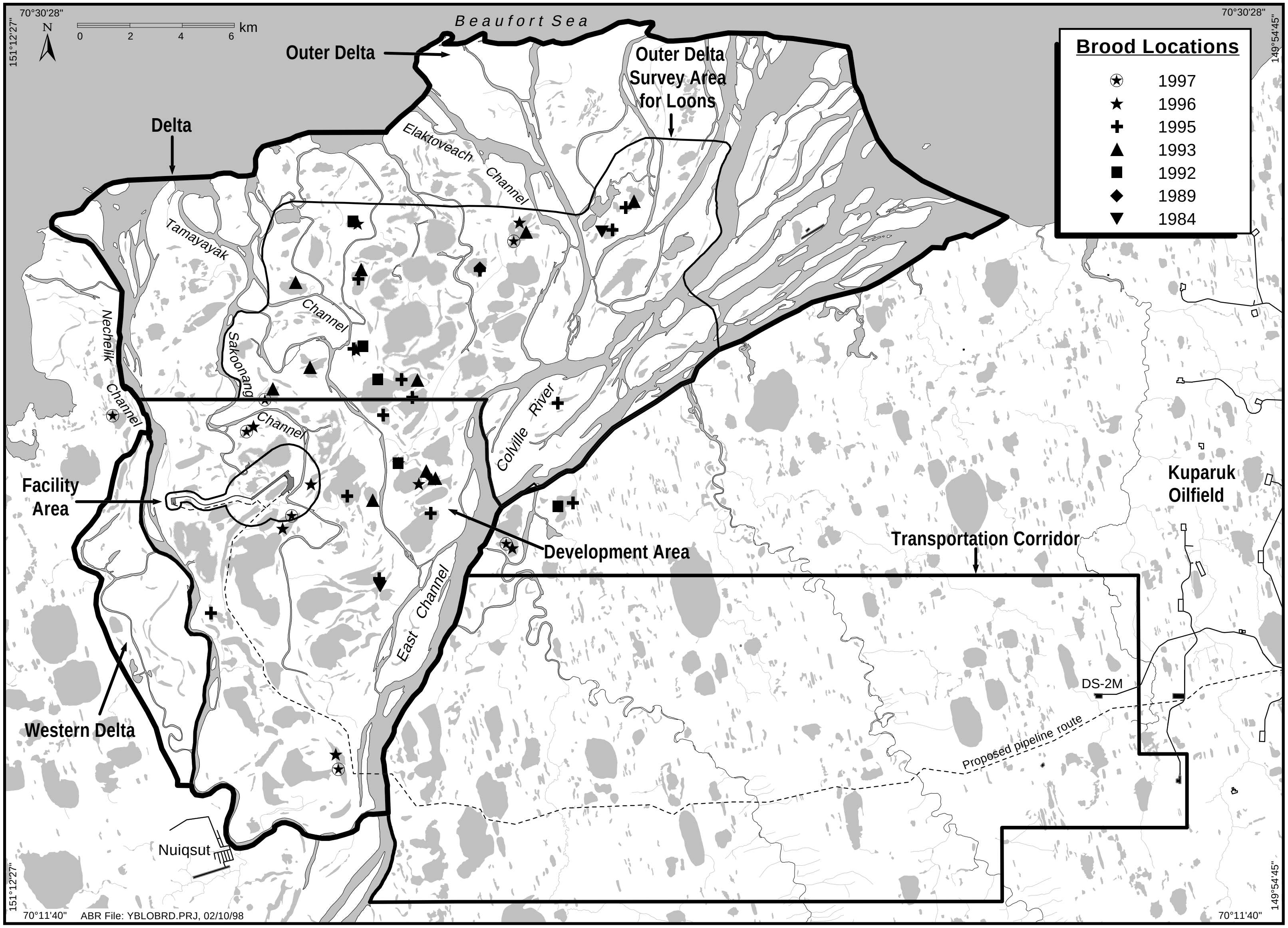

Figure 16. Distribution of Yellow-billed Loon broods observed during aerial and ground surveys in the Delta survey area, Colville River Delta, Alaska, 1984, 1989, 1992, 1993, and 1995–1997.

Table 24. Numbers and densities of loons and their broods counted on aerial surveys conducted by fixed-wing aircraft in 1992 and 1993, and by helicopter in 1995–1997, in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska (Johnson et al. 1997, this study).

		Yellow-billed Loon					Pacific Loon[a]			Red-throated Loon[a]		
		Number			Number/km²		Number			Number		
Area	Year	Adults	Broods	Young	Birds	Broods	Adults	Broods	Young	Adults	Broods	Young
Delta (324 km²)												
	1997	65	5	8	0.20	0.02	153	15	17	24	5	6
	1996	62	6	6	0.19	0.02	89	25	30	19	6	9
	1995	49	11	15	0.15	0.03	182	34	40	49	7	9
	1993	29	7	7	0.09	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 km²)												
	1997	38	4	7	0.23	0.02	91	12	14	19	5	6
	1996	30	3	3	0.18	0.02	69	21	26	13	5	8
	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	10	1	1	7	0	0
Facility Area (9 km²)												
	1997	4	1	2	0.44	0.11	2	0	0	2	1	2
	1996	0	0	0	0	0	6	2	3	1	0	0
	1995	0	0	0	0	0	2	1	2	0	0	0
	1993	0	0	0	0	0	0	0	0	0	0	0
Outer Delta[c] (155 km²)												
	1997	27	1	1	0.17	0.01	62	3	3	5	0	0
	1996	32	3	3	0.21	0.02	20	4	4	6	1	1
	1995	24	7	9	0.16	0.05	92	22	26	44	6	8
	1993	14	4	4	0.09	0.03	21	1	1	0	0	0
	1992[b]	3	1	1	0.03	0.01	11	5	5	14	0	0
Transportation Corridor (343 km²)												
	1997	13	0	0	0.04	0	56	3	3	1	0	0
	1996	3	0	0	0.01	0	42	11	14	0	0	0
	1995[d]	7	0	0	0.03	0	185	15	18	9	0	0
	1993	5	0	0	0.01	0	0	0	0	0	0	0

[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 km² were surveyed on the Delta, 93 km² were surveyed on the Outer Delta, 26 km² were surveyed in the Development Area, and the Transportation Corridor and the Facility Area were not surveyed.
[c] Portion of the Outer Delta described as the Loon Outer Delta survey area in Figure 14.
[d] In 1995, the Transportation Corridor was 274 km² in area.

of broods (12) found by North (1986, derived from Table 10) during intensive ground surveys of the delta in 1984. In both 1995 and 1997, we observed broods that contained >1 young. At the time of our brood-rearing surveys, chicks were about 2 to 6 weeks of age, based on estimated hatch dates from 11 to 28 July (North and Ryan 1988).

We counted 38 adult Yellow-billed Loons and 4 broods in the Development Area during the 1997 brood-rearing survey (Figure 16). In the years when we surveyed the Development Area in its entirety, the density of Yellow-billed Loons increased from 1993 to 1997 (Table 24), but brood densities remained similar among years (0.02 broods/km^2). The increase in adult density from 1993 to 1995 possibly was due to the change in the survey platform from fixed-wing aircraft to helicopter. The decrease in adult density from 1996 to 1997 was a result of a shift in use between years from the Outer Delta to the Development Area: loon densities of the entire delta were similar in both years but differed within the two subareas. The highest density of loons (0.30 birds/km^2) was based on the number of loons seen in 1992 within a 26-km^2 survey plot, which was not representative of the entire Development Area (169 km^2).

During the aerial brood-rearing survey in the Facility Area in 1997, we saw two pairs of Yellow-billed Loons, one with a brood of two young (Figure 12). This year is the first time that we found Yellow-billed Loons in the Facility Area during the aerial brood-rearing survey (Table 24), although we have seen Yellow-billed Loons in previous years on lakes intersected by the Facility Area boundary. On ground surveys, however, we saw Yellow-billed Loons in the Facility Area every year from 1995 to 1997 (1997 locations in Figure 17). In 1996, we found two broods during ground surveys; one was on the same lake as the 1997 brood, but outside of the Facility Area boundary, and another was on a nesting lake in the eastern part of the Facility Area. We found no broods in the Facility Area in 1993 or 1995.

On the Outer Delta, we counted 27 Yellow-billed Loons and found 1 brood in 1997 (Figure 16). The density of adults in 1997 was relatively similar to 1995 and 1996, years when we also used a helicopter as the survey platform (Table 24). In 1993, when we surveyed the Outer Delta by fixed-wing aircraft, the density of adults was about half that in 1995–1997, and in 1992, when we surveyed sample plots, the density was about one-sixth that in 1995–1997. Brood densities varied among our five years of study on the Outer Delta, regardless of the survey method. The density in 1997 (0.01 broods/km^2), however, was the lowest that we have recorded. The highest density of broods on the Outer Delta was recorded in 1995 (0.05 broods/km^2) when we counted seven broods.

In 1997, we found Pacific and Red-throated loons and their broods throughout the Delta survey area (Figure 18). The numbers of birds and broods for both species were higher in the Development Area than on the Outer Delta in 1996 and 1997 (Table 24). These numbers, however, were not representative of the actual number of Pacific and Red-throated loons with broods. These loon species can rear their young on smaller waterbodies than Yellow-billed Loons; because our survey did not include all waterbodies, some broods were missed. Moreover, because our survey intensity for these smaller waterbodies varied among years and survey coverage was never complete, we cannot compare annual abundance or calculate densities for these two species.

During combined aerial and ground surveys of the Facility Area in 1997, we did not find any Pacific Loon broods in the Facility Area, although we did see 9 broods and a total of 12 young in the larger ground-search area (27 km^2, Figure 12). In 1996, we found 4 Pacific Loon broods and 6 young in the Facility Area, and 12 broods and 17 young in the ground-search area for that year (18 km^2). For Red-throated Loons in 1997, we found two broods with two young each in the Facility Area and an additional two broods with one young each in the larger ground-search area. In 1996, we counted three Red-throated Loon broods in the Facility Area and three additional broods within the ground-search area; all broods had one young, except for one with two young. In 1995, we counted five Pacific Loons broods and no Red-throated broods on combined aerial and ground surveys, and in 1993, we found one Pacific Loon brood and one Red-throated Loon brood during a ground survey.

Transportation Corridor—In 1997, we counted 13 adult Yellow-billed Loons during the aerial survey

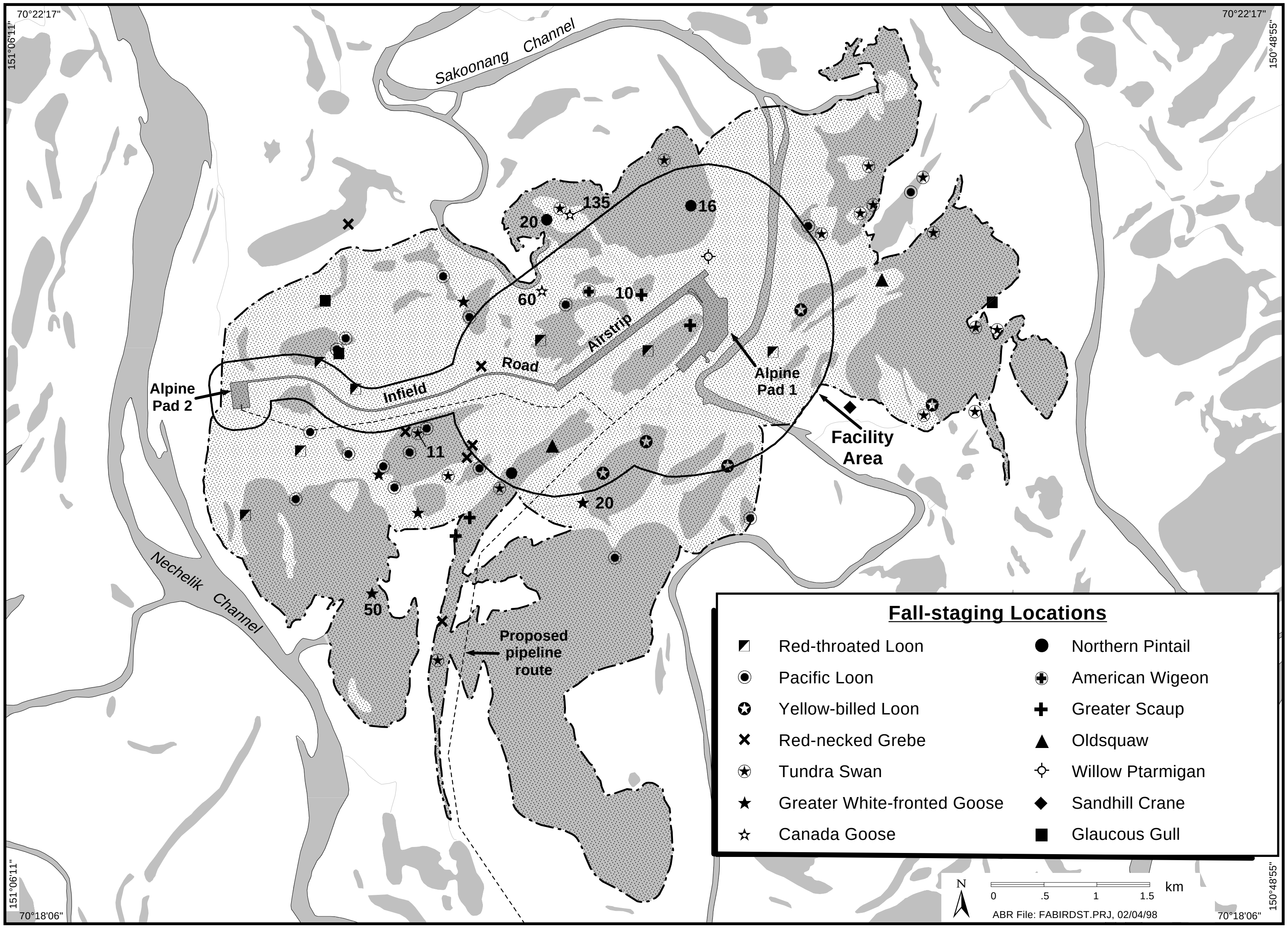

Figure 17. Distribution of fall-staging groups of various waterbirds observed during ground surveys near the Facility Area, Colville River Delta, Alaska, August 1997.

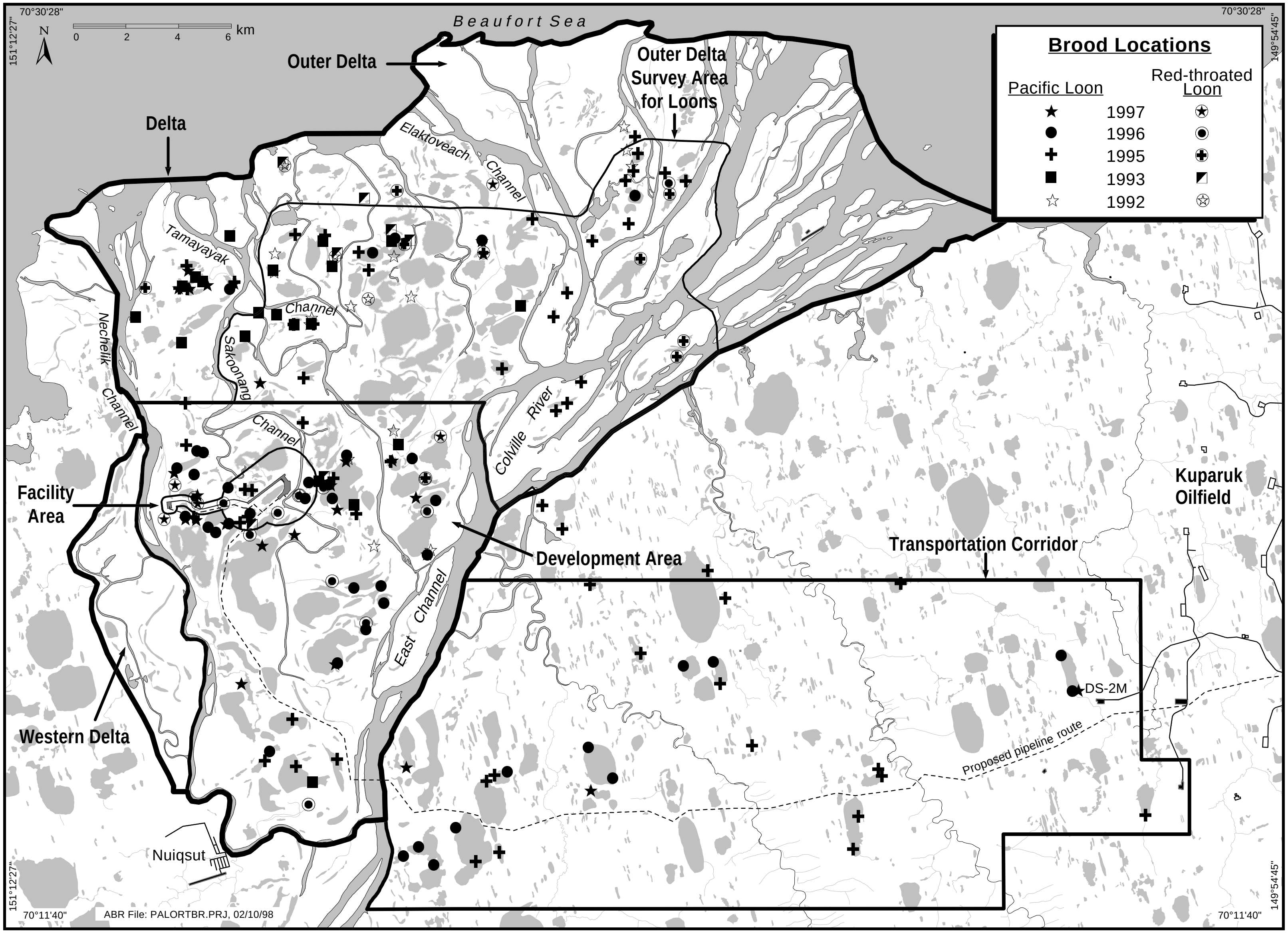

Figure 18. Distribution of Pacific and Red-throated loon broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, and 1995–1997.

in the Transportation Corridor, but none had broods. We saw seven of the birds (as pairs and singles) in the western part of the corridor and found the remaining six in a flock in a large lake in the north-central part of the corridor. In other years when the Transportation Corridor was surveyed (1993, 1995, 1996), we counted from three to seven loons, none with broods, and all in similar locations to those in 1997 (Table 24). During aerial surveys in 1992 and 1995–1997, we found one Yellow-billed Loon brood in each year north of the Transportation Corridor in one of two nesting lakes near the East Channel of the Colville River (Figure 15).

During the aerial brood-rearing survey in 1997, we saw 56 adult Pacific Loons and 3 broods in the Transportation Corridor (Figure 18, Table 24). This count represents only the number that we encountered opportunistically along our survey route and does not represent the total number using the Transportation Corridor. Our survey route was similar to that in 1996, when we saw a similar number of Pacific Loons, but we counted more broods in 1996 than in 1997. In 1995, when we conducted an intensive survey in the Transportation Corridor during the brood-rearing season, we saw 185 adult Pacific Loons and 15 broods. Although the number of broods was similar in 1995 and 1996, the number of adults was four times greater in 1995, and may have included a large number of nonbreeding or staging individuals. In 1993, no Pacific Loons were seen during a cursory search of the Transportation Corridor; the Transportation Corridor was not surveyed in 1992. We rarely saw Red-throated Loons in the Transportation Corridor during the four years of surveys: only nine in 1995 and one in 1997, none of which had broods.

HABITAT SELECTION

Nesting

Delta—During four years of aerial surveys on the delta (1993, 1995–1997), 53 Yellow-billed Loon nests were found in 7 of 19 available habitats (Table 25). Habitat selection values for 1997 are reported in Appendix C5, and values for previous years were reported by Johnson et al. (1996, 1997). Three preferred habitats accounted for 35 (66%) of the 53 nests: Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, and Wet Sedge–Willow Meadow. Nests were built on peninsulas, shorelines, islands, or in emergent vegetation, of which the latter two could be classified as part of a waterbody at the scale of our habitat map. Wet Sedge–Willow Meadow was the habitat most frequently used for nesting (21 nests or 40% of all nests), and it was the most abundant habitat on the delta (25% of total area). A larger sample of nests (combined from aerial and ground surveys) confirmed the importance of Wet Sedge–Willow Meadow; it was used 3.5 times as frequently (46% of all nests) as any other habitat (Table 26). Three habitats significantly avoided by nesting Yellow-billed Loons—River or Stream, Riverine or Upland Shrub, and Barrens—were unused and occupied a large portion of the delta (35% of the total).

Because Yellow-billed Loons usually raise broods on the lakes where they nest, forage in lakes within their territories, and use lakes for escape habitat, waterbodies adjacent to nest sites are probably more important than the habitats on which the nests actually are built. To evaluate which waterbodies were used most commonly by Yellow-billed Loons during nesting, we measured the distance from the nest to the nearest waterbody on the digitized map and summarized the distance by waterbody type (Table 26). Average distance to the nearest waterbody habitat was 0.01 km (polygon ponds were not mapped individually and, therefore, are not included as waterbodies). Nests were found at similar distances to water during three other studies on the Arctic Coastal Plain (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989). Nests found during our study occurred most commonly near Deep Open Water without Islands (51% of all nests), Tapped Lake with High-water Connection (27%), and Deep Open Water with Islands or Polygonized Margins (18%).

North (1986) found that similar waterbody types were used by nesting Yellow-billed Loons on the Colville Delta in 1983 and 1984. Eleven (48%) of 23 nests occurred on Deep-*Arctophila* lakes, 9 (39%) were on Deep-Open lakes, and 1 (0.04%) each were on ponds <0.5 ha, ponds 0.5-1.0 ha, and shallow lakes >1.0 ha with emergent sedge or grass. Deep lakes as described by North (1986) include the two Deep Open Water types and Tapped Lakes with High-water Connections that we have described.

Table 25. Habitat selection (pooled among years) by nesting Yellow-billed Loons in the Delta survey area, Colville River Delta, Alaska, 1993 and 1995–1997 (Johnson et al. 1997, this study). See Appendix C5 for 1997 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	ns
Tapped Lake w/Low-water Connection	19.38	0	0	6.0	-1.00	ns
Tapped Lake w/High-water Connection	19.57	8	15.1	6.1	0.42	prefer
Salt Marsh	5.64	0	0	1.7	-1.00	ns
Tidal Flat	0.06	0	0	<0.1	-1.00	ns
Salt-killed Tundra	7.48	0	0	2.3	-1.00	ns
Deep Open Water w/o Islands	21.09	7	13.2	6.5	0.34	ns
Deep Open Water w/Islands or Polygonized Margins	3.58	6	11.3	1.1	0.82	prefer
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	ns
Shallow Open Water w/Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	ns
River or Stream	38.33	0	0	11.9	-1.00	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	10.00	5	9.4	3.1	0.51	ns
Aquatic Grass Marsh	1.20	1	1.9	0.4	0.65	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	5	9.4	9.2	0.01	ns
Wet Sedge–Willow Meadow	80.84	21	39.6	25.0	0.23	prefer
Moist Sedge–Shrub Meadow	9.10	0	0	2.8	-1.00	ns
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	ns
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	avoid
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	avoid
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	53	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Although North and Ryan (1988) reported that Yellow-billed Loons did not nest on tapped lakes, they did not discriminate Tapped Lakes with High-water Connections, which may appear to be untapped because they commonly are connected to channels by low, vegetated areas that do not flood every year. The small waterbodies where North (1986) found nests probably correspond to our Aquatic Sedge with Deep Polygons, Shallow Open Water without Islands, and Aquatic Grass Marsh. Consistent with our observations, North (1986) found that nests on small waterbodies (<10 ha) always were near (<70 m) larger waterbodies.

Transportation Corridor—In 1997, we did not find any Yellow-billed Loon nests in the Transportation Corridor. We did, however, find one Yellow-billed Loon nest in the Transportation Corridor in 1996. That nest was in Nonpatterned Wet Meadow and was located 0.02 km from Deep Open Water without Islands. Nests have not been found in the Transportation Corridor during other survey years, although nests were found north of this area (Figure 14).

Brood-rearing

Delta—During aerial surveys in 1995–1997, we found 22 Yellow-billed Loon broods in three habitats on the delta (Tapped Lake with High-water Connection and both types of Deep Open Water), of which only the two types of Deep Open Water were preferred (Table 27). Deep Open Water without Islands was used eight times as often as Deep Open

Table 26. Habitat use by nesting Yellow-billed Loons and distance to nearest waterbody based on aerial and ground surveys in the Delta and Transportation Corridor survey area, Colville River Delta, Alaska, 1992, 1993, and 1995–1997 (S. Earnst 1995–1997, unpubl. data; Johnson et al. 1997; this study).

Habitat	No. of Nests	Use (%)	Mean Distance to Waterbody[a] (km)
HABITAT USED			
Tapped Lake w/High-water Connection	10	12.3	
Deep Open Water w/o Islands	8	9.9	
Deep Open Water w/Islands or Polygonized Margins	9	11.1	
Aquatic Sedge w/Deep Polygons	8	9.9	
Aquatic Grass Marsh	1	1.2	
Nonpatterned Wet Meadow	7	8.6	
Wet Sedge–Willow Meadow	37	45.7	
Moist Sedge–Shrub Meadow	1	1.2	
Total	81	100	
NEAREST WATERBODY HABITAT			
Tapped Lake w/High-water Connection	22	27.2	<0.01
Deep Open Water w/o Islands	41	50.6	0.01
Deep Open Water w/Islands or Polygonized Margins	15	18.5	<0.01
Shallow Open Water w/o Islands	2	2.5	0.01
Aquatic Grass Marsh	1	1.2	0
Total	81	100	0.01

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

Water with Islands or Polygonized Margins (73% vs. 9% of all broods, respectively). No shallow water habitats were used during brood-rearing. Wet Sedge–Willow Meadow and Barrens, the two most abundant habitats in the survey area, were the only habitats avoided during brood-rearing on the delta. The concurrence of habitats preferred during nesting and brood-rearing reaffirms the importance of large, deep waterbodies to breeding Yellow-billed Loons. North (1986) found that similar lake types were used during brood-rearing in 1983 and 1984. Small lakes (<13.4 ha) were not used during brood-rearing, but coastal wetlands (probably equivalent to our Tapped Lake with High-water Connection or Brackish Water) were used by two broods (North 1986).

Transportation Corridor— We found no broods of Yellow-billed Loons in the Transportation Corridor during any year of survey.

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 on the Arctic Coastal Plain of Alaska (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983). Brant arrive on the 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 (>950; Martin and Nelson 1996) on the delta are located within a colony or group of colonies (hereafter, the Anachlik Colony-complex) consisting of at least nine islands centered around Anachlik Island near the mouth of the East Channel (Simpson et al. 1982, Renken et al. 1983, Martin and Nelson 1996). Brant began nesting at the Anachlik Colony-complex in the 1960s, nesting first on Anachlik Island, but expanding to Char, Brant, and Eskimo islands by the late 1970s–early 1980s (Martin and

Table 27. Habitat selection (pooled among years) by Yellow-billed Loons during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1995–1997 (Johnson et al. 1997, this study). See Appendix C5 for 1997 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	ns
Tapped Lake w/Low-water Connection	19.38	0	0	6.0	-1.00	ns
Tapped Lake w/High-water Connection	19.57	4	18.2	6.1	0.50	ns
Salt Marsh	5.64	0	0	1.7	-1.00	ns
Tidal Flat	0.06	0	0	<0.1	-1.00	ns
Salt-killed Tundra	7.48	0	0	2.3	-1.00	ns
Deep Open Water w/o Islands	21.09	16	72.7	6.5	0.84	prefer
Deep Open Water w/Islands or Polygonized Margins	3.58	2	9.1	1.1	0.78	prefer
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	ns
Shallow Open Water w/Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	ns
River or Stream	38.33	0	0	11.9	-1.00	ns
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	10.00	0	0	3.1	-1.00	ns
Aquatic Grass Marsh	1.20	0	0	0.4	-1.00	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	0	0	9.2	-1.00	ns
Wet Sedge–Willow Meadow	80.84	0	0	25.0	-1.00	avoid
Moist Sedge–Shrub Meadow	9.10	0	0	2.8	-1.00	ns
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	ns
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	ns
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	avoid
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	22	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Nelson 1996). These four islands remain the core of the colony-complex, but Brant now nest in limited numbers on at least five other islands. Additional nesting locations for Brant are scattered across the delta, primarily in the northern half (Smith et al. 1993, 1994; Johnson et al. 1996, 1997).

After eggs hatch in early July, most Brant brood-rearing groups move from nesting areas to salt marshes along the coast. A large percentage (>50%; J. Helmericks, pers. comm.) of brood-rearing groups from the Anachlik Colony-complex moves northeast towards Oliktok and Milne points (Stickney et al. 1994, Anderson et al. 1997). Some remain on Anachlik Island, and others move to the area northwest of the East Channel (J. Helmericks, pers. comm.). Brant from the smaller colonies probably use salt marshes from the Elaktoveach Channel west to 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– to late August (Johnson and Herter 1989). Major river deltas, such as the Colville Delta, provide important resting and feeding areas for Brant at that time (Johnson and Richardson 1981). These fall-staging Brant tend to use areas along the coast that are similar, but not limited, to those used by brood-rearing groups (Smith et al. 1994).

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—During aerial and ground surveys of the Delta survey area in 1997, we counted 92 Brant nests at 19 locations, excluding the Anachlik Colony-complex (Figure 19). We saw 552 Brant on the delta, 547 of which were counted during the aerial survey and 5 of which were seen on the ground survey and were affiliated with nests. Our count of nests was more than twice that seen in 1995 and 1996, and our count of Brant was 5 times greater than that in 1995 and 1996 (Table 28). In 1997, Brant occupied 11 of 19 nesting locations (consisting of ≥1 nest each) previously identified on the delta (excluding the Anachlik Colony-complex) and 8 new nesting locations. Some of the new nesting locations were within a few hundred meters of older locations and may represent a shifting of birds from previous nearby locations. Other nesting locations were at sites where adults were seen in previous years, but no nests were observed. The increase in the total number of nesting colonies in 1997 probably represents normal annual variation in nesting activity by Brant.

The substantial increase in numbers of Brant during nesting in 1997 may represent failed breeders from the Anachlik Colony-complex or failed- or nonbreeders that migrated to the delta from other areas such as the Kuparuk Oilfield or Howe Island in the Sagavanirktok River Delta. This latter colony was disrupted by bear predation during incubation (Lynn Noel, LGL Alaska Research Associates, Anchorage, AK, pers. comm.). Tundra Swans also showed substantial increases in numbers recorded during the nesting surveys (this report), including some swans that were probably failed breeders from the adjacent Kuparuk Oilfield (Anderson et al. 1998a, this report).

We recorded 10 Brant nesting locations in the Development Area during aerial and ground surveys in 1997, substantially greater than the 1-5 colonies counted in previous years (Figure 19; Johnson et al. 1997). One colony, which was used in each of the previous four years, had no nests in 1997, although a new location a few hundred meters southwest had at least seven nests. We found three Brant nesting locations (one nest apiece) in the Facility Area in 1997, and four (one nest each) just outside its boundary (Figure 20); nest success was less than 20%. In both 1995 and 1996, only one nest was found within the Facility Area.

In 1997, almost half (nine) of the Brant nesting locations, excluding the Anachlik Colony-complex, occurred on the Outer Delta (Figure 19). In previous years, we found Brant at two (1992) to seven (1993) colonies in this area. The distributional patterns that we have observed in all years on the delta were consistent with longer-term studies conducted between the Colville and Kuparuk rivers that found that most (≥75%) Brant nest within 5 km of the coast (Stickney et al. 1994); the percentage on the Colville Delta is >90% because of the size of the Anachlik Colony-complex.

Transportation Corridor—Few Brant have been recorded nesting in the Transportation Corridor since we began our survey (Figure 19). In 1997, we counted four Brant and three nests at one colony that was used four out of five years; on another survey in early July, we counted seven nests at this colony. Only two nesting colonies are known in the corridor, and another colony is located just outside of the eastern border. In previous years, we never found >4 nests at any location, so the July count was the largest ever recorded during the study period for a colony in the Transportation Corridor.

Brood-rearing

Delta—Data from both a multi-year banding study in the neighboring oilfields and our surveys indicate that brood-rearing groups of Brant from the Colville Delta disperse as far east as Beechey Point (Anderson et al. 1996, Martin and Nelson 1996), and as far west as the Tingmeachsiovik River (Smith et al. 1994). Within the Delta in 1997, we counted 422 Brant (254 adults/subadults and 168 goslings) at eight locations during a systematic survey for geese (Figure 21, Table 29). The size of Brant flocks during rearing ranged from 16 to 130 birds, and the mean percentage of goslings equaled 41% (range = 0–56%, n = 8) compared to 48–52% in previous years.

The number of Brant observed on the delta during brood-rearing in 1997 was the third lowest count since surveys were started by USFWS in 1988 (Table 29), although the survey methodology in 1997 was not directly comparable to that in previous years. This low number reflected poor productivity at the

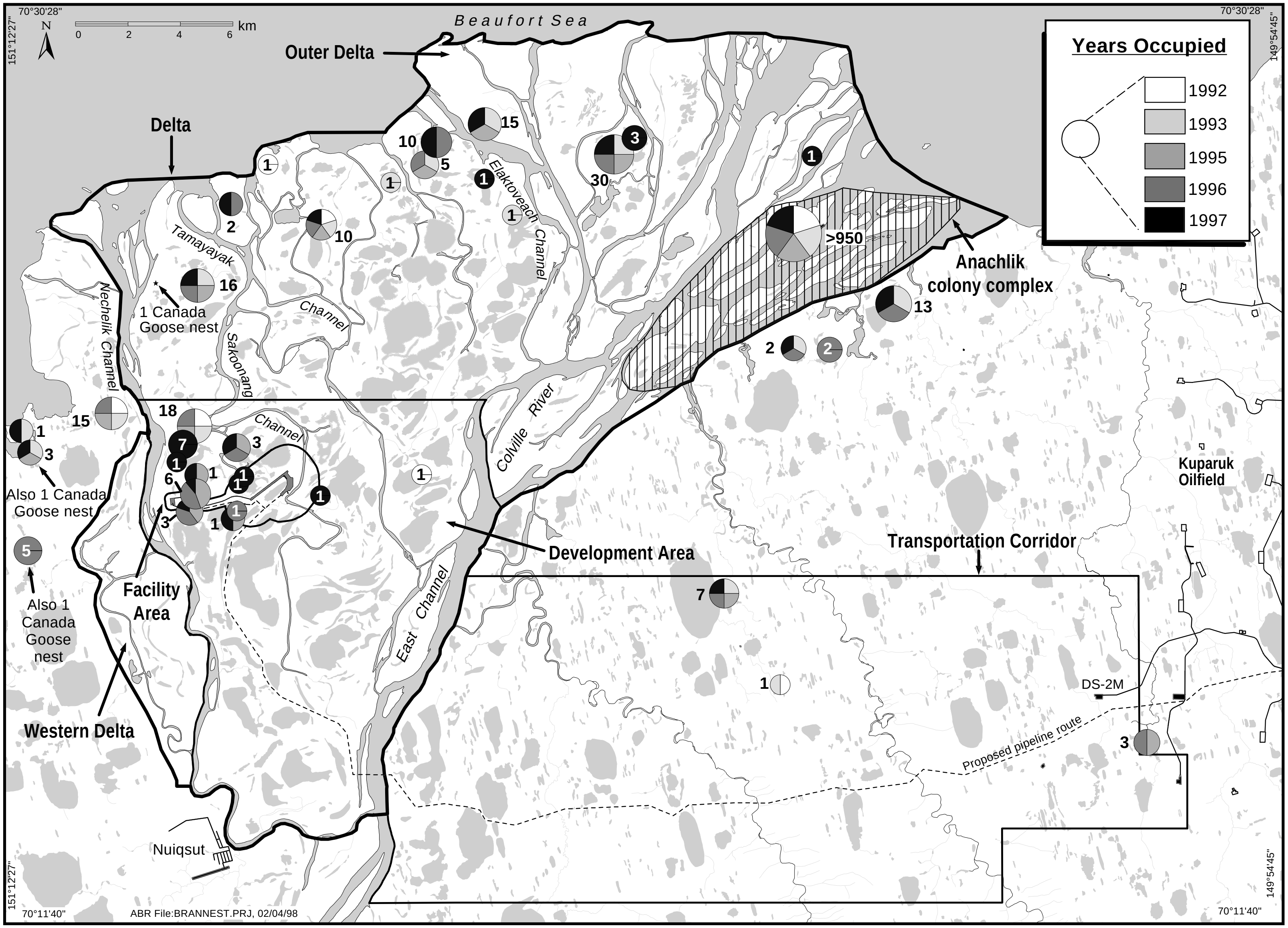

Figure 19. Distribution and nest counts of Brant colonies and Canada Goose nests located during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, and 1995–1997.

Table 28. Distribution and abundance of Brant and nests counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, 1995–1997 (Johnson et al. 1997, this study). The Facility Area combines aerial and ground data.

Survey Area	Year	No. of Locations	No. of Nests	No. of Adults
Delta	1997	14	87	547
	1996	9	34	95
	1995	6	19	72
	1993	6	52	202
	1992	2	8	297
Development Area	1997	5	12	4
	1996	3	20	38
	1995	1	7	18
	1993	1	10	20
	1992	1	5	10
Facility Area	1997	3	3	4
	1996	1	1	1
	1995	1	1	1
	1993	0	0	0
	1992	0	0	0
Outer Delta	1997	9	75	543
	1996	6	14	57
	1995	5	12	54
	1993	5	42	182
	1992	1	3	287
Transportation Corridor	1997	1	3	4
	1996	1	4	10
	1995	1	1	4
	1993	2	5	30
	1992	1	1	11

Anachlik Colony-complex in 1997 (J. Helmericks, pers. comm.). Aerial surveys in the Kuparuk Oilfield also indicated that substantially fewer birds had moved from the Anachlik Colony-complex to brood-rearing areas between Oliktok and Milne points (ABR, unpubl. data). The number of Brant in brood-rearing groups on the delta in 1997 was lower than the number (538 birds) in the adjacent region between the Kuparuk River and Kalubik Creek, which is another destination for brood-rearing groups from the large Anachlik Colony-complex. The largest count of adults and goslings observed during brood-rearing occurred in 1995, when 1,480 birds were seen, and the lowest count occurred in 1992, when only 45 adults and no goslings were seen. The absence of goslings in 1992 was due, in part, to predation of the Anachlik Colony-complex by a bear (J. Helmericks, pers. comm.).

In the Development Area in 1997, we saw one small group of Brant (8 adults, 8 young); however, the predominant pattern for most Brant is to rear their broods along the coast (Stickney and Ritchie 1996). A study in the adjacent Kuparuk Oilfield found four of six radio-tagged Brant that nested inland reared their broods on inland lakes (Stickney 1997). These Brant were in small brood-rearing groups (<10 broods) and represented only a small percentage of total number of brood-rearing Brant in the oilfield.

Transportation Corridor—In the years when we conducted surveys in the Transportation Corridor, we saw no brood-rearing groups of Brant (Figure 21). We also did not observe any Brant in this area during the systematic brood-rearing survey for geese in 1997. This area has none of the salt-adapted vegetation that Brant prefer during brood-rearing.

Wildlife Habitat Types

- Open Nearshore Water (marine)
- Brackish Water
- Tapped Lake w/Low-water Connection
- Tapped Lake w/High-water Connection
- Salt Marsh
- Tidal Flat
- Salt–killed Tundra
- Deep Open Water w/o Islands
- Deep Open Water w/Islands or Polygonized Margins
- Shallow Open Water w/o Islands
- Shallow Open Water w/Islands or Polygonized Margins
- River or Stream
- Aquatic Sedge Marsh
- Aquatic Sedge w/Deep Polygons
- Aquatic Grass Marsh
- Young Basin Wetland Complex
- Old Basin Wetland Complex
- Nonpatterned Wet Meadow
- Wet Sedge–Willow Meadow
- Moist Sedge–Shrub Meadow
- Moist Tussock Tundra
- Riverine or Upland Shrub
- Barrens (riverine, eolian, lacustrine)
- Artificial (water, fill, peat road)

Proposed Facilities

- In-field Facilities
- Pipelines

Brant Nests

- 1997
- 1996
- 1995

Photo-interpretation of habitat types based on 1992 CIR photography
Map registered to SPOT image base map
Projection: UTM Zone 5, Datum NAD 27
ABR File: BrntNeFacHab.PRJ, 10/29/98

N

0 .25 .5 .75 1 km

Figure 20. Brant nests and habitats in the Facility Area, Colville River Delta, Alaska, 1995-1997.

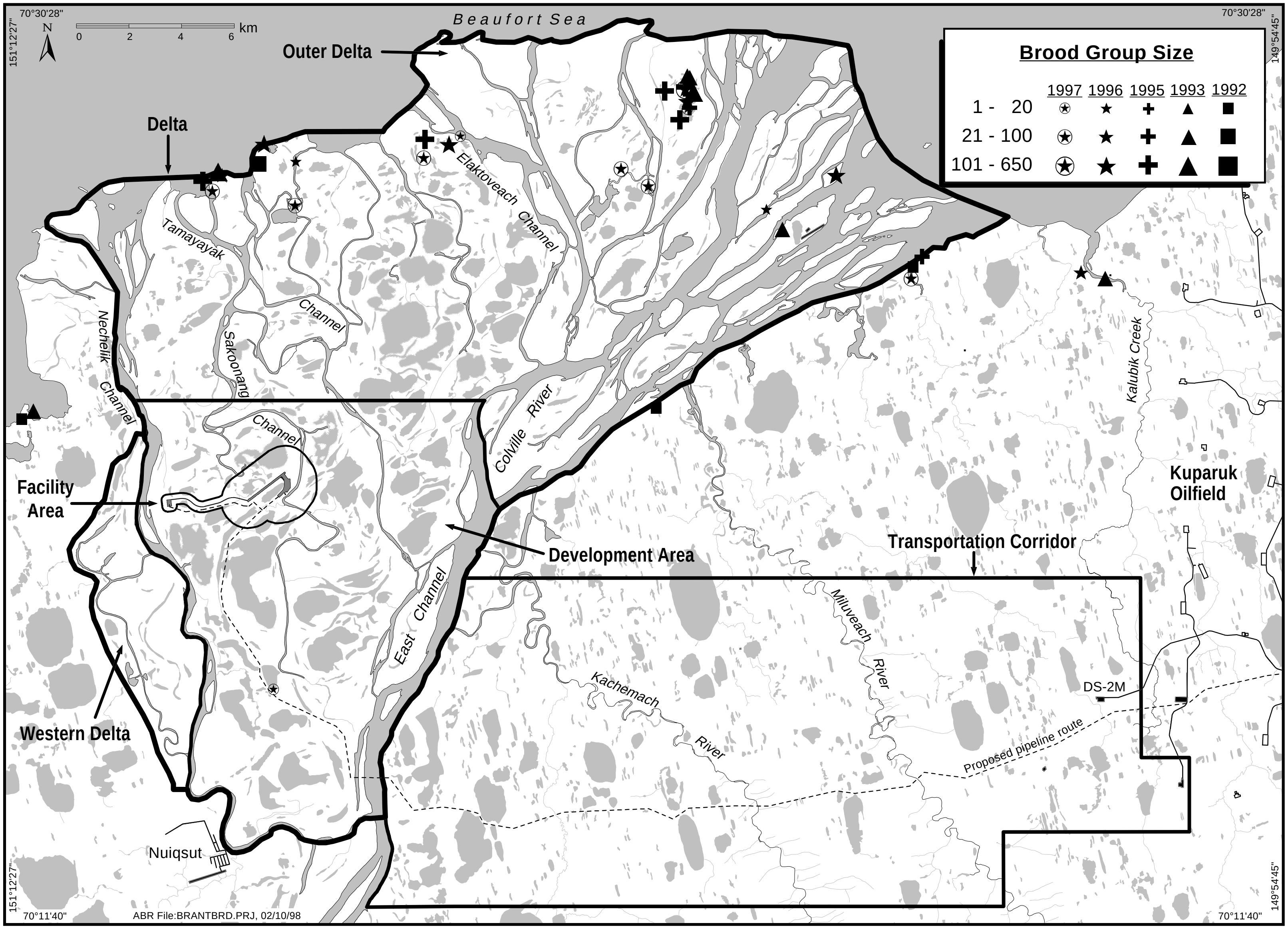

Figure 21. Distribution and size of Brant brood-rearing groups observed during aerial surveys in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, and 1995–1997.

Table 29. Abundance, distribution and percent of goslings of Brant in brood-rearing groups during late July-early August on the Colville River Delta, Alaska. Data for years prior to 1992 are from Bayha et al. (1992); data for 1992, 1993, and 1995–1997 are from ABR (unpubl. data) and this study.

Year	East Channel to Elaktoveach Channel	Elaktoveach Channel to Nechelik Channel	Total Birds	No. of Groups	Percent Goslings
1997	242	180	422	8	40
1996	490	503	993	7	52
1995	1,175	305	1,480	6	48
1993	590	130	720	5	52
1992	0	45	45	2	0
1991[a]	410	100	510	No data	No data
1990[a]	433	195	628	No data	No data
1988[a]	70	103	173	No data	No data

[a] Counts were an average of two surveys except in 1991, when one survey was conducted between the Elaktoveach and Nechelik channels.

The small number of birds that do nest in this area may move to salt marshes between Kalubik Creek and the Miluveach River.

Fall Staging

Delta—During fall staging in 1997, we saw 227 Brant in the 5 locations on the delta, and group sizes ranged from 20 to 80 birds ($\bar{x}$ = 45 birds) (Figure 22). The number of Brant counted on the delta during this coastal survey in 1997 was lower than in 1996 (1,327 birds), 1995 (469 birds), and 1993 (355 birds), but was similar to that in 1992 (200 birds). A systematic, delta-wide survey (50% coverage) for staging geese conducted one day prior to the coastal survey in 1997 recorded 387 Brant at 15 locations. The difference in numbers between surveys could reflect differences in methodology, but more likely indicated variations in use (i.e., some groups seen during the systematic survey had departed the delta prior to the coastal survey).

We saw no Brant either in the Facility Area or Development Area during fall staging in 1997 (Figure 22). In 1996, we saw three groups in the Development Area, and we saw one group just south of the Facility Area in 1995.

Transportation Corridor—In previous years, we have not seen Brant in the Transportation Corridor during fall staging. The systematic staging survey conducted for all geese in 1997 confirmed that Brant do not occur in this area during fall staging, most likely because this area lacks the salt-affected habitats that Brant use during this season.

HABITAT SELECTION

Brant primarily use coastal areas during nesting, brood-rearing, and fall staging (Figures 19, 21, and 22). 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 (low numbers in these areas may result from a lack of suitable habitat). Therefore, we restricted our analysis to those portions of the Outer Delta that we surveyed completely in 1992, 1993, and 1995–1997; the brood-rearing analysis included 1992, 1993, 1995, and 1996 (in 1997, we did not conduct a comparable coastal survey), but differed from the analysis conducted the previous year in that the number of iterations performed during the Monte Carlo simulation was increased from 500 to 1,000.

Nesting

Thirteen colonies (excluding the Anachlik Colony-complex) comprising 87 nests (maximal estimate among all years) have been used by nesting Brant in that part of the Outer Delta that was surveyed consistently among years (Table 30). At those

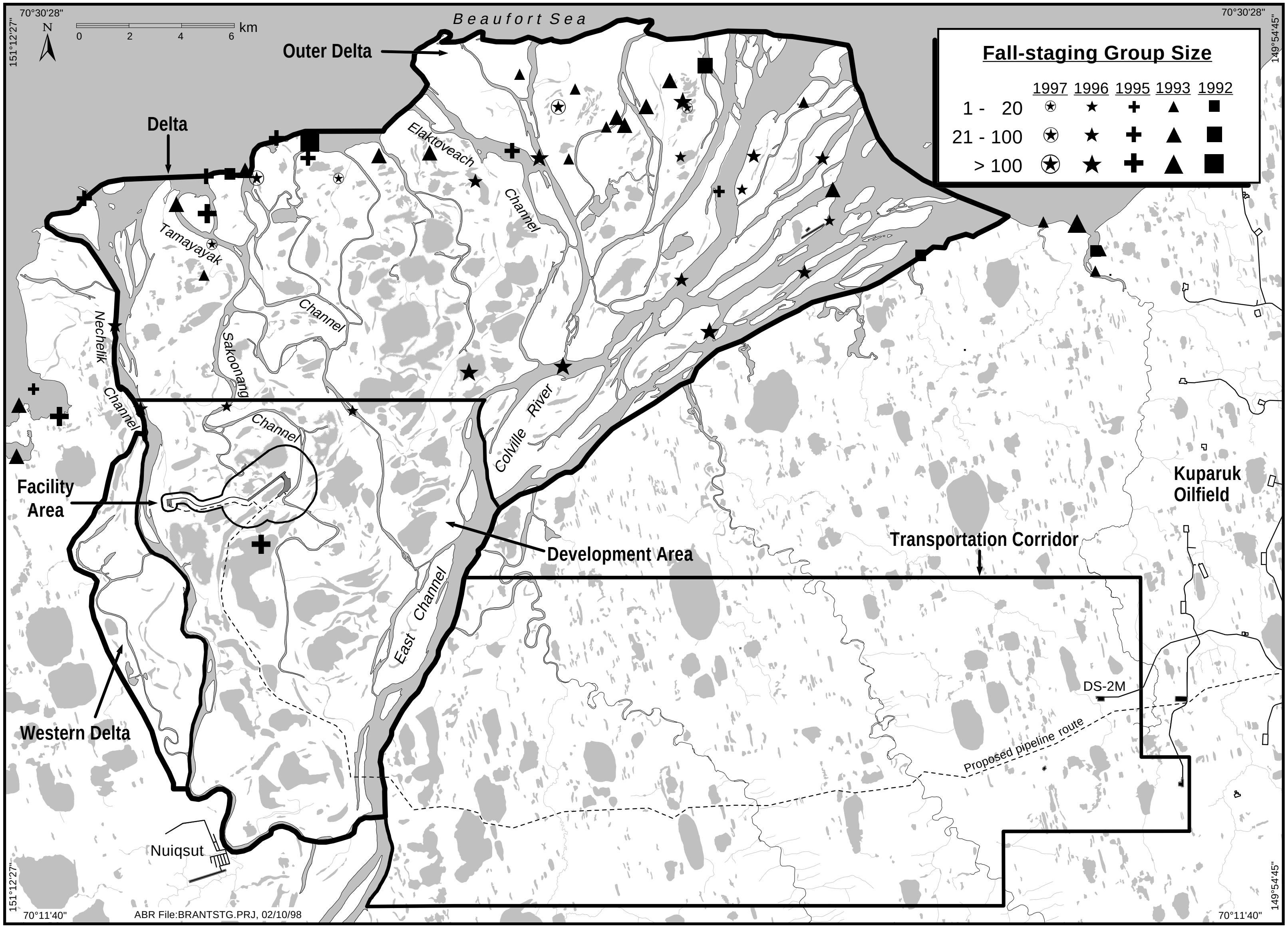

Figure 22. Distribution and size of Brant fall-staging groups observed during aerial surveys in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, and 1995–1997.

Table 30. Habitat selection by nesting Brant (based on the cumulative locations of colonies) in the Outer Delta survey area, Colville River Delta, Alaska, 1993, and 1995–1997 (Johnson et al. 1997, this study).

Habitat	Area (km^2)	Max. Est. of Nests	No. of Colonies	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	0	0	0	4.2	-1.00	ns
Brackish Water	6.41	5	3	23.1	2.6	0.80	prefer
Tapped Lake w/Low-water Connection	5.54	0	0	0	2.2	-1.00	ns
Tapped Lake w/High-water Connection	2.20	0	0	0	0.9	-1.00	ns
Salt Marsh	13.11	10	2	15.4	5.2	0.48	ns
Tidal Flat	55.89	0	0	0	22.3	-1.00	ns
Salt-killed Tundra	23.25	30	4	30.8	9.3	0.54	prefer
Deep Open Water w/o Islands	2.07	0	0	0	0.8	-1.00	ns
Deep Open Water w/Islands or Polygonized Margins	2.64	10	1	7.7	1.1	0.76	ns
Shallow Open Water w/o Islands	0.70	0	0	0	0.3	-1.00	ns
Shallow Open Water w/Islands or Polygonized Margins	0.26	0	0	0	0.1	-1.00	ns
River or Stream	49.41	0	0	0	19.7	-1.00	ns
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	7.62	1	1	7.7	3.0	0.43	ns
Aquatic Grass Marsh	0.37	16	1	7.7	0.1	0.96	prefer
Young Basin Wetland Complex	0	-	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	-	0	-	-
Nonpatterned Wet Meadow	15.33	0	0	0	6.1	-1.00	ns
Wet Sedge–Willow Meadow	16.55	15	1	7.7	6.6	0.08	ns
Moist Sedge–Shrub Meadow	2.49	0	0	0	0.1	-1.00	ns
Moist Tussock Tundra	1.68	0	0	0	0.7	-1.00	ns
Riverine or Upland Shrub	1.25	0	0	0	0.5	-1.00	ns
Barrens (riverine, eolian, lacustrine)	32.99	0	0	0	13.2	-1.00	ns
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	ns
Total	250.25	87	13	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated for colony locations only.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

colonies, nesting Brant used 7 of 21 available habitats, and 3 of those habitats—Brackish Water, Salt-killed Tundra, and Aquatic Grass Marsh—were preferred. No habitats were avoided. Although Aquatic Grass Marsh was preferred, it contained only one colony with 16 nests. Brackish Water and Salt-killed Tundra contained the most colonies (3 and 4 colonies, respectively), and Salt-killed Tundra contained more nests (30) than all other habitats. Basin Wetland Complexes, which typically are preferred by Brant elsewhere on the Arctic Coastal Plain (Stickney and Ritchie 1996), were not available in the Outer Delta survey area.

The islands in the Anachlik Colony-complex, which contain >950 nests, consist of large areas of Barrens (including partially vegetated areas), Wet Sedge–Willow Meadow, and Tidal Flat (which periodically is flooded and not available for nesting), and smaller proportions of Nonpatterned Wet Meadow, Moist Sedge–Shrub Meadow, Salt-killed Tundra, Salt Marsh, Aquatic Sedge with Deep Polygons, and both types of Deep and Shallow Water (Table 31). No quantitative information is available on the location of nests in these habitats, so they were not included in our selection analysis. Several islands that supported colonies (e.g., Plover, Swan, and Turnstone islands) contain large proportions of Barrens, but only on Brant Island, where the only other habitat available is Tidal Flat, are Brant known to nest almost exclusively in Barrens. An unknown proportion of the Brant on Char Island also nest in Barrens, but more nests in this colony are located in the adjacent Salt Marsh. The use of Barrens by Brant in the Anachlik Colony-complex is notable because Brant did not nest in this habitat elsewhere on the delta (Table 30).

Table 31. Habitat availability for islands in the Anachlik Brant Colony-complex, Colville River Delta, Alaska. Brant nests were counted during ground searches in 1993 (Martin and Nelson 1996). The colonies at Seal Island and Snow Goose Lake were not in areas classified for habitat.

	Availability (%)								
Habitat	Anachlik Is. (278 nests)	Brant Is. (194 nests)	Char Is. (128 nests)	Dune Is. (29 nests)	Eskimo Is. (103 nests)	Plover Is. (63 nests)	Swan Is. (61 nests)	Turnstone Is. (37 nests)	White-front Is. (29 nests)
Open Nearshore Water (marine)	0	0	0	0	0	0	0	0	0
Brackish Water	0	0.7	0	0	0	0	0.5	0	0
Tapped Lake w/Low-water Connection	0	0	0	0	0	0	0	0	0
Tapped Lake w/High-water Connection	0	0	0	0	0	0	0	0	6.4
Salt Marsh	0.3	0	3.9	0	0	1.5	8.3	11.9	0
Tidal Flat	14.5	96.1	88.9	0	0	0	0	0	0
Salt-killed Tundra	2.0	0	0	3.7	30.7	0	0	0	3.4
Deep Open Water w/o Islands	0	0	0	4.3	0	0	1.0	0	0.1
Deep Open Water w/Islands or Polygonized Margins	7.0	0	0	6.7	0	0	0	0	0.6
Shallow Open Water w/o Islands	1.1	0	0	0.7	0	0.2	0	0	0.2
Shallow Open Water w/Islands or Polygonized Margins	1.3	0	0	0.8	0	0	0	0	0.9
River or Stream	0	0	0	0	0	0	0	0	0
Aquatic Sedge Marsh	0	0	0	0	0	0	0	0	0
Aquatic Sedge w/Deep Polygons	6.1	0	0	8.8	0	0	0	0	7.1
Aquatic Grass Marsh	0	0	0	0	0	0	0	0	1.8
Young Basin Wetland Complex	0	0	0	0	0	0	0	0	0
Old Basin Wetland Complex	0	0	0	0	0	0	0	0	0
Nonpatterned Wet Meadow	32.3	0	0	14.4	0	0	7.8	0	9.8
Wet Sedge–Willow Meadow	20.4	0	0	32.4	0	0	0	0	52.7
Moist Sedge–Shrub Meadow	3.4	0	0	0	29.3	0	10.6	0	0
Moist Tussock Tundra	0	0	0	0	0	0	0	0	0
Riverine or Upland Shrub	1.0	0	0	2.3	0	0.9	0	3.3	0.1
Barrens (riverine, eolian, lacustrine)	10.1	3.2	7.3	25.9	40.0	97.4	71.8	84.8	16.9
Artificial (water, fill, peat road)	0.6	0	0	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100
Total area (km^2)	4.0	2.4	1.0	4.4	0.5	1.2	1.4	0.9	3.0

Surveys of nesting Brant from Prudhoe Bay to as far west as Kasegaluk Lagoon indicate that islands at the mouths of river deltas have supported larger numbers of Brant than have mainland colonies (Ritchie 1996; ABR, unpubl. data). In the oilfields in particular, the largest colonies (100–250 nests) are located on islands at the mouth of the Kuparuk River delta and on Howe and Duck islands, near the mouth of the Sagavanirktok River delta. These islands tend to be isolated from the mainland during spring breakup, which provides some protection from terrestrial predators such as arctic foxes and may be more important to nesting Brant than the specific habitats occupying the islands. Isolated barrier islands also are used by Brant nesting in Kasegaluk Lagoon in northwestern Alaska (Divoky 1978, Lehnhausen and Quinlan 1981, Ritchie 1996) and those nesting off the coast of the oilfields on the Niakuk Islands and other areas of the arctic coast (Johnson and Herter 1989; Ritchie et al. 1990; ABR, unpubl. data). These islands usually are composed of sand or gravel, with minimal vegetation, similar to the Barrens habitat used by Brant in the Anachlik colony-complex.

We collected detailed information on the habitat of 24 individual nests located during ground searches in the Development Area in 1995–1997 (Table 32). Over half of the nests were in either Deep Open Water with Islands or Polygonized Margins (9 nests) or in Shallow Open Water with Islands or Polygonized Margins (5 nests). Additional nests were in Aquatic Sedge with Deep Polygons, Nonpatterned Wet Meadow, Salt Marsh, Tapped Lake with High-water Connection, and Wet Sedge–Willow Meadow. The largest colony located during ground searches in 1995 (6 nests) straddled two different habitat types (Deep Open Water with Islands or Polygonized Margins and Aquatic Sedge with Deep Polygons). All nests except one were located <1 m from permanent water. The nests were near lake habitats, which included Deep Open Water (both types; 67% of nests), Shallow Open Water with Islands or Polygonized Margins (21%), and Tapped Lakes (both types; 12%).

Brood-rearing

During brood-rearing in 1993, 1995, and 1996, we saw 28 groups of Brant in 9 different habitats, with salt-affected habitats receiving the greatest use (Table 33). Over all years, Brackish Water was used by the most Brant brood groups (seven) and was the

Table 32. Habitat use and nearest waterbody habitat of individual Brant nests located during ground searches in the Development Area, Colville River Delta, Alaska, 1995–1997 (Johnson et al. 1997, this study).

Habitat	No. of Nests	Use (%)
HABITAT USED		
Tapped Lake w/High-water Connection	1	4.2
Salt Marsh	1	4.2
Deep Open Water w/Islands or Polygonized Margins	9	37.5
Shallow Open Water w/Islands or Polygonized Margins	5	20.8
Aquatic Sedge w/Deep Polygons	4	16.7
Nonpatterned Wet Meadow	2	8.3
Wet Sedge–Willow Meadow	2	8.3
Total	24	100
NEAREST WATERBODY HABITAT[a]		
Tapped Lake w/Low-water Connection	1	4.2
Tapped Lake w/High-water Connection	2	8.3
Deep Open Water w/o Islands	2	8.3
Deep Open Water w/Islands or Polygonized Margins	14	58.3
Shallow Open Water w/Islands or Polygons	5	20.8
Total	24	100

[a] Nearest waterbody (≥ 0.25 ha in size) was measured from the digital map.

Table 33. Habitat selection (pooled among years) by Brant brood-rearing groups in the Outer Delta survey area, Colville River Delta, Alaska, 1993, 1995, and 1996 (Johnson et al. 1997).

Habitat	Area (km^2)	No. of Brood-rearing Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	4	14.3	4.8	0.50	ns
Brackish Water	6.29	7	25.0	2.9	0.79	prefer
Tapped Lake w/Low-water Connection	5.17	0	0	2.4	-1.00	ns
Tapped Lake w/High-water Connection	2.06	0	0	0.9	-1.00	ns
Salt Marsh	12.61	3	10.7	5.8	0.30	ns
Tidal Flat	55.89	4	14.3	25.5	-0.28	ns
Salt-killed Tundra	22.22	3	10.7	10.1	0.03	ns
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	ns
Deep Open Water w/Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	ns
Shallow Open Water w/o Islands	0.53	0	0	0.2	-1.00	ns
Shallow Open Water w/Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	ns
River or Stream	43.15	2	7.1	19.7	-0.47	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	6.40	1	3.6	2.9	0.10	ns
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	ns
Wet Sedge–Willow Meadow	9.33	1	3.6	4.3	-0.09	ns
Moist Sedge–Shrub Meadow	1.73	0	0	0.8	-1.00	ns
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	ns
Riverine or Upland Shrub	0.81	0	0	0.4	-1.00	ns
Barrens (riverine, eolian, lacustrine)	28.08	3	10.7	12.8	-0.09	ns
Artificial (water, fill, peat road)	0.02	0	0	0	-1.00	ns
Total	219.06	28	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated for colony locations only.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

only preferred habitat on the delta. The other salt-affected habitats used included Open Nearshore Water, Salt Marsh, Salt-killed Tundra, and Tidal Flat. River or Stream was the only habitat that was used significantly less than its availability (i.e., avoided). Brood-rearing groups frequently moved into nearby water when disturbed by our survey aircraft, so the use of waterbodies probably is the result of broods moving from adjacent foraging habitat (most likely Salt Marsh) as our aircraft approached. Brood-rearing groups tended to be close to three types of waterbody habitats: Brackish Water (20 of 39 groups), River or Stream (12 groups), and Open Nearshore Water (7 groups) (Table 34). The mean distance of brood-rearing groups to the nearest waterbody was 0.10 km.

In addition to the brood-rearing groups seen on coastal surveys in previous years in the Delta survey area, we saw some groups just outside the survey boundaries and some groups during other surveys (Figure 21). The habitats used by these additional groups (Table 34) were not appreciably different than those used by Brant seen on the coastal surveys in the Delta survey area (Table 33), and reaffirmed the importance of salt-affected habitats and the coastal zone to Brant during the brood-rearing season.

GREATER WHITE-FRONTED GOOSE

BACKGROUND

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

Table 34. Habitat use by Brant and distance to nearest waterbody during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, and 1995–1997 (Johnson et al. 1997, this study). Brood-rearing groups were located during aerial surveys (coastal Brant surveys in years previous to 1997 and the goose systematic survey in 1997) and include groups located just outside the Delta survey area boundaries.

Habitat	No. of Brood-rearing Groups	Use (%)	Mean Distance to Waterbody [a] (km)
HABITAT USED			
Open Nearshore Water (marine)	5	12.8	-
Brackish Water	11	28.2	-
Salt Marsh	3	7.7	-
Tidal Flat	4	10.3	-
Salt-killed Tundra	5	12.8	-
River or Stream	6	15.4	-
Aquatic Sedge w/Deep Polygons	1	2.6	-
Wet Sedge–Willow Meadow	1	2.6	-
Barrens (riverine, eolian, lacustrine)	3	7.7	-
Total	39	100	
NEAREST WATERBODY HABITAT			
Open Nearshore Water (marine)	7	18.0	0.01
Brackish Water	20	51.3	0.17
River or Stream	12	30.7	0.02
Total	39	100	0.10

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

Coastal Plain of Alaska (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983).

DISTRIBUTION AND ABUNDANCE

Nesting

During ground surveys in 1997, we located 45 White-fronted Goose nests (3.2 nests/km^2) in the ground-search area that included the Facility Area (Figure 23). The density of nests found was higher than the density (2.0 nests/km^2) recorded in approximately the same area in 1996 (Johnson et al. 1997) and almost double that reported previously for other parts of the delta (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). Most nests (36 of 45, 80%) found in 1997 were in Wet Sedge–Willow Meadow; other habitats used for nesting included Moist Sedge–Shrub Meadow (3 nests, 6%), Nonpatterned Wet Meadow (4 nests, 11%), Aquatic Sedge with Deep Polygons (2 nests, 4%), Deep Open Water with Islands or Polygonized Margins (1 nest, 2%), and Riverine or Upland Shrub (1 nest, 2%). Within these habitats, most nests (84%) were on polygon ridges or small hummocks, microsites similar to the nesting sites reported by Simpson and Pogson (1982). Nests were <1–400 m ($\bar{x}$ = 72.5 m) from the nearest permanent waterbody. The average clutch size in 1997 was 3.8 eggs (*n* = 37 nests), similar to the values reported in other studies on the Colville Delta (Simpson and Pogson 1982; Simpson 1983; Smith et al. 1993, 1994; Johnson et al. 1996, 1997). Of 44 nests that we revisited, 36 (82%) were successful, 5 (11%) failed, and 3 (3%) had unknown fates.

We found 25 White-fronted Goose nests (2.7 nests/km^2) within the Facility Area boundary in 1997 (Figure 23), up from 13 nests (1.5 nests/km^2) in 1996 (Johnson et al. 1997). Nests occurred in four of the six habitats noted previously; they were not found in Nonpatterned Wet Meadow or Deep Open Water with Islands or Polygonized Margins.

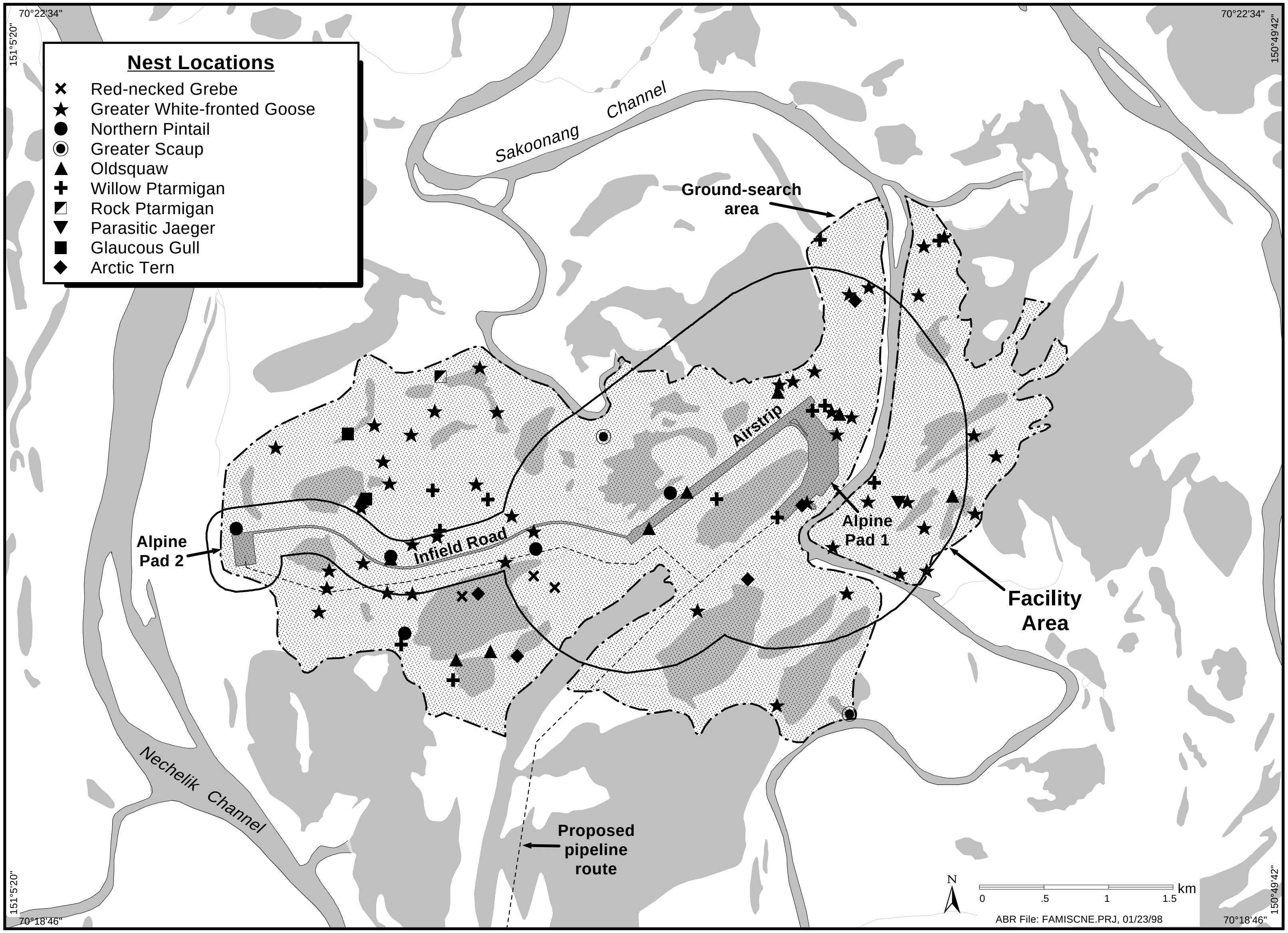

Figure 23. Nest locations of selected birds observed during ground surveys near the Facility Area, Colville River Delta, Alaska, late June 1997.

Brood-rearing

In 1997, we conducted a systematic aerial survey (50% coverage) to collect information on the distribution and group sizes of brood-rearing and molting White-fronted Geese (Table 2). In 1996, we conducted the first systematic survey (25% coverage), whereas in previous years, brood-rearing information for White-fronted Geese was collected opportunistically during aerial surveys conducted for Brant and eiders. In 1997, we saw 2,394 White-fronted Geese in 45 groups in both the delta and Transportation Corridor, or almost twice the number seen in any other year (1,347 in 1995), and substantially greater than in 1996, when we saw 553 in 16 groups in the same area. Group sizes in 1997 ranged between 9 and 225 individuals ($\bar{x}$ = 53.2).

Delta—On the systematic aerial survey in 1997, we saw 2,126 White-fronted Geese in 40 groups on the delta (Figure 24). These groups generally were distributed throughout the study area and typically occurred in or near water, including Open Nearshore Water, Brackish Water, Tapped Lakes (both types), Deep Open Water (both types), and River or Stream. Most groups (26 of 40 groups, 65%) were in either Brackish Water or both types of Deep Open Water. Goslings composed 35% of the total number of birds (743 of 2,126).

During aerial surveys in the Development Area, we counted 484 White-fronted Geese in 11 groups; none occurred within the Facility Area. However, during ground surveys in the ground-search area (27 km^2), we observed 152 White-fronted Geese (36% goslings) in 21 groups, 3 of which were in the Facility Area (Figure 25). In the 1996 ground-search area (18 km^2), we saw 154 geese in 17 groups, 3 of which were in the Facility Area. In 1995, we saw 1 group of 28 geese (75% goslings) during a ground survey. Although the occurrence of White-fronted Geese within the Facility Area was low in 1997, we also recorded brood-rearing and molting groups using lakes just outside the Facility Area during various incidental helicopter surveys there (Figure 25). The percentage of goslings seen during both aerial and ground surveys in 1997 was smaller than that seen in 1996 (55% during the aerial survey of the entire Delta, 57% during the ground survey in the Development Area). Whether these decreases reflect poor productivity or the influx of adults from other areas is uncertain.

During the aerial survey on the Outer Delta, we recorded 1,642 White-fronted Geese in 29 groups (45% goslings). We saw no geese on the Western Delta in 1997, but saw 50–60 geese in both 1995 and 1996.

Transportation Corridor—We saw 268 White-fronted Geese in 5 groups in the Transportation Corridor during an aerial survey in late July 1997 (Figure 24). The overall percentage of goslings was 16% for groups in the Transportation Corridor. The number of birds seen in 1997 was 50% greater than the number of birds seen in 1996, but survey coverage was twice that of 1996. The percentage of goslings seen in 1997 was about a third of that seen in 1996 (47%), suggesting that productivity was poor in 1997.

Fall Staging

Delta—During fall staging in 1997, large numbers of White-fronted Geese, in groups that averaged <30 birds, were distributed throughout the delta in a variety of aquatic and terrestrial habitats (Figure 26). This pattern of staging distribution was different from that seen in 1996, when these geese were concentrated around river channels and large lakes in fewer, but larger groups. White-fronted Geese did not concentrate near the coast, as did Brant, and were abundant inland in the Development Area. On the systematic survey (50% coverage) for fall-staging geese, we saw 1,732 birds in 49 groups on the delta in 1997; in contrast, we recorded 1,356 birds in 28 groups seen on a similar survey, but with 25% coverage in 1996. Prior to 1996, we made observations opportunistically during surveys for focal species (Figure 27). Hence, the level of effort devoted to sampling White-fronted Geese varied among years. Counts of fall-staging White-fronted Geese seen on the delta during 1991, 1992, and 1995, were 555, 1,807, and 491 geese, respectively (Johnson et al. 1997). In addition, we saw 2,250 geese on another survey in August 1992. Our data are insufficient to determine whether this annual variation in numbers was due to differences in survey timing and intensity or to actual changes in abundance.

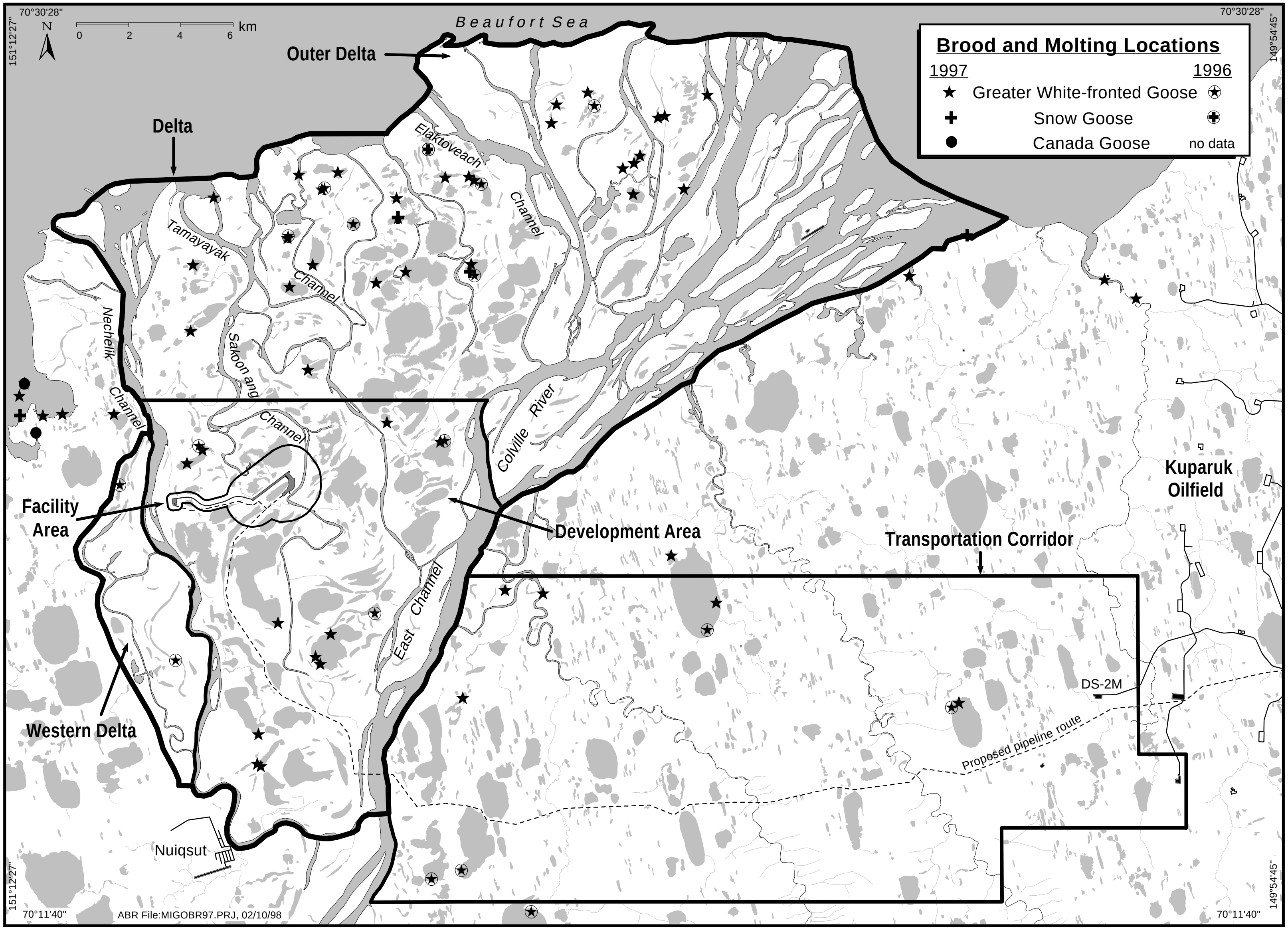

Figure 24. Distribution of brood-rearing and molting groups of Greater White-fronted, and Snow, and Canada geese observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, July 1996 and 1997.

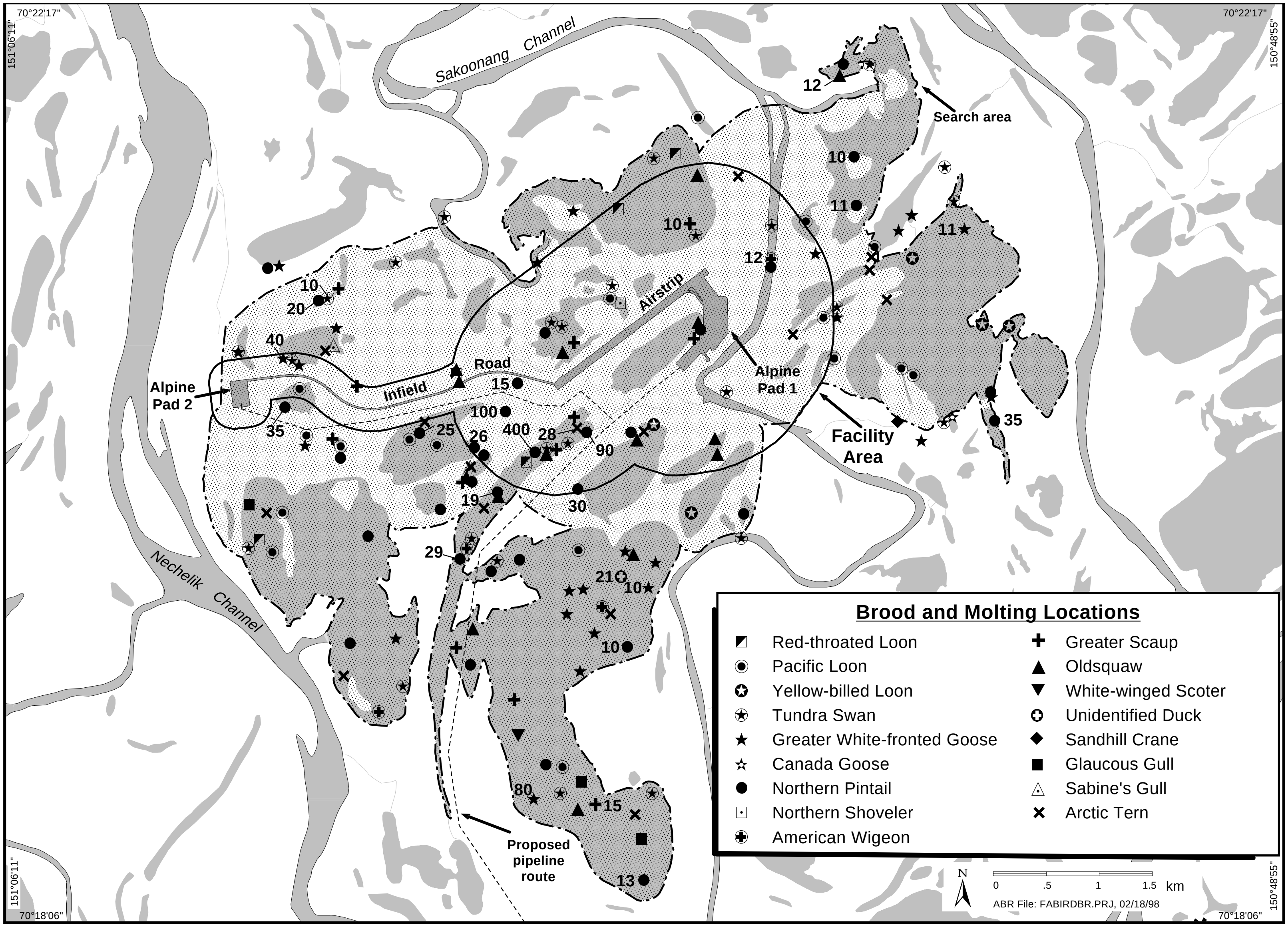

Figure 25. Distribution of brood-rearing and molting groups of various waterbirds observed during aerial and ground surveys near the Facility Area, Colville River Delta, Alaska, July 1997.

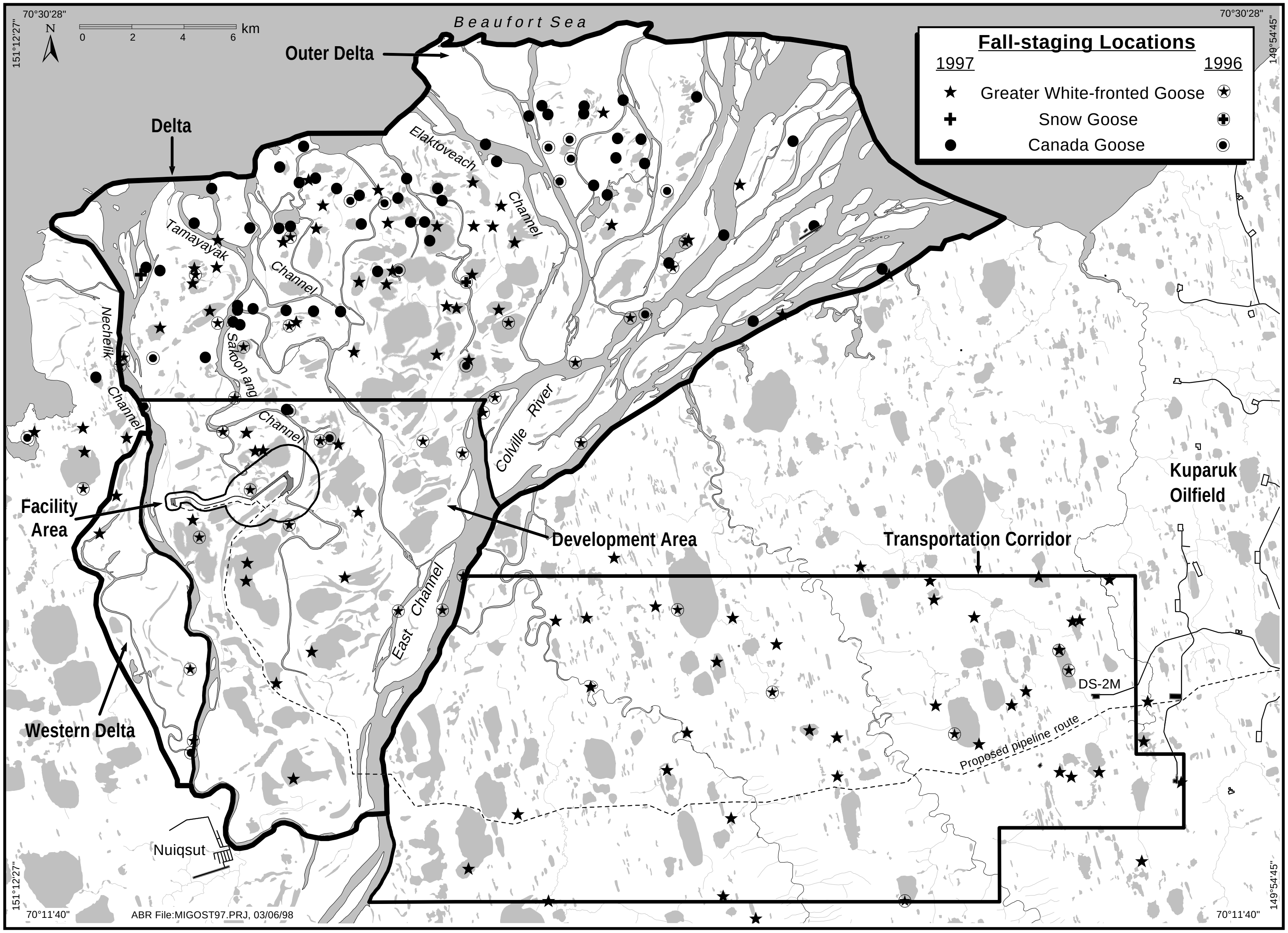

Figure 26. Distribution of fall-staging groups of Greater White-fronted, Snow, and Canada geese observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, August 1996 and 1997.

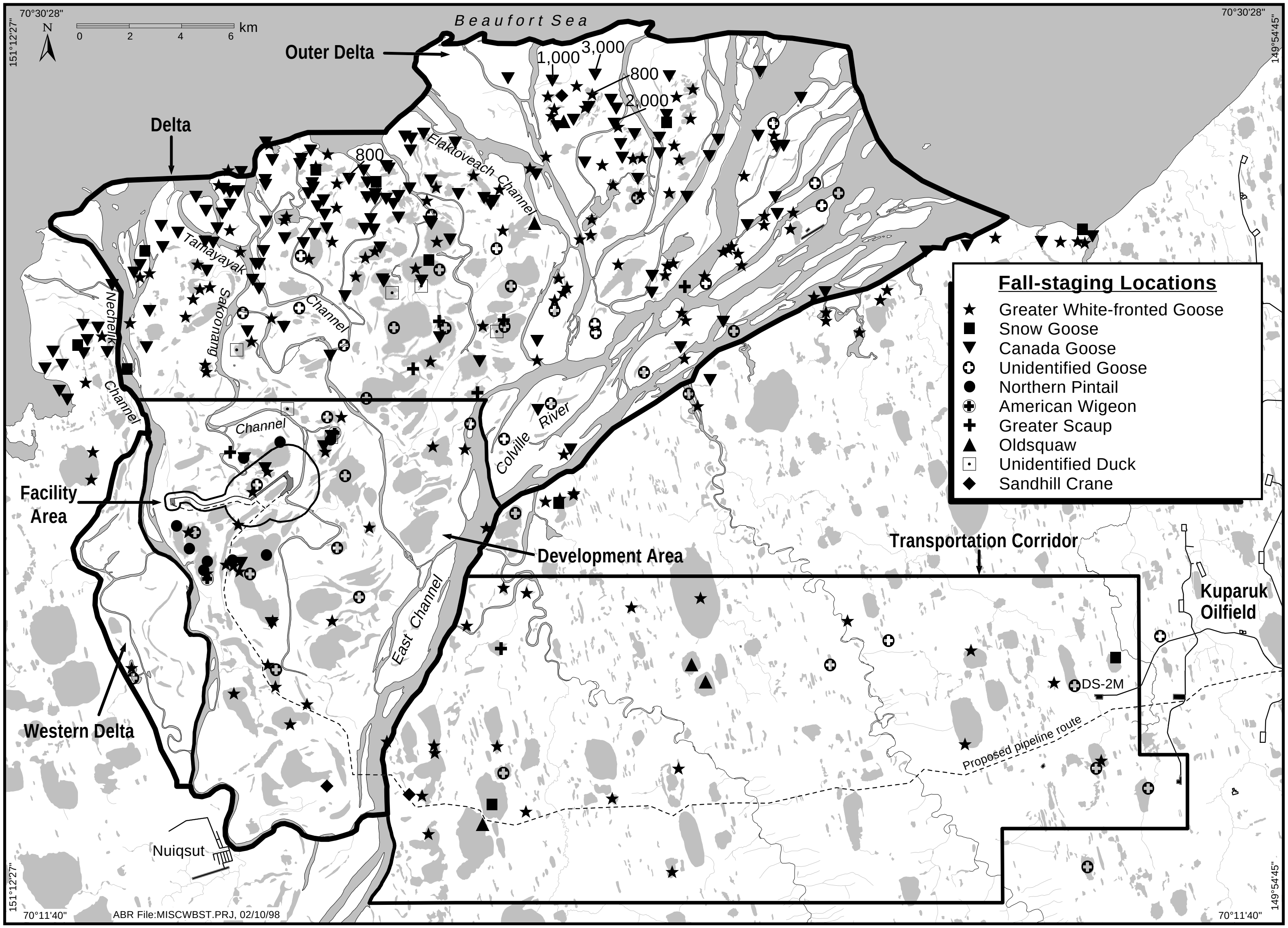

Figure 27. Distribution of fall-staging groups of various waterbird species observed opportunistically during aerial surveys in August for geese, loons, and Tundra Swans in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1988, 1990–1993, and 1995–1997.

In the Development Area, we saw 12 groups containing 758 White-fronted Geese during the fall-staging survey in 1997 (Figure 26). During a ground survey on 14 August, we saw 5 groups containing 87 geese near, but not in, the Facility Area. In 1991, 1992, and 1995, we counted 194, 20, and 130 birds, respectively, in the Development Area (Figure 27).

Few White-fronted Geese occurred in the Facility Area during the five years that we recorded geese on staging surveys. No groups occurred in this area in 1997. In 1996, we saw one group of 35 birds in the Facility Area and another group of 35 was seen there in 1991 (Figure 27). No White-fronted Geese were seen in the Facility Area in 1992 or 1995.

On the Outer Delta, we saw 909 White-fronted Geese in 35 groups during the systematic fall-staging survey in 1997 (Figure 26). In 1996, we saw 564 geese on a systematic survey, and, in 1995, we saw 361 geese incidentally. The largest numbers were seen in 1992, when we counted 1,787 and 2,250 White-fronted Geese incidentally on other surveys. In 1991, we saw 343 geese on the Outer Delta during a swan survey (ABR, unpubl. data).

Transportation Corridor—During fall staging in 1997, we saw 33 groups totaling 894 White-fronted Geese during a systematic survey in the Transportation Corridor (Figure 26). This total was more than twice the number we recorded in 1996 (399 geese), when we had half the survey coverage. In 1995, we recorded only one group of 30 birds during a swan survey in the same area. On aerial surveys for swans in 1988, 1990, and 1991, we counted 18–354 geese in the Transportation Corridor (Johnson et al. 1996).

SNOW GOOSE

BACKGROUND

Early in this century, Snow Geese may have nested commonly and gathered for molting and brood-rearing in widespread portions of the Arctic Coastal Plain (Anderson 1913, Bailey 1948, Gabrielson and Lincoln 1959). In the past few decades, however, 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, Fairbanks, AK, pers. comm.). Today, three small colonies (26 to ≤400 nests) are known from the Sagavanirktok, Ikpikpuk, and Kukpowruk river deltas (Ritchie and Burgess 1993). In addition, small numbers of Snow Geese and a few nests have been recorded from the area between the Kuparuk Oilfield and Kasegaluk Lagoon (King 1970; Ritchie and Burgess 1993; ABR, unpubl. data). Currently in Alaska, large numbers of Snow Geese occur during fall staging only in the Arctic National Wildlife Refuge (Johnson and Herter 1989).

DISTRIBUTION AND ABUNDANCE

Nesting

Few nests have been found on the Colville Delta in any year. In 1997, we found one nest on the Outer Delta. We found no Snow Goose nests on the Colville Delta in 1996, although we saw a few scattered nests just west of the delta, near the mouth of Fish Creek. In 1995, one Snow Goose nest was seen during an aerial survey; in both 1993 and 1994, two nests were found each year during ground searches (Johnson et al. 1996). All nests were <5 km from the coast in the Outer Delta survey area.

Brood-rearing

Small numbers of Snow Geese have been seen in most years during brood-rearing surveys for Greater White-fronted Geese and Brant. In 1997, we saw three groups of brood-rearing Snow Geese totaling 12 adults and 16 goslings, the largest number of birds seen so far on the Delta (Figure 24). In both 1995 and 1996, we saw only one group of Snow Geese during the aerial surveys for brood-rearing geese (Figure 28); the group seen in 1995 was without goslings. All brood-rearing groups were seen on the Outer Delta. No Snow Geese were recorded during surveys in 1992 or 1993, however.

Fall Staging

During late August 1997, we saw one group (6 birds) of Snow Geese on the systematic goose survey and four groups (37 birds) during the coastal survey the next day (Figure 26); all were seen on the Outer Delta. We saw three Snow Geese in one group on the Outer Delta in late August 1996, 20 on the

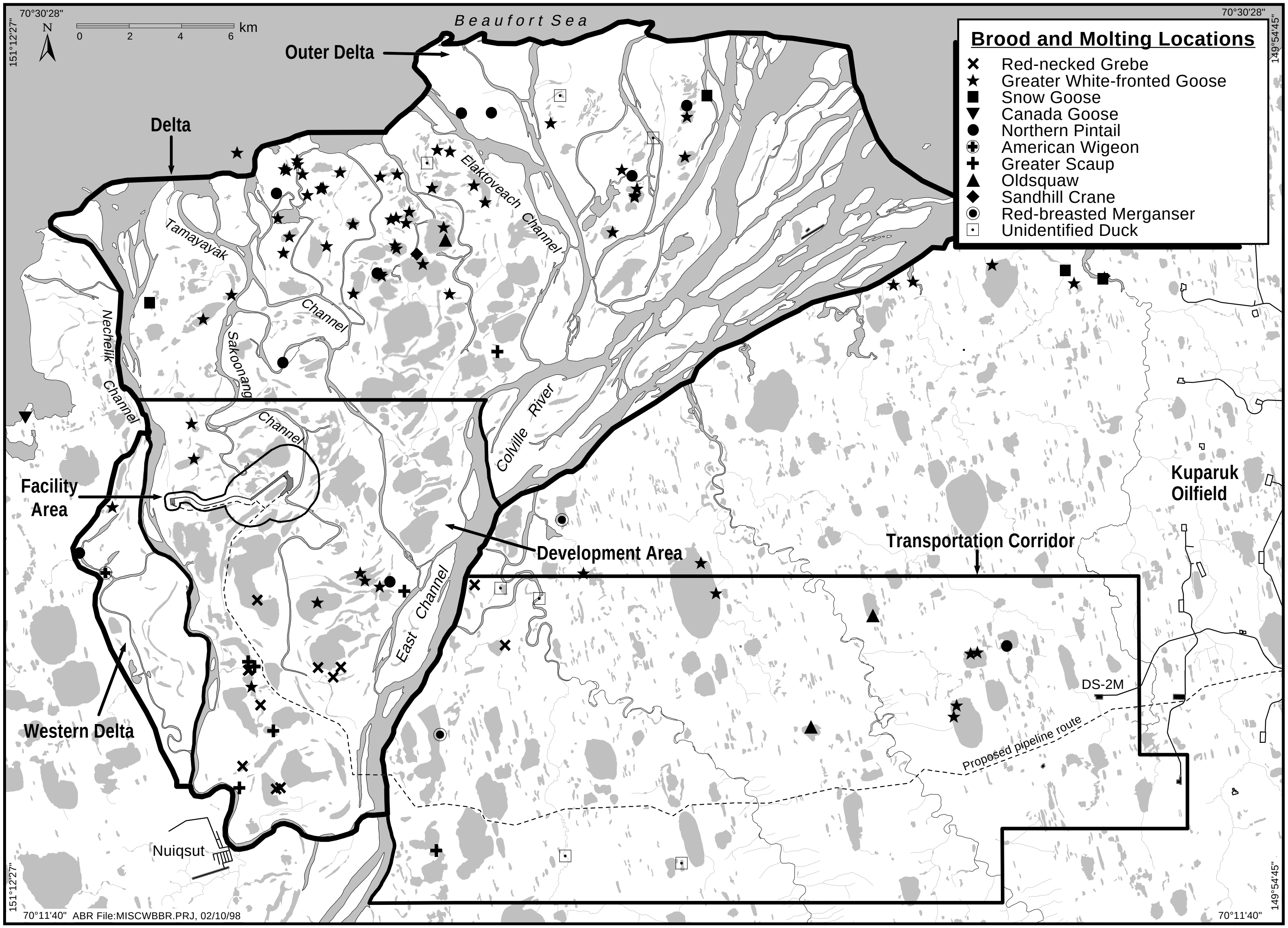

Figure 28. Distribution of brood-rearing and molting groups of various waterbird species observed opportunistically during aerial surveys in July and August in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, and 1995–1997.

Outer Delta and 12 in the Transportation Corridor in 1995, and 6 were seen in the Transportation Corridor in 1991 (Figure 27). No Snow Geese were seen during staging surveys in 1992 or 1993.

CANADA GOOSE

BACKGROUND

Several hundred Canada Geese nest along the banks and bluffs of the upper Colville River (Kessel and Cade 1958). Prior to 1996, Canada Geese were not reported nesting either on the Colville Delta or in NPR–A. Canada Geese nest in scattered locations on the Arctic Coastal Plain east of the Colville River (Ritchie et al. 1991; ABR, unpubl. data) and commonly nest on islands in 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). Although the Colville Delta has not been identified as an important molting or brood-rearing area for Canada Geese, it is important during fall migration (Smith et al. 1994), when geese traveling along the Beaufort Sea coast stop and feed (Johnson and Richardson 1981, Garner and Reynolds 1986).

DISTRIBUTION AND ABUNDANCE

Nesting

In 1997, we found one Canada Goose nest on the Outer Delta near the Nechelik Channel and two nests just west of the delta in NPR-A (Figure 19). At one of these locations in the NPR-A, we saw 10 Canada Goose nests in 1996, the first documented record of them nesting close to the delta or in the NPR-A (Johnson et al. 1997). However, local residents have observed Canada Geese nesting in the NPR-A at least since the 1980s (J. Helmericks, pers. comm.). The nest found on the Outer Delta was the first record we have of a Canada Goose nest on the delta.

Brood-rearing

In 1997, we observed two Canada Geese (adults or subadults) in the Development Area during a ground survey in mid-July, which is only the second record of these geese on the delta during the brood-rearing/molting period (Figure 25). The only other year when Canada Geese were seen on the delta was 1993, when a group of 30 was seen during a ground survey on the Outer Delta.

Fall Staging

During fall staging, Canada Geese occurred in large numbers and used coastal areas of the Outer Delta more than other areas on the delta. In 1997, we recorded 2,101 Canada Geese in 52 groups during the systematic survey (50% coverage) for geese (Figure 26). One day later, we recorded 1,932 Canada Geese in 46 groups during the coastal staging survey for Brant. These numbers were greater than those observed in all other years, except 1992, when we counted 10,950 Canada Geese (Figure 27). In 1996, the only other year a systematic survey (25% coverage) was conducted, we recorded 1,486 Canada Geese in 15 groups on the delta. In other years, the numbers seen incidentally were less: 923 birds in 1995, 825 birds in 1993, and 310 birds in 1991. It is unclear what influences the annual variability in numbers of Canada Geese and their use of the delta during fall staging, but some of this variability probably is an artifact of the intensity and timing of aerial surveys.

In 1997, we saw only 1 group of 12 Canada Geese in the Development Area (Figure 26) during the aerial survey, but we saw 2 groups of 195 birds during a ground survey around the Facility Area on 14 August; one of these groups was in the Facility Area (Figure 17). We saw 3 groups containing 426 geese in the Development Area in 1996 and 1 group of 75 birds in 1995 (Figure 27). The only other observation of this species in the Development Area was in 1991, when 65 geese were seen, 30 of which occurred in the Facility Area (ABR, unpubl. data).

On the Outer Delta in 1997, we saw 2,089 Canada Geese in 51 groups (Figure 26). We saw 1,050 geese on the Outer Delta in 1996 and 245 geese in 1991. In 1993 and 1992, all Canada Geese seen on the delta were in the Outer Delta survey area (Figure 27).

No Canada Geese were seen in the Western Delta survey area during fall staging in 1997, although 10 were seen there in 1996 (Figure 26). No staging groups of Canada Geese occurred in the Transportation Corridor in any year.

OTHER BIRDS

BACKGROUND

The Colville River Delta provides varied and productive habitats for many bird species for feeding, breeding, molting, and staging (Seaman et al. 1981, Meehan 1986). In spring, the early availability of open water and snow-free areas attract many migrants and breeding birds to the delta (Rothe et al. 1983, Meehan 1986). Diving ducks feed and loaf on flooded tapped lakes, and geese and dabbling ducks use vegetated areas inundated by high water (Rothe et al. 1983). Shorebirds, passerines, and ptarmigan concentrate along river channels, and jaegers, gulls, and terns feed in the nearshore marine waters of the outer delta (Rothe et al. 1983, Seaman et al. 1981). Breeding birds can begin nesting 1–1.5 weeks earlier on the delta than at inland sites nearby, which are still frozen and snow-covered (Rothe et al. 1983). Egg-laying for all species occurs from early June to early July, and hatching occurs from late June through late July. By August, nonbreeding waterfowl have regained flight after the molt and form pre-migratory flocks. Waterfowl with broods remain in protective wetlands on the delta through August, until the young are capable of flight. Shorebirds are attracted to the salt marshes and tidal flats of the delta, particularly during the post-breeding season in August, because of high invertebrate abundance and the large amount of exposed shoreline at that time (Andres 1989). The prolonged presence of open water on the delta during fall provides resources for late migrants and may be critical to the survival of some juvenile waterbirds (Markon et al. 1982).

DISTRIBUTION AND ABUNDANCE

We recorded the presence and location of breeding bird species in the proposed footprint within the Facility Area (Figure 23) by conducting an intensive ground survey on 25–26 June 1997. Because this survey was conducted late in the nesting period of shorebirds and passerines, we did not attempt to locate nests for these birds because the number found would have underestimated the actual number of nesting attempts. However, we did search for waterfowl and loon nests. During this survey, we recorded flying birds and birds on the ground (non-flying) separately. We counted the greatest number of birds (flying and non-flying combined) at Alpine Pad 1 (103), followed by the Infield Road (85), the Airstrip (83), and Alpine Pad 2 (10; Table 35). The number of birds observed on the ground appeared to be related to the size of the footprint: we counted most at Alpine Pad 1 (90), the largest footprint, and fewer at the Airstrip (58), the Infield Road (48), and Alpine Pad 2 (9). Of the five most abundant species seen on the ground at all sites (Lapland Longspur, Semipalmated Sandpiper, Pectoral Sandpiper, Red-necked Phalarope, and Savannah Sparrow), only the passerine species were seen at each site. The high number of birds seen at Alpine Pad 1 was due to larger numbers of passerines and shorebirds, particularly Semipalmated and Pectoral sandpipers and Red-necked Phalaropes. Flying birds accounted for 27% of all the birds recorded. The most common species seen flying were Pacific Loons, Parasitic Jaegers, Arctic Terns, shorebirds, passerines, and small flocks of waterfowl.

At all sites combined, we counted 23 species on the ground and another 2 species flying; the majority of species at each site were seen on the ground (Table 35). Total numbers of species were similar at Alpine Pad 1, the Infield Road, and the Airstrip. At Alpine Pad 2, we saw only three species of birds (Savannah Sparrow, Lapland Longspur, and Parasitic Jaeger), but that is where we counted the greatest number of Savannah Sparrows. Shorebirds contributed the most to species diversity, and most of these species (9) occurred at Alpine Pad 1. Waterfowl were the second most diverse group of birds; the highest number of species (five) occurred at the Infield Road. The Infield Road traverses the most habitats, including numerous small ponds and an Aquatic Grass Marsh, where we commonly saw waterfowl. Waterfowl were not as common at the other three sites, which were predominantly drier habitats such as Wet Sedge–Willow Meadow and Moist Sedge–Shrub Meadow.

Nesting

During nesting surveys in the Facility Area and vicinity (Figure 23) in June 1997, we found nests of many bird species other than the focal species (see previous sections for focal species nests) (Table 36). Within the Facility Area (9 km^2), we found nests of Red-necked Grebe, Northern Pintail, Greater Scaup,

Table 35. Numbers and locations of birds counted during the intensive breeding-bird survey of proposed gravel footprints in the Facility Area of the Alpine Development, Colville River Delta, Alaska, 25–26 June 1997. Sites are shown in Figure 23.

	Airstrip (12.7 ha)		Infield Road (5.9 ha)		Alpine Pad 1 (16.4 ha)		Alpine Pad 2 (4.1 ha)		All Areas (39.1 ha)	
Species	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]
Pacific Loon	0	2	2	4	0	0	0	0	2	6
Red-necked Grebe	0	0	2	2	0	0	0	0	2	2
Tundra Swan	0	0	1	1	0	1	0	0	1	2
Greater White-fronted Goose	0	3	2	18	2	2	0	0	4	23
Northern Pintail	0	0	7	20	0	1	0	0	7	21
Greater Scaup	0	4	0	2	0	0	0	0	0	6
Oldsquaw	1	1	2	2	0	0	0	0	3	3
Willow Ptarmigan	2	2	1	1	0	0	0	0	3	3
Sandhill Crane	0	0	2	2	0	0	0	0	2	2
Black-bellied Plover	1	1	0	0	1	1	0	0	2	2
American Golden Plover	1	1	0	0	1	1	0	0	2	2
Semipalmated Sandpiper	12	15	9	9	23	24	0	0	44	48
Pectoral Sandpiper	10	13	4	4	11	12	0	0	25	29
Dunlin	0	0	0	0	6	6	0	0	6	6
Stilt Sandpiper	1	1	0	0	2	2	0	0	3	3
Long-billed Dowitcher	0	1	1	1	1	1	0	0	2	3
Red-necked Phalarope	2	6	6	9	11	14	0	0	19	29
Red Phalarope	2	2	1	1	1	1	0	0	4	4
Parasitic Jaeger	1	1	0	1	0	1	0	1	1	4
Glaucous Gull	0	0	0	0	0	1	0	0	0	1
Arctic Tern	0	3	0	0	1	1	0	0	1	4
Yellow Wagtail	1	3	0	0	0	0	0	0	1	3
Savannah Sparrow	2	2	3	3	2	2	6	6	13	13
Lapland Longspur	22	22	5	5	27	29	3	3	57	59
Common Redpoll	0	0	0	0	1	3	0	0	1	3
Total birds	58	83	48	85	90	103	9	10	205	281
Total species	13	18	15	17	14	18	2	3	23	25

[a] Total includes non-flying and flying birds.

Oldsquaw, Willow Ptarmigan, Parasitic Jaeger, and Arctic Tern, as well as nests of shorebirds and songbirds. In addition, we found nests of Rock Ptarmigan and Glaucous Gulls within that part of the ground-search area surrounding the Facility Area. Because our nesting surveys were designed to locate nests of large waterbirds (e.g., loons, grebes, and waterfowl), and because some habitats (e.g., Riverine or Upland Shrub) were searched less intensively than others, these nest counts should only be considered an indication of the presence of the species in the area and not an accurate estimate of their abundance.

Our ground-search area in 1997 overlapped extensively with the ground-search areas in 1995 (Johnson et al. 1996: Figure 18) and 1996 (Figure 10). In all three years, we found nests of many of the same species, although numbers and locations of nests differed among years. The Facility Area also differed in location and size among these three years (see Figure 18 in Johnson et al. [1996] and Figure 17 in Johnson et al. [1997] for 1995 and 1996 boundaries, respectively). Our search was less intensive in 1995 than in subsequent years, so we will not discuss the results of that year's nest survey. All of the nests recorded in the 1996 Facility Area also were located within the 1997 Facility Area boundary (for 1996 locations, see Appendix D1). We found 22 species nesting there in the 2 years combined; 14 (64%) of those species nested in each year (Table 36). In 1996 only, we found one nest each of Green-winged Teal and Long-tailed Jaeger in the Facility Area, and one of Northern Shoveler in the surrounding ground-search area. In 1997 only, we found nests of Red-necked Grebe, Greater Scaup,

Table 36. Numbers of bird nests and broods of selected species found during ground surveys of the Facility Area, Colville River Delta, Alaska, 1996 and 1997. Search area boundaries are displayed in Figures 10 and 12.

	Number of Nests				Number of Broods			
	1996[a]		1997		1996[a]		1997	
Species	Facility Area (8.6 km^2)	Ground-Search Area (17.1 km^2)	Facility Area (9.3 km^2)	Ground-Search Area (14.2 km^2)	Facility Area (8.6 km^2)	Ground-Search Area (18 km^2)	Facility Area (9.3 km^2)	Ground-Search Area (27.2 km^2)
Red-necked Grebe	0	0	2	3	0	2	0	1
Greater White-fronted Goose	13	35	25	45	3	17	2	16
Green-winged Teal	1	1	0	0	0	0	0	0
Northern Pintail	1	2	4	5	0	1	1	1
Northern Shoveler	0	1	0	0	0	0	0	0
Greater Scaup	0	0	1	2	0	0	2	4
Oldsquaw	4	7	6	9	1	6	0	1
Willow Ptarmigan	1	1	5	12	1	1	0	0
Rock Ptarmigan	0	0	0	1	0	0	0	0
Sandhill Crane	0	0	0	0	0	0	0	1
Black-bellied Plover	0	0	1	2	0	0	0	0
American Golden Plover	1	1	1	1	0	0	0	0
Bar-tailed Godwit	1	1	0	0	0	0	0	0
Semipalmated Sandpiper	16	27	8	16	1	1	1	1
Pectoral Sandpiper	6	6	2	2	0	0	0	0
Dunlin	2	3	1	2	0	0	0	0
Stilt Sandpiper	4	4	1	1	0	0	0	0
Long-billed Dowitcher	1	2	2	2	0	0	0	0
Common Snipe	0	0	1	1	0	0	0	0
Red-necked Phalarope	9	23	10	15	0	0	0	0
Red Phalarope	5	9	7	11	0	0	0	0
Parasitic Jaeger	1	1	1	1	0	1	0	0
Long-tailed Jaeger	1	1	0	0	0	0	0	0
Glaucous Gull	0	0	0	2	0	1	0	2
Sabine's Gull	0	1	0	0	0	0	0	0
Arctic Tern	0	0	3	5	1	2	1	2
Short-eared Owl	0	1	0	0	0	0	0	0
Savannah Sparrow	1	1	1	1	no data	no data	no data	no data
Lapland Longspur[b]	no data	no data	no data	no data	no data	no data	no data	no data
Total nests or broods	68	128	82	139	7	32	7	29
Total species	17	20	19	21	5	9	5	9

[a] The boundaries of the Facility Area and search area in 1996 overlapped with, but differed from, those in 1997. See Figure 17 in Johnson et al. (1997) for boundaries in 1996.

[b] Lapland Longspur nests and broods were numerous, but numbers of nests and broods found were not recorded.

and Arctic Tern in the Facility Area and a Rock Ptarmigan nest in the ground-search area (Figure 23). We found 12 Willow Ptarmigan nests in 1997 in the ground-search area, compared with one in 1996. Notable for shorebirds was a Bar-tailed Godwit nest found in 1996 and a Common Snipe nest found in 1997, both within the respective Facility Areas. In 1995, when a less-intensive ground search was conducted, only White-fronted Goose nests were found in the Facility Area, although nests of Northern Pintail, Oldsquaw, Glaucous Gull, Sabine's Gull, and Arctic Tern were found nearby.

We revisited nest sites of waterfowl in July 1997 (after the hatch) to determine the fate of nests in the ground-search area. Nests were determined to be successful if egg membranes were detached from the eggshells. Using this technique, we could determine nest fate for most waterfowl species, but not for species such as ptarmigan, shorebirds, gulls, or Arctic Terns, whose eggshells and membranes rarely are found after hatch. We also could not determine the fate of nests on inaccessible islands, as was the case for three Red-necked Grebe nests. Of the 13 duck nests found during the nesting survey in the ground-search area, only one Northern Pintail was successful, a success rate of 8%. During the brood-rearing survey, we found three additional nests: one active Northern Pintail nest and one failed and one successful Oldsquaw nest. One Arctic Tern and two Glaucous Gull nests were considered successful, based on the presence of broods near the nest site.

In 1995–1997, we collected observations of Red-necked Grebes during aerial surveys for focal species because little is known about the bird's presence on the Colville Delta. Red-necked Grebes are considered uncommon on the Arctic Coastal Plain (Brackney and King 1994), and Gerhardt et al. (1988) classified the species as a visitant ("a nonbreeding species without a definable seasonal pattern") to the delta. Prior to our discovery of a nest in the southern part of the Development Area in 1996, the only other record, to our knowledge, of a Red-necked Grebe nesting in this area was a nest found south of the delta, at the junction of the Itkillik and Colville Rivers in 1949 (Nelson 1953). In 1997, we found three Red-necked Grebe nests on a lake that is partially within the Facility Area (Figure 23) and one nest in the southern part of the Development Area. Other researchers on the delta reported finding a Red-necked Grebe nest on the Outer Delta in 1997 (S. Earnst, pers. comm.). In 1996, we repeatedly saw up to three Red-necked Grebes in the Facility Area on the same lake that supported the nests in 1997, but we did not find a nest on the lake that year. Nests of Red-necked Grebes consist of a floating vegetation mat and occur in lakes with extensive amounts of emergent grasses or sedges; consequently, their nests may easily be overlooked. These records suggest that the delta is at least part of a breeding range expansion for this species.

Brood-rearing

In 1997, we conducted two ground surveys, one for eiders and one for loons, during brood-rearing in the Facility Area and vicinity (Table 2). The ground-search area was slightly larger for the brood-rearing survey than for the nesting survey in the Facility Area and vicinity because we also used a helicopter to search large lakes adjacent to the Facility Area (Figure 29). In the Facility Area, we saw broods of Northern Pintail, Greater Scaup, and Arctic Tern in 1997 (Table 36). Within the area searched surrounding the Facility Area, we found additional broods of Red-necked Grebe, Greater Scaup, Oldsquaw, Sandhill Crane, Glaucous Gull, and Arctic Tern.

In the Facility Area in 1996, we found one brood each of Oldsquaw, Willow Ptarmigan, and Arctic Tern (for 1996 locations see Appendix D2). Outside the Facility Area, but within the search area, we found broods of Red-necked Grebe, Northern Pintail, Oldsquaw, Parasitic Jaeger, Glaucous Gull, and Arctic Tern. In 1995, we saw two scaup broods in the Facility Area and two Oldsquaw broods in the ground-search area.

In addition to the Red-necked Grebe brood found near the Facility Area, we found three Red-necked Grebe broods and four separate adults in the southern part of the Development Area during an aerial survey (Figure 28). One brood was on the same lake as the Red-necked Grebe nest that we found earlier in the season, and the other two broods were on a lake where we found a brood in 1996. Based on the number and location of nests and broods that we found in 1997, we determined that at least seven pairs of Red-necked Grebes nested on the delta in 1997. In 1996, at least four pairs of Red-necked Grebes nested on the delta. We did not find any Red-necked Grebe nests or broods on the delta in 1995, but we did have four sightings of birds in the Development Area and Transportation Corridor.

During the brood-rearing period in July, many nonbreeding waterfowl and failed breeders used areas of the delta, particularly waterbodies, for feeding and refuge during molt. We did not conduct specific surveys for non-focal waterfowl (other than geese, beginning in 1996), but did record incidental sightings during surveys for focal species (Figure 25). However, in 1997, we recorded locations of all broods and groups of nonbreeding waterbirds near the Facility Area (Figure 25) during ground and helicopter surveys in July. We saw groups of Northern Pintail on lakes in the Facility Area throughout July. On 16 July, we saw three large groups in the Facility Area: one group of ~400 birds and two groups of ~100 birds each. We saw an additional 6 groups of Northern Pintail, ranging in size from 19 to 35 birds, in the ground-search area on the same day. We saw American Wigeon,

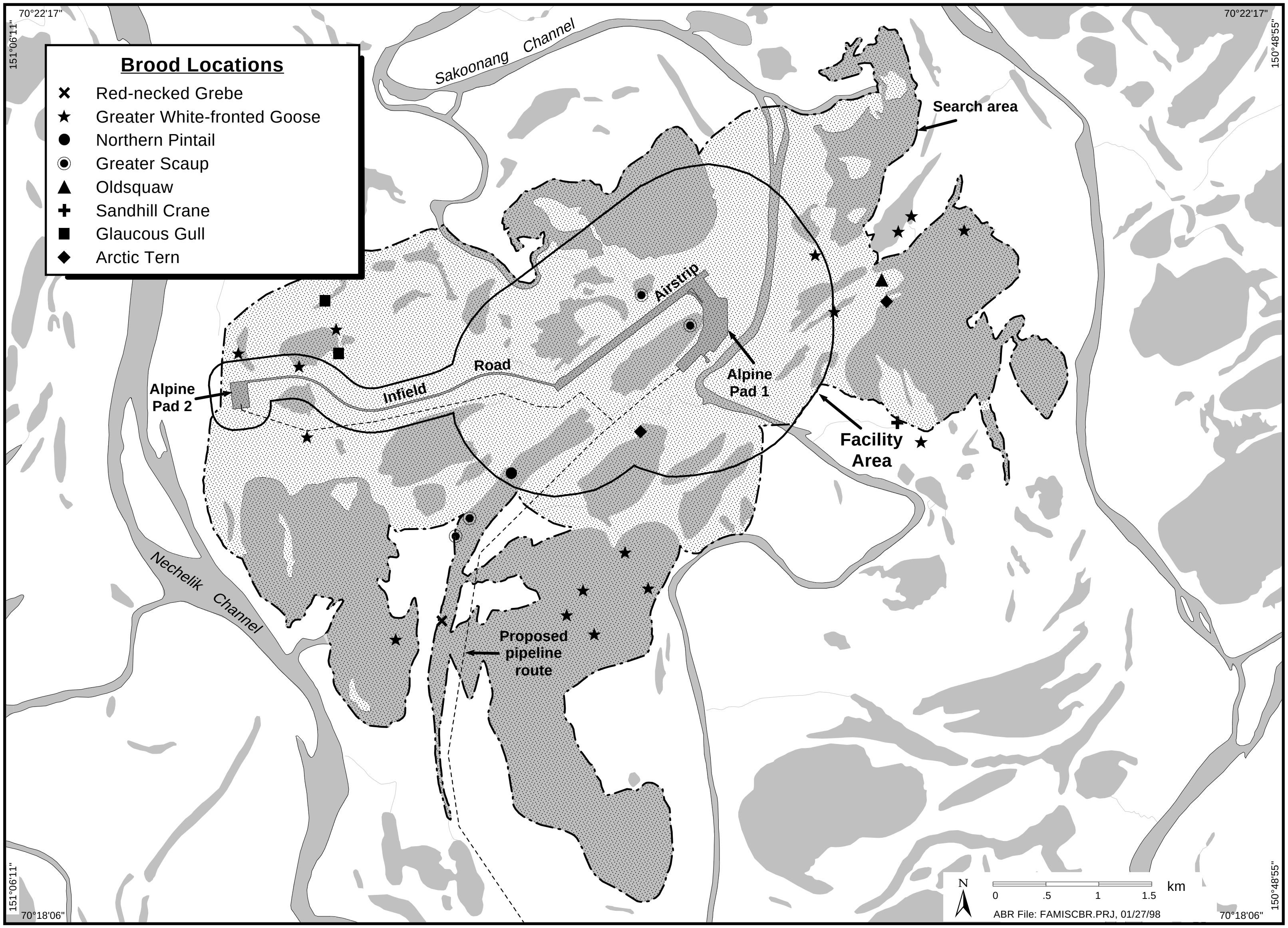

Figure 29. Brood locations of selected birds observed during ground surveys in July and August near the Facility Area, Colville River Delta, Alaska, 1997.

Northern Shoveler, Greater Scaup, and Oldsquaw in smaller groups, ranging from 1 to 15 birds. We observed a group of 28 Arctic Terns feeding in the same area as two of the large groups of Northern Pintails. Generally, Tapped Lakes (both types) attracted the largest numbers of groups and species. However, two notable lakes (lakes M9524 and M9525 [Moulton 1996: Figure 2]) contained groups of ≥100 Northern Pintail in their Aquatic Grass Marsh margins, which was generally where the highest densities of ducks were seen.

Fall Staging

During aerial surveys for focal species, we recorded sightings of fall-staging ducks opportunistically in 1997 and in previous years (Figure 27). In 1997, we saw small groups of Greater Scaup (10–25 birds) on the Outer Delta and in the Development Area and 2 groups of Oldsquaw (25 and 40 birds) in the Transportation Corridor. In August 1997, we saw two small groups of Northern Pintails (16 and 20 birds) at a tapped lake in the northern part of the Facility Area. In contrast, in 1995 and 1996, we saw large groups of ducks both on the delta and in the Transportation Corridor. In 1996, we saw ~100 American Wigeon and ~500 Northern Pintail feeding in three tapped lakes near the Facility Area and 2 groups of unidentified ducks (50 and 400 birds) at two tapped lakes on the Outer Delta. In 1995, we saw large groups of Greater Scaup and unidentified ducks on the Outer Delta, Northern Pintail in the Development Area, and Oldsquaw in the Transportation Corridor. Because sightings in each year were incidental, they do not represent complete counts of the delta for fall-staging ducks.

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 edge 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 varies seasonally, as virtually the entire herd moves 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 typically occurs near the end of the first week of June (Curatolo and Reges 1984, Whitten and Cameron 1985). The TLH calves and summers in a core area surrounding Teshekpuk Lake, about 80 km west of the Colville Delta, and disperses across the coastal plain in winter, traveling south of the Brooks Range in some years (Silva 1985, Carroll 1992, Philo et al. 1993).

The Colville Delta was not surveyed routinely during the caribou calving season until our Colville wildlife studies began in 1992; complete surveys of the Colville Delta and Transportation Corridor during calving season were conducted in 1992 (Smith et al. 1993), 1993 (Smith et al. 1994), and 1995 (Johnson et al. 1996). Except for partial (33%) coverage in 1981 and one year (unspecified) in the 1978–1980 period, calving surveys of the CAH by ADFG ended at or east of the East Channel of the Colville River (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 (e.g., Cameron et al. 1988, Lawhead and Cameron 1988). Similarly, past surveys of the TLH stopped at the western bank of the Nechelik Channel (Reynolds 1982).

By the calving season, caribou of the CAH separate into western and eastern segments, which tend to remain on their respective sides of the Sagavanirktok River and Prudhoe Bay Oilfield throughout the summer (Lawhead and Curatolo 1984). The CAH caribou that occur on the Colville Delta in summer belong to the western segment of the herd.

Caribou movements during midsummer are influenced predominantly by mosquitoes (*Aedes* spp.) and oestrid flies (*Hypoderma tarandi* and *Cephenemyia trompe*) (White et al. 1975, Roby 1978). Mosquitoes typically emerge in abundance near the coast by the end of June or beginning of July, some (after their emergence inland), 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), so caribou normally move to the coast to escape 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). When insect harassment declines or ceases due to low temperatures or windy weather, CAH caribou move inland to the south or southwest (White et al. 1975, Lawhead and Curatolo 1984). CAH caribou generally remain within 30 km of the coast throughout the mosquito season (Lawhead and Curatolo 1984).

Harassment of caribou by oestrid flies typically lasts from mid-July into August (Dau 1986). Fly-harassed caribou use unvegetated and elevated sites, such as pingos, mud flats, river bars, gravel pads, and roads, as relief habitat. 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 breeding season (rut) in October. Little use is made of the study area during the rut (Smith et al. 1994).

Use of the Colville Delta by CAH caribou for relief from insect harassment during midsummer monitored sporadically between 1983 and the beginning of our studies (Lawhead and Curatolo 1984, Cameron et al. 1995). Use of the delta for insect relief has been greatest 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, Fairbanks, AK, unpubl. data), when the herd was increasing. In addition, telemetry surveys in the 1990s demonstrated that some TLH caribou occasionally use the delta during periods of mosquito harassment (G. Carroll, ADFG, Barrow, AK, pers. comm.). The extent of contact and exchange of individuals between these two herds has not been quantified, but a small amount of interchange of collared caribou has occurred (G. Carroll, pers. comm.).

The most recent photographic census of the CAH (19–20 July 1997) resulted in a count of 19,730 caribou (ADFG, unpubl. data). This count represents a 9% increase from the previous census in July 1995 (18,093 caribou), which was 23% lower than the preceding count in July 1992 (23,444 caribou). The herd grew at a high rate during the 1970s and early 1980s (Whitten and Cameron 1983), but growth slowed by the late 1980s (Cameron 1994). The TLH also declined by 1995, but due to a difference in previous census dates, the magnitude of decline cannot be compared directly between the two herds. The most recent census of the TLH (July 1995) totaled 25,076 caribou (Bente 1996), down 9% from the high count of 27,686 caribou in July 1993 (Machida 1994).

CALVING SEASON

Snowmelt in the Colville–Kuparuk region occurred ~1½–2 weeks later than normal in 1997. Extensive snow cover remained during our surveys on 1–3 June, a time when it normally has begun to melt into a patchy, complex pattern that confounds counts of caribou. During those surveys, snow cover was essentially 100% in the Kuparuk South survey area, ≥90% over most of the Colville Delta and Colville East survey areas (decreasing to as low as 50–70% in windblown portions of the uplands along the southern edge of Colville East) and 80–85% in the Kuparuk Field survey area. We did not encounter the patchy snow cover typical of the intermediate stages of snow melt until our second set of surveys (10–12 June). During those surveys, snow cover ranged from 5% to 70% (mostly 20–60%) in different areas: Colville East, 5–40%; Kuparuk Field, 10–70% and Kuparuk South, 5–40%. Snow cover was disappearing rapidly by the end of our calving surveys, averaging 5–10% by the time of our composition counts on 13–15 June. Therefore, to adjust the counts from the second set of surveys, we applied a sightability correction factor (SCF = 1.88; Smith et al. 1994) to compensate for caribou obscured by patchy snow (20–70% cover). The contrast in timing of snowmelt between 1996 and 1997 was striking; the early timing of melt in 1996 and the late timing in 1997 are at the extreme ends of the range we have observed since 1983.

Delta Area

We saw no caribou on the Colville Delta during either set of surveys in the 1997 calving season (Figures 30–33, Table 37). On 1 June, no caribou were seen on transects in the entire Colville Delta survey area (637 km^2), nor were any seen during the eider pre-nesting surveys in mid-June. This dearth of caribou on the Colville Delta during calving is consistent with the pattern observed in all previous surveys. Few adults and virtually no calves were seen on the delta in the 1992, 1993, 1995, and 1996 calving seasons (Smith et al. 1993, 1994; Johnson et al. 1996, 1997). Two transect surveys of portions of the Colville Delta during 1979–1981 also found few caribou; instead, most of the small number found in this general area (0–12 caribou on each of 5 transects) occurred more than 16 km inland (Whitten and Cameron 1985). Whitten and Cameron suggested that the low numbers of caribou on the Colville Delta during calving probably reflected avoidance of flooding during spring breakup; this suggestion is plausible, given the large volume of runoff in the channels of the Colville River during calving. In addition, we suggest that the low availability of tussock tundra—the habitat type most preferred by cow caribou during calving (Kuropat and Bryant 1980)—may contribute to the low density of caribou on the delta at that time of year.

East of the Colville River

In marked contrast to the absence of caribou from the Colville Delta, we found relatively large numbers of caribou east of the delta in 1997 (Table 37). Caribou were most concentrated in the eastern portion of the Colville East survey area and, to a lesser extent, in the Kuparuk South survey area (Figures 30–33). Counts from the first survey (1–3 June) were extrapolated to population estimates of 555 ± 76 caribou in Colville East and 286 ± 55 caribou in Kuparuk South; the corresponding density estimates were 0.4 and 0.5 caribou/km^2, respectively. Early June counts did not need to be adjusted for sightability because snow cover was uniform.

By 10–12 June, total caribou numbers and density had increased in both the Colville East and Kuparuk South areas: the unadjusted estimates were 2,150 ± 292 caribou for Colville East (1.6 caribou/km^2) and 765 ± 107 caribou for Kuparuk South (1.3 caribou/km^2). After applying the sightability correction factor, the adjusted estimates were 2,821–812 large caribou in Colville East and 1,022 – 298 in Kuparuk South. Similar adjustments could not be computed for calves due to the lack of a suitable correction factor (Smith et al. 1994). However, if the adjusted densities of large caribou are combined with the observed densities of calves, the minimal densities would be 2.6 and 2.1 caribou/km^2 in the Colville East and Kuparuk South areas, respectively. In the adjacent Kuparuk Field survey area (Lawhead et al. 1998) on 11 June, the observed caribou density (0.15 caribou/km^2) and minimal adjusted density (0.25 caribou/km^2) were an order of magnitude lower than in Colville East and Kuparuk South. Most calving evidently occurred in the Colville East and Kuparuk South areas, where the density of calves on the second survey (0.5 and 0.4 calves/km^2, respectively) exceeded the total caribou density in the Kuparuk Field area.

Comparison with previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997) shows a sharp decrease in the peak numbers and densities of caribou in the survey areas in 1997. This decrease was due primarily to low numbers in the Kuparuk South area. Total density has been lower but more consistent in Colville East than in Kuparuk South; the 1997 density for the former area fell within the range (1.5–2.4 caribou/km^2) observed in 1992–93 and 1995–1996. In contrast, the total density of 7.3 caribou/km^2 in Kuparuk South in 1996 was the highest recorded in our studies, up from the previous high of 5.1 caribou/km^2 in that area in 1995. Peak densities in 1997 were only about half as high as the 1995–1996 peaks. Whitten and Cameron (1985: 36) related the distribution of calving by CAH caribou to the timing of snowmelt and extent of flooding, stating that "early snowmelt and dry conditions resulted in greater numbers of caribou near the coast." Our survey results for 1996 and 1997 support this generalization. The lower densities of caribou in our survey areas in 1997 imply that a greater proportion of calving by the western segment of the CAH occurred south of 70° N latitude (the southern boundary of our surveys) than in other recent years.

The estimated number of caribou present during the calving season in our survey areas has represented ~25–50% of the total CAH in recent years. In 1997, our combined estimates for all four survey areas

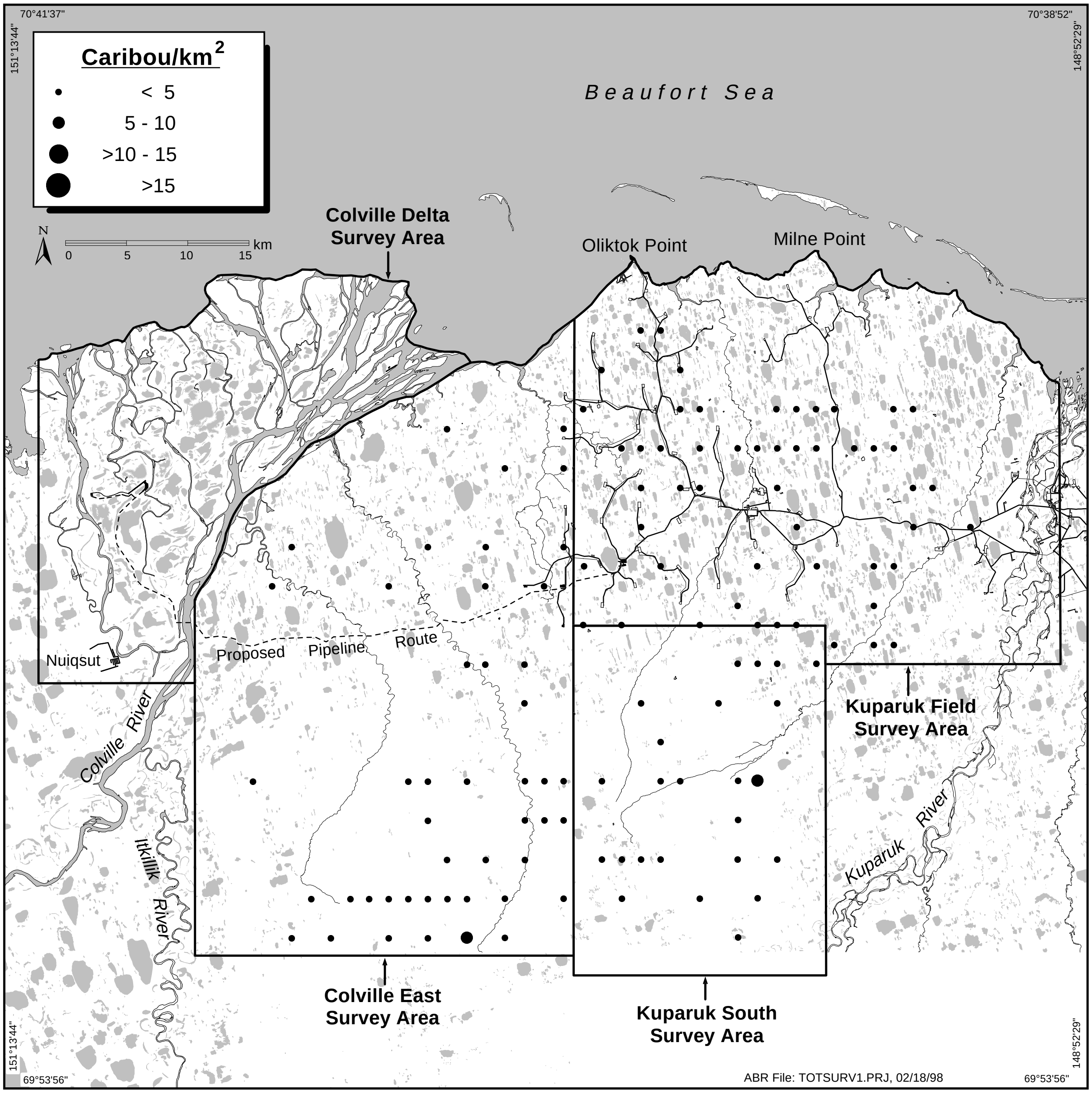

Figure 30. Distribution and density of caribou (adults and calves) in the Colville and Kuparuk survey areas, 1–3 June 1997. Dots represent centers of transect segments (3.2 km × 0.8 km) in which caribou were observed.

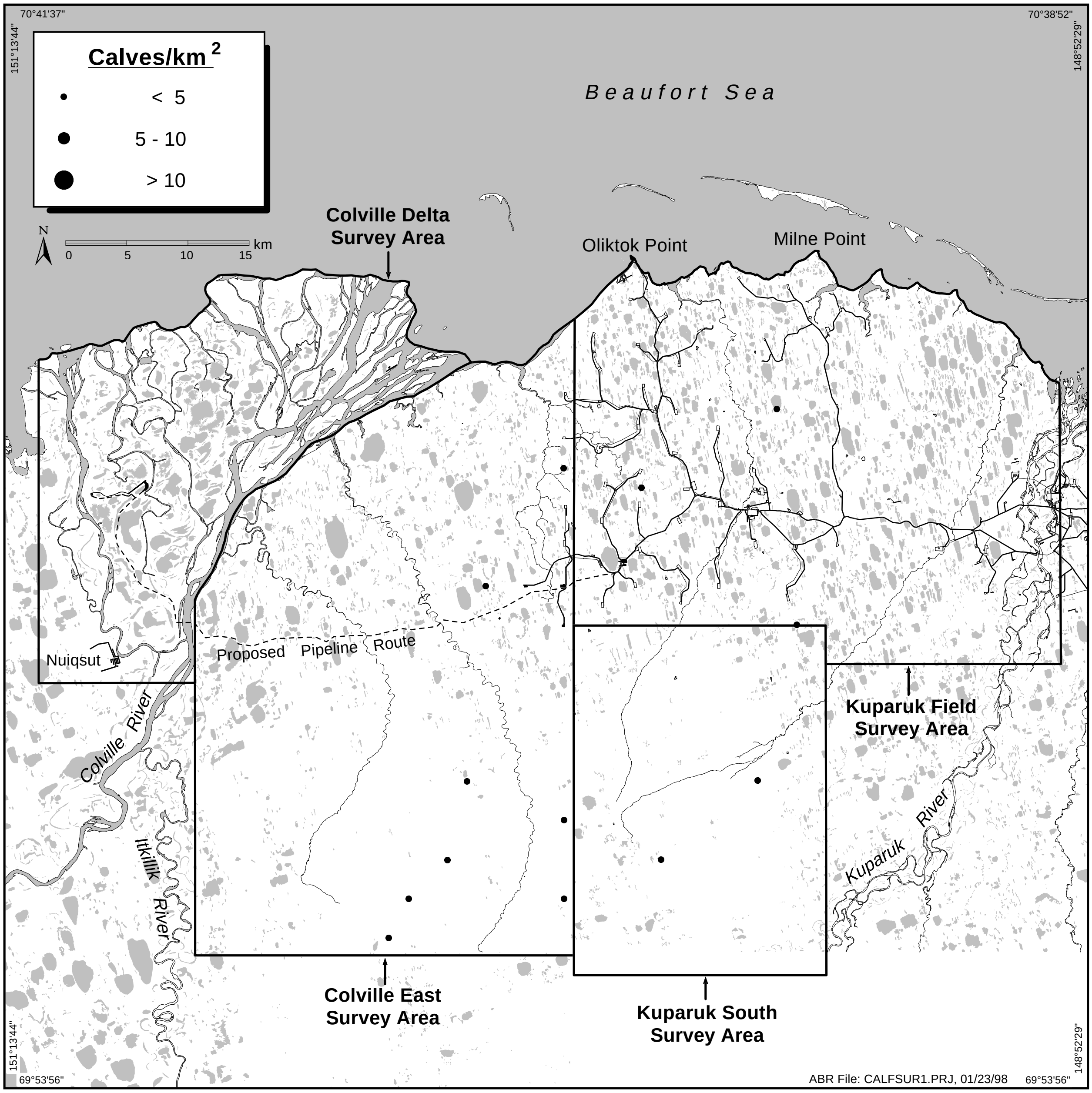

Figure 31. Distribution and density of calf caribou in the Colville and Kuparuk survey areas, 1–3 June 1997. Dots represent centers of transect segments (3.2 km × 0.8 km) in which caribou were observed.

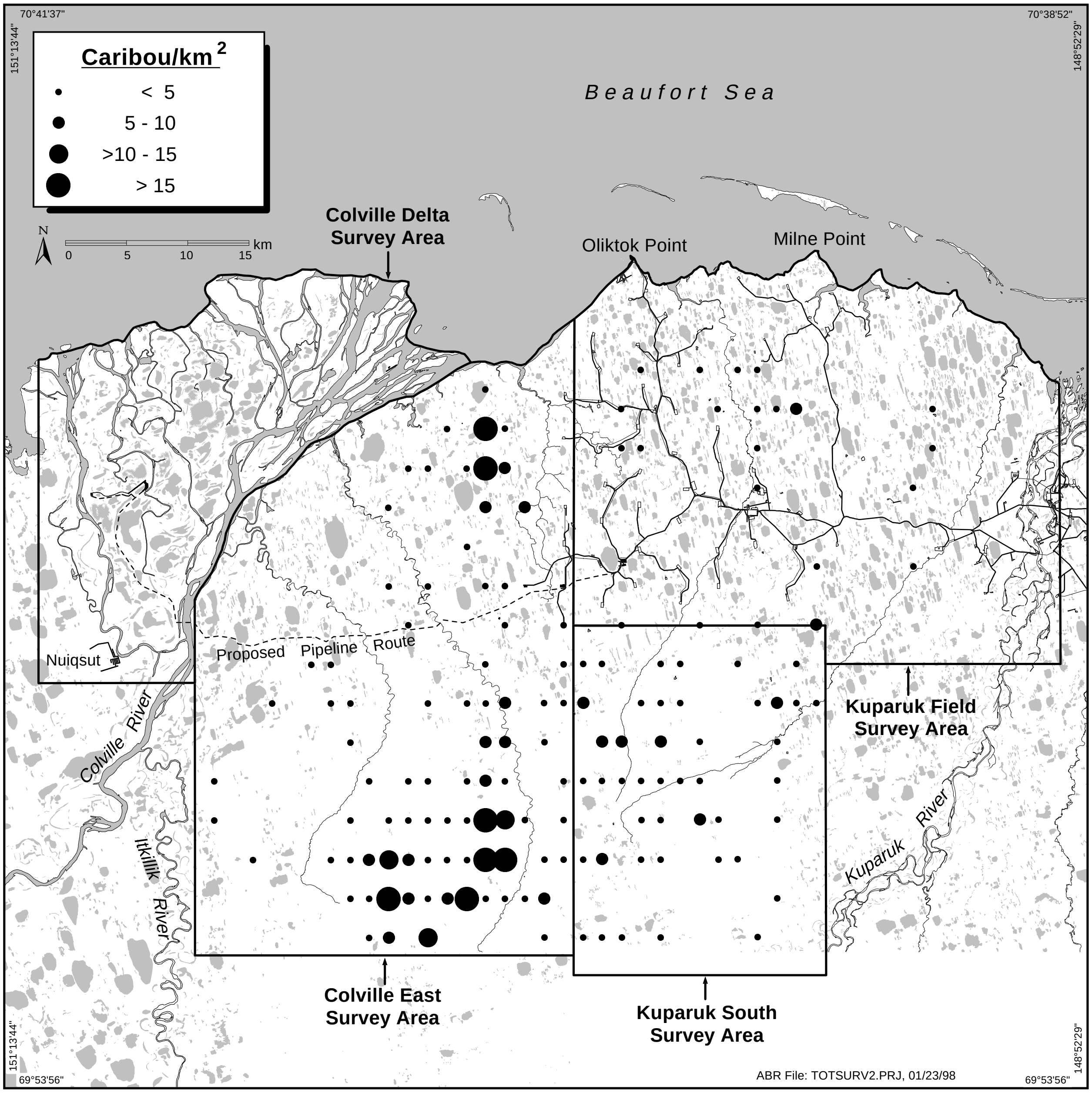

Figure 32. Distribution and density of caribou (adults and calves) in the Colville and Kuparuk survey areas, 10–12 June 1997. Dots represent centers of transect segments (3.2 km × 0.8 km) in which caribou were observed.

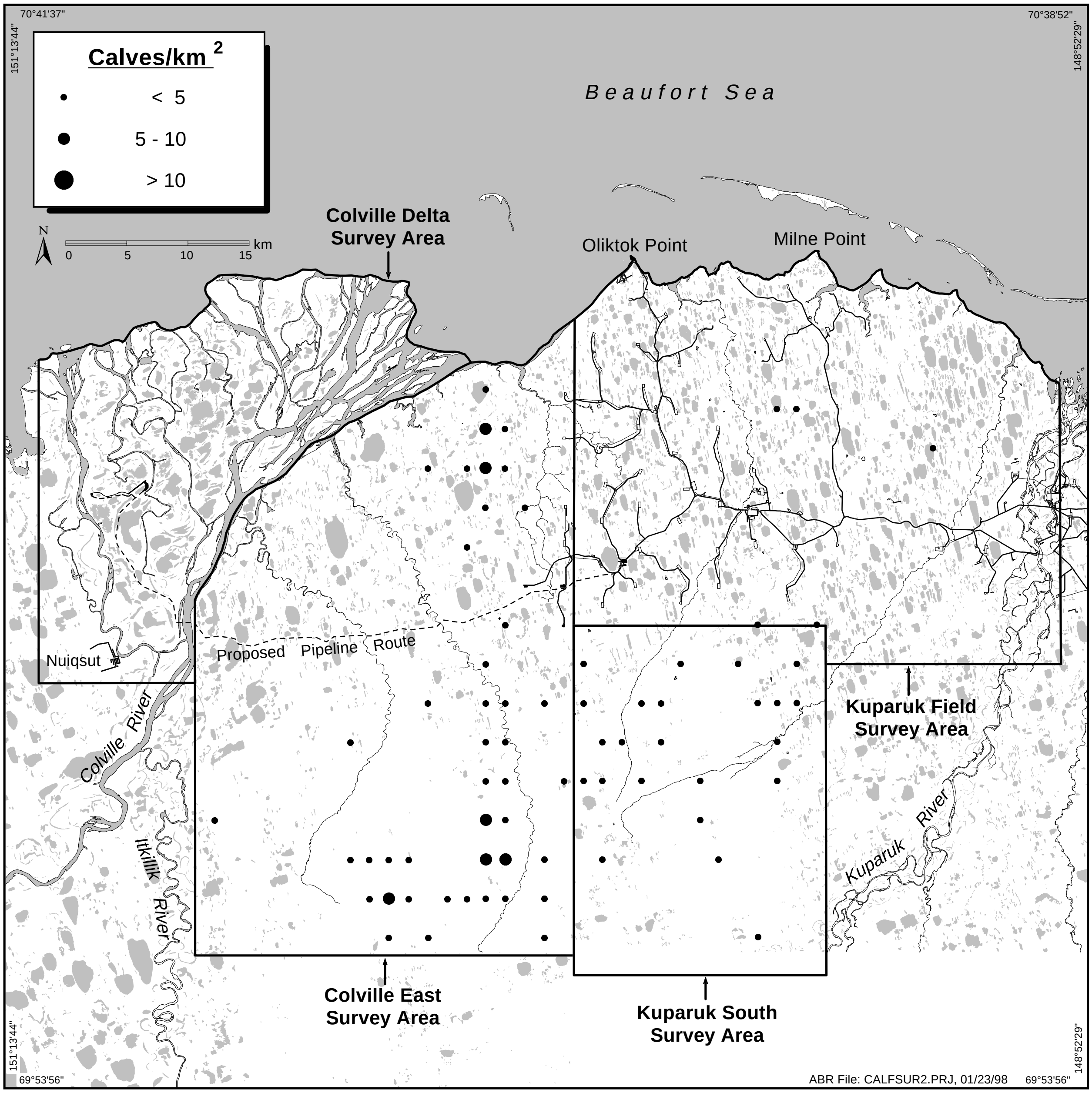

Figure 33. Distribution and density of calf caribou in the Colville and Kuparuk survey areas, 10–12 June 1997. Dots represent centers of transect segments (3.2 km × 0.8 km) in which caribou were observed.

Table 37. Counts and population estimates of caribou (± 80% confidence interval [CI]) during the calving season in the Colville and Kuparuk survey areas, Alaska, 1997. The adjusted population estimate was calculated by multiplying the population estimate (large caribou only) by a sightability correction factor (SCF = 1.88; Smith et al. 1994) on dates when caribou were obscured by patchy snow (20–70% cover).

			Counts			Population Estimate[e]				Adjusted Population Estimate	
						Total		Calves		Large Caribou[f]	
Survey Area[a]	Date	Area Surveyed[b] (km^2)	Total[c]	Calves	Total Area[d] (km^2)	No.	± CI	No.	± CI	No.	± CI
Colville Delta	1 June	142	0	0	636	0	-	0	-	-	-
	12–20 June	636	0	0	636	0	-	0	-	0	-
Colville East	1–2 June	685	279	30	1,362	555	76	60	12	-	-
	10–12 June	664	1,081	325	1,321	2,150	292	646	106	2,821	812
Kuparuk South	2 June	301	144	21	599	286	55	42	12	-	-
	12 June	301	385	111	599	765	107	221	37	1,022	298
Kuparuk Field	3 June	554	205	16	1,137	421	54	33	9	-	-
	11 June	554	83	21	1,137	170	44	43	17	239	84

[a] Refer to Figure 30 for locations.
[b] Area of transect segments that were surveyed.
[c] Total = cows + calves + yearlings + bulls.
[d] Total area within the boundaries of the survey area.
[e] Count of caribou expanded to the total area.
[f] Large caribou = cows + yearlings + bulls (SCF for calves not available).

totaled ~5,500–5,800 caribou (including sightability adjustments) in mid-June. This total represents slightly less than 30% of the July 1997 count of 19,730 caribou for the CAH. In 1996, our total was 9,482 caribou, or 52% of the estimated 1995 herd size of 18,093 caribou. In 1995, the total number estimated in 3 of the 4 survey areas (no Kuparuk Field survey was done that year) was 4,828 caribou (27% of the 1995 herd size); the comparable figure in those three areas for 1996 was 7,024 caribou (39% of the 1995 herd size).

From 1978 (when systematic surveys began) to 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–Milne concentration area" in the vicinity of the Kuparuk and Milne Point oilfields) and between the Shaviovik and Canning rivers east of Prudhoe Bay (Lawhead and Curatolo 1984, Whitten and Cameron 1985, Lawhead and Cameron 1988, Cameron et al. 1992). Since then, 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 (Smith and Cameron 1992; Cameron and Ver Hoef 1996). The pattern seen in 1993 and 1995–1997, when the highest densities occurred south and west of the Kuparuk Oilfield and east of the Colville River, indicates that the area of most concentrated calving has shifted southwest of the Kuparuk–Milne concentration area.

The southwestern shift in the distribution of most concentrated calving activity does not mean that caribou have abandoned the traditional Kuparuk–Milne calving area, however. Although the relatively low number of caribou (estimated at 170–421 caribou) using the Kuparuk Field area in early to mid-June 1997 was consistent with the trend of lower numbers there since the late 1980s, the number using the area varies greatly among years. For instance, a large number of caribou used the Kuparuk Field survey area during the 1996 calving season (estimated at 2,458 caribou on 11 June; Lawhead et al. 1997), even though most of the

Table 38. Sex and age composition of caribou groups observed in the Kuparuk South–Colville East (combined sample) and Kuparuk Field survey areas during helicopter surveys in the 1997 calving season.

altitude and decreasing snow cover on the latter dates. The percentages of all sex and age groups (except bulls) are comparable with composition percentages reported by ADFG for previous years in which calf production was high (Woolington 1995). As in past years, bulls were undercounted in our 1997 composition surveys (0.5% overall), judging from the average of 5.6% (range 2–14%) in ADFG surveys during 1978–1992 (Woolington 1995). Misclassification of young bulls as cows would cause our estimate of the calf:cow ratio to be somewhat below the actual value for the herd.

Yearlings constituted 23.9% of our composition sample in the Kuparuk South–Colville East survey areas. This figure is substantially higher than that calculated for the Kuparuk Field area, where few yearlings were present (1.6%, or 3 yearlings: 100 cows). The overall percentage for the combined composition sample (n = 2,372 caribou in the Colville East–Kuparuk South and Kuparuk Field survey areas) was relatively high: 18.1% yearlings and 40 yearlings:100 cows (Table 38). The distribution of yearlings in 1997 was less uniform than in other recent years, in that the proportion of yearlings was highest near the southern edge of the survey areas. The number of yearlings in the CAH varies substantially among years (5–22%; Woolington 1995), depending on both calf production in the preceding year and overwinter survival (Whitten and Cameron 1983). The high number of yearlings we counted in 1997 reflected the high calf production of 1996, whereas the low number of yearlings in 1996 reflected low calf production in 1995 (Johnson et al. 1996).

INSECT SEASON

In the 1995 and 1996 insect seasons, we concentrated on the Development Area, Western Delta, and Transportation Corridor survey areas (Johnson et al. 1996, 1997), which are located south of the outer portions of the Colville Delta that were surveyed most often in 1992 and 1993 (Smith et al. 1993, 1994). In 1997, we enlarged our survey area with additional east–west-oriented transects south of the Transportation Corridor (Figure 35). We conducted aerial observations of caribou (both systematic transect surveys and nonsystematic reconnaissance flights) on 27 days between 28 June and 31 July, recorded incidental sightings on 7 and 14–15 August, and flew a final transect survey on 22 August (Table 39).

Despite the late snowmelt in 1997, insect harassment began in late June at about the normal time expected from studies in the 1980s and early 1990s in the Kuparuk Oilfield (Johnson and Lawhead 1989, Lawhead and Flint 1993, Lawhead et al. 1994). The first few mosquitoes were noted on 21 June by our ground observers on the Colville Delta and by other researchers south of the Transportation Corridor (L. Moulton, MJM Research, Bainbridge Island, WA, pers. comm.). As mosquitoes emerged in low numbers on 23 June, caribou began to aggregate and move slowly into the southwestern portion of the Kuparuk Oilfield (CPF-2 area); however, moderate-to-severe harassment by mosquitoes did not occur until 28–29 June. Widespread harassment by oestrid flies began by 12 July, although isolated instances of characteristic fly-avoidance behavior by caribou were seen on 1 and 8 July. In all, we noted moderate or severe mosquito harassment on 18 days and fly harassment on 16 days in 1997; simultaneous harassment by both mosquitoes and oestrid flies occurred on at least 12 days (1, 12, 14–17, 19–20, 23–26 July).

Caribou movements in the 1997 insect season fit a general pattern seen in recent years: caribou moved eastward out of the study area in late June–early July and did not return in numbers until mid- to late July. Weather conditions prior to 28–29 June resulted in mild mosquito harassment on several days, causing a slow movement of caribou upwind (easterly) toward the Kuparuk River. The 279 caribou (in 26 groups; Table 39) moving eastward on the delta and Transportation Corridor on 28 June was the largest number we saw until 12 July (although we flew no surveys specifically for caribou on the delta from 6 July to 22 July, observers conducting surveys for other species also looked for caribou). Coastal habitats were not used extensively until 29 June, when the temperature reached 22° C and mosquitoes were active even on the outer Colville Delta. On 30 June, at least 3,245 caribou aggregated along the coast outside of our study area (from Back Point eastward to the Kuparuk River), and 6,350 were found between Beechey Point and the Kuparuk River (≥30 km east of the Colville Delta) on 1 July, when the temperature at the

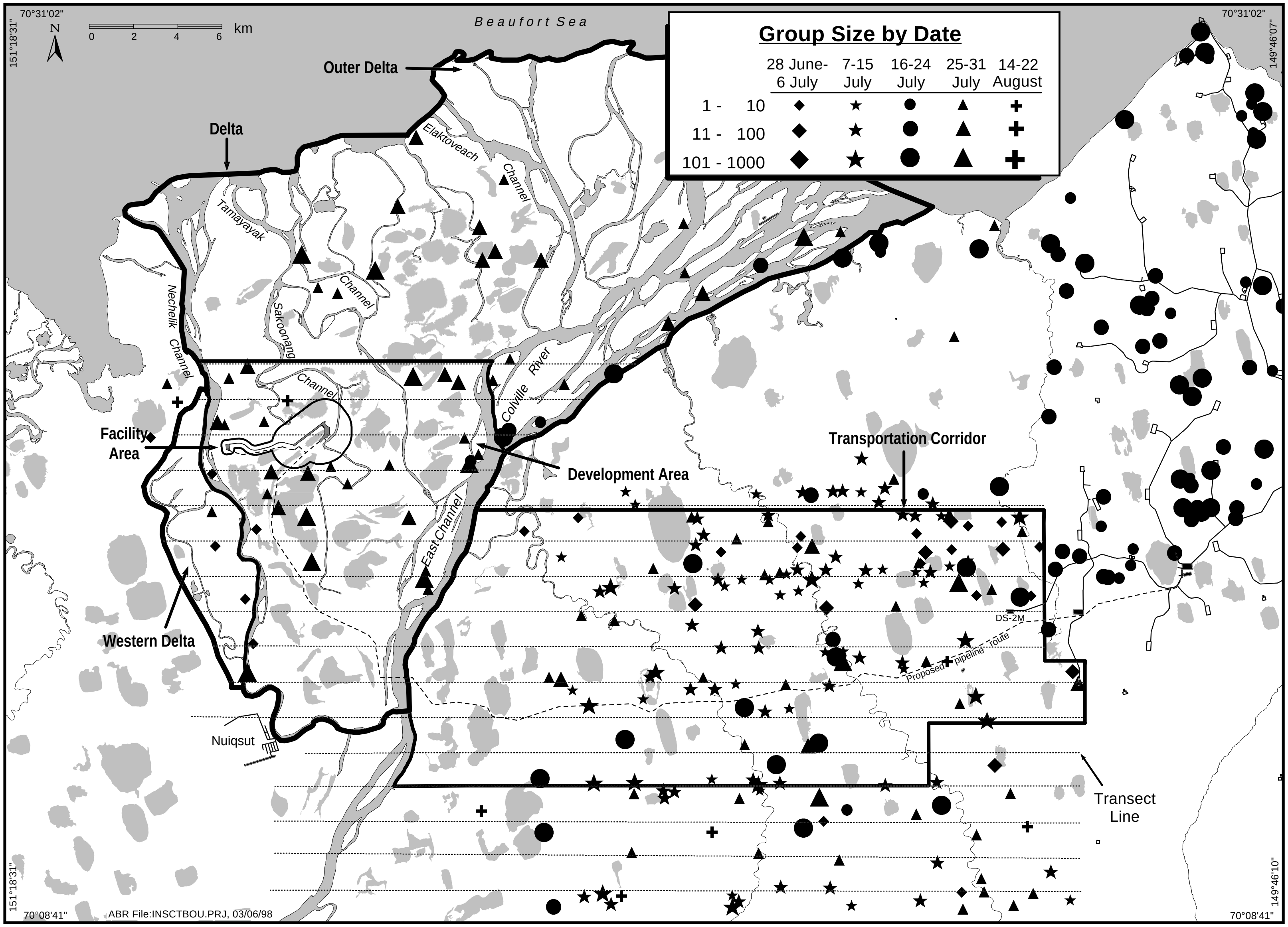

Figure 35. Distribution of caribou observed on systematic and reconnaissance aerial surveys of the Development Area and Transportation Corridor during the insect season, Colville River Delta, Alaska, 28 June–22 August 1997. Survey coverage was not uniform over the entire area portrayed (see Table 39).

Table 39. Numbers of caribou observed during aerial surveys of strip transects (1.6-km spacing) in the Delta (Development Area and Western Delta) and Transportation Corridor survey areas during the insect season, Colville River Delta, Alaska, 1997. Complete systematic coverage of all transect lines was not attempted on each survey, and caribou also were observed outside of these survey areas.

	Development Area and Western Delta			Transportation Corridor and Adjacent Area to South		
Date	Groups	Individuals	No. of Lines Surveyed[a]	Groups	Individuals	No. of Lines Surveyed[b]
28 June	4	25	5	22	254	6
3 July	1	1	2	0	0	4
4 July	-	-	0	0	0	2
5 July	0	0	2	0	0	4
6 July	-	-	0	0	0	2
8 July	-	-	0	1	2	2
11 July	-	-	0	0	0	2
12 July	-	-	0	5	1,941	3
13 July	-	-	0	39	2,455	6
14 July	-	-	0	35	2,402	5
15 July	-	-	0	0	0	1
16 July	-	-	0	0	0	2
19 July	-	-	0	0	0	1
21 July	-	-	0	2	1,114	1
22 July	1	1	5	9	2,774	5
23 July	0	0	4	2	1,130	4
24 July	0	0	3	2	1,700	4
26 July[c]	1	100	0	-	-	0
27 July	13	1,214	11	7	63	10
29 July	5	295	8	27	648	7
30 July	2	240	6	0	0	6
31 July	5	230	6	6	234	5
22 August	1	1	6	5	10	6

[a] Of 11 transect lines in the Development Area and Western Delta subareas of the Delta study area.
[b] Of 9 transect lines in the Transportation Corridor plus 3 more lines south of it, as depicted in Figure 35.
[c] Incidental observation during a waterbird brood-rearing survey; no caribou transects flown.

Kuparuk camp reached 24° C. We found no aggregations on the Colville Delta at that time.

Cooler temperatures and generally easterly winds suppressed insect activity on most days during 2–10 July (except for periods of harassment on 4–5 July) and caribou remained east of the study area, especially in the Kuparuk River floodplain and vicinity inland to 70° 10' N latitude. Caribou began to move to the south and west from the Kuparuk River during that period, however, and moved into our study area from the east on 12 July, when we saw five groups totaling 1,941 animals in the Transportation Corridor east of the Miluveach River. Despite some insect harassment during 12–14 July, caribou remained in the Transportation Corridor and adjacent area to the south until the night of 14–15 July, when they moved northeast into the western Kuparuk Oilfield. A westerly movement by 1,500–2,000 animals occurred on 15–16 July, but they did not reach the Transportation Corridor before severe insect harassment on 17 July drove them north again to the coast. Caribou generally remained near the coast during 17–20 July, moving inland a few miles at night but returning to the coast during the day; it was during this period that ADFG flew the 1997 photocensus and we were able to follow caribou movements in the Kuparuk Oilfield effectively by road surveys (Figure 35). A few scattered single animals and small groups (not mapped on Figure 35), but no large groups, were seen on the outer Colville Delta and nearby coastline during this period.

The most consistent use of the study area by caribou in the 1997 insect season occurred during the last third of July. On 21 July, caribou moved southwest through the western Kuparuk Oilfield and into the eastern Transportation Corridor, by evening >1,000 animals were visible west of the DS-2M pad. The number of caribou seen in the Transportation Corridor and adjacent area to the south peaked on 22 July, when 9 groups totaling 2,774 caribou were recorded on the transect survey. Despite insect harassment, caribou movements were variable with no pronounced coastal movement, although several groups approached the coast along the East Channel of the Colville River. At least 1,035 caribou moved onto islands in the northeastern delta (north of the Development Area) on 23 July, while 1,130 caribou remained in the Transportation Corridor. Over the next two days, two groups of caribou totaling 1,700 animals were present in the Transportation Corridor, during a period of insect harassment. No survey was flown on 25 July, but the location of caribou on 26 July and the presence of heavy trails on river mud strongly suggested that the large groups from the Transportation Corridor had moved west across the East Channel onto the delta on 25 July.

The movements by caribou onto the delta on 23–25 July began a period of use of the Development Area during the last week of July. The number of caribou there peaked on 27 July, when 1,214 caribou in 13 groups moved south through the area after rapidly cooling temperatures caused insect harassment to cease. We saw several groups totaling 230–295 caribou in the Development Area through 31 July, and a few hundred caribou were scattered widely through the Transportation Corridor during that time as well, moving in varying directions in response to periodic insect harassment. The influence of mosquitoes on caribou movements (aggregation and coastal movement) declined during the second half of July as fly harassment became more common, and the last day of moderate or severe mosquito harassment in 1997 was 26 July. Fly harassment continued to mid-August, however, judging from incidental observations of fly avoidance behavior as late as 14 August. We saw few caribou in the study area on our final transect survey on 22 August.

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). Based on our five years of surveys (1992, 1993, 1995, 1996, 1997), discussions with local residents, and incidental observations in past years (e.g., Lawhead and Curatolo 1984), it is evident that the Colville Delta is used annually by CAH caribou for insect relief. The numbers moving onto the delta vary each year, however, in response to changes in weather and the resulting levels of insect activity. These numbers are impossible to predict, but our surveys provide a range of what can be expected. The largest numbers in our surveys were seen in 1996 (3,340 caribou near the Elaktoveach Channel on 14 July; Johnson et al. 1997) and 1992 (3,300 caribou near the Kupigruak Channel on 18 July; Smith et al. 1993). In most years, the Outer Delta is used by the largest aggregations, probably because the barrens and tidal flats close to the ocean offer the most effective relief from insect harassment.

The largest numbers using the Development Area have occurred as caribou were drifting southward in the absence of insect harassment (1,950 caribou on 17 July 1996 and 1,214 caribou on 27 July 1997). Our observations to date indicate that use of the Development Area by large groups (>1,000 animals) of insect-harassed caribou is rare. The value of the Development Area to caribou probably peaks in the second half of July and early August, as small groups and individuals seek relief from oestrid fly harassment on elevated landforms, river and lake barrens, and dunes.

At the beginning of the insect season, insect-harassed caribou cross the Transportation Corridor as small groups coalesce in the first major coastward movements of the season. Although this type of movement was not seen in 1996 (due to the early onset of mosquito harassment immediately following calving), it occurred in 1995 and 1997 and also may have occurred in 1992 and 1993. Westerly and southwesterly movements in mid-July 1995–1997 resulted in use of the corridor by large numbers of caribou. The greatest use of the Transportation Corridor by caribou occurred during the 1996 insect season, as a result of the influx of ~7,000 caribou during 8–10 July; the peak numbers using the area in 1995 and 1997 were lower, but we have observed >1,000 caribou in the Transportation Corridor each year. Because the corridor is located relatively far inland from the coast (compared with the normal range of daily movements by caribou during the insect season), it is used more frequently by small groups for feeding and resting during insect-free periods than by large aggregations of insect-harassed caribou throughout the insect season. However, large groups of caribou harassed by both mosquitoes and oestrid flies have occurred there annually in the second half of July.

ARCTIC AND RED FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Red foxes are common in the foothills and mountains of the Brooks Range, but are restricted largely to major drainages (such as the Colville and Sagavanirktok rivers) on the coastal plain, where they are much less common than the arctic fox (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).

Arctic foxes in northern Alaska breed in late March or April, and pups are born in late May or June after a gestation period of ~52 days (Chesemore 1975); pups first emerge from dens at 3–4 weeks of age (Garrott et al. 1984). Dens are occupied from late spring until pups disperse in mid-August (Chesemore 1975). Throughout their range, arctic fox litters average 4–8 pups but can range up to 15 pups (Chesemore 1975, Follmann and Fay 1981, Strand et al. 1995).

Survival of arctic fox pups to weaning is highest in years when small mammals are abundant (Macpherson 1969). Causes of pup mortality include predation, starvation, and sibling aggression (Macpherson 1969, Garrott and Eberhardt 1982, Burgess et al. 1993). For both arctic and red foxes, small mammals are the most important year-round prey, supplemented by caribou and marine mammal carcasses and, in summer, by arctic ground squirrels and nesting birds and their eggs; garbage is eaten when available (Chesemore 1968, Eberhardt 1977, Garrott et al. 1983b).

Several studies of arctic foxes in and near the North Slope oilfields have been conducted since the late 1970s (Eberhardt 1977; Eberhardt et al. 1982, 1983; Fine 1980; Burgess et al. 1993). Before our surveys in recent years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997), the research of greatest relevance on the Colville Delta was that by Garrott (1980; also see Garrott et al. 1983a), who studied arctic foxes in the region in the late 1970s.

DEN NUMBERS, DISTRIBUTION, AND OCCUPANCY

Unlike previous years (1992–1993 and 1995–1996), we did not fly systematic transect surveys in 1997 to search for dens in the Transportation Corridor and Delta (Development Area and Western Delta) areas. Instead, we focused on checking known dens to assess their status and evaluate pup production. During the den status checks in late June and early July, we also conducted opportunistic searches by helicopter of suitable-looking habitats to locate additional sites. The soil disturbance and fertilization by foxes at den sites results in a characteristic, lush flora that makes the sites easily visible from the air after “green-up” of vegetation (Chesemore 1969, Garrott et al. 1983a).

During five years of surveys and contacts with other observers, we have located 50 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 36) and have searched unsuccessfully for one other den used in 1983 (M. North, unpubl. data). In 1997, we found two more dens in the Transportation Corridor on the den status survey and found another on the Western Delta during the eider pre-nesting survey. During our 1997 visit to one den that was used historically by red foxes (J. Helmericks, pers. comm.), we reclassified it as an arctic fox den, based on the most recent sign found there. After the 1997 field season, S. Earnst (unpubl. data) provided the locations of three other

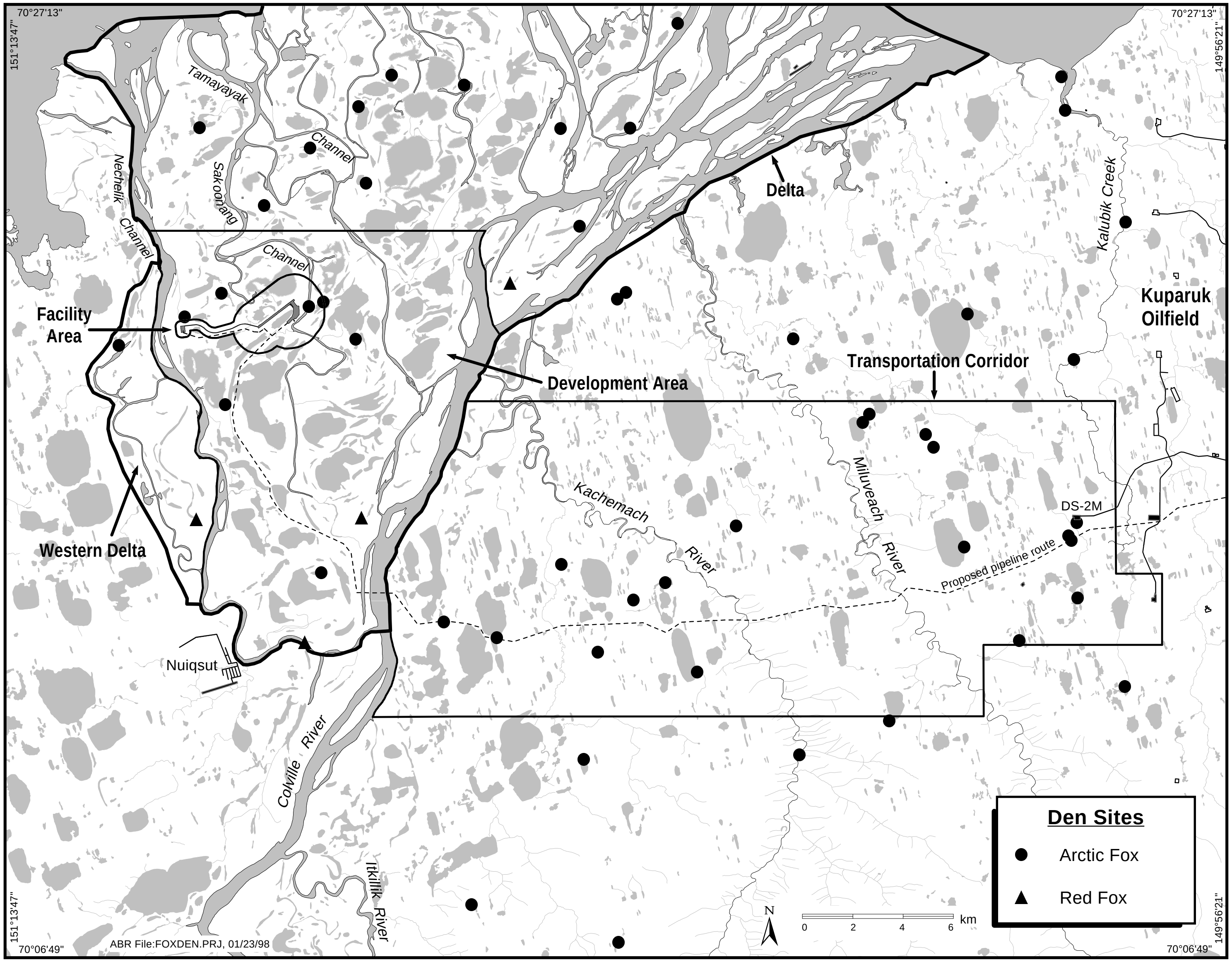

Figure 36. Distribution of arctic and red fox dens found during aerial and ground surveys in 1992, 1993, and 1995–1997 on the Colville River Delta and Transportation Corridor, Alaska. Survey coverage was not uniform over the entire area portrayed.

dens used by arctic foxes on the outer Colville Delta between 1994 and 1997. We have never searched for dens on the Outer Delta during systematic aerial surveys. Hence, we expect that more dens are present in that area (which has been confirmed by J. Helmericks [pers. comm.], who knows of several den sites that we have not found). Nevertheless, our sample of confirmed dens has increased in each year of study, from 6 dens in 1992 to 55 dens in 1997. Although more den sites will be found with further survey effort, the rate at which new sites are being added is declining.

All 4 red fox dens and 19 arctic fox dens are on the Colville Delta, 18 arctic fox dens are in the Transportation Corridor, and the remaining 14 arctic fox dens are located north and south of the corridor (Table 40). The overall density of arctic fox dens (active and inactive) in the combined Delta (551 km^2) and Transportation Corridor (343 km^2) survey areas is 1 den/22 km^2. The density in the Delta area (1 den/29 km^2) is lower than that in the Transportation Corridor (1 den/19 km^2; Table 41), probably due to the low number of dens (and lower search intensity) on the Outer Delta. The overall density is higher than the 1 den/34 km^2 reported by Eberhardt et al. (1983) for their Colville study area (which extended farther east–west than ours, but not as far inland). The densities we report for arctic foxes 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 slightly higher than the mean densities reported for large areas of tundra in the Northwest Territories (1 den/36 km^2; Macpherson 1969) and Siberia (1 den/32 km^2; Boitzov 1937, as cited in MacPherson 1969) (Table 41). Excluding the historically used site reported by Helmericks, the density of red fox dens in the Delta area was 1 den/138 km^2; few data for this species are available for comparison from other arctic tundra areas.

Based on brief visits at 44 arctic fox dens and longer observations at 22 of those dens between 23 June and 20 July, we confirmed that pups were present at five dens and strongly suspected that pups were present at two more dens. We observed pairs of adults sleeping at four other "active" dens, although we saw no pups at those sites. Thus, the number of dens with pups was in the range of 5–11 (11–25%) of the 44 arctic fox dens checked; the remaining dens showed signs of occasional use by adults only or were completely inactive. Pups were known or suspected to be present only at arctic fox dens on the delta or north of the Transportation Corridor; the presence of pups was not confirmed at any of the dens in the corridor.

Den occupancy by litters in 1997 (11–25%) was the lowest we have observed during our studies. In contrast, den occupancy in 1996 was the highest on record for the Colville area (67%; Johnson et al. 1997). In 1995, litters were present at 13 (38%) of 34 arctic fox dens examined (Johnson et al. 1996), and in 1993, 12 (52%) of 23 dens were occupied by litters (Smith et al. 1994). Low-intensity survey coverage late in the 1992 season resulted in a sample that was too small to calculate meaningful percentages. In their Colville study area, Eberhardt et al. (1983) reported that the percentage of dens containing pups (comparable to our natal and secondary categories combined) ranged from 6% to 55% in a 5-year period, 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 dens examined over 5 years were used as natal dens in any one year (Smits and Slough 1993).

In any year, estimates of pup production must be considered minimal because pups often remain underground for extended periods, making it difficult to obtain reliable counts. In 1997, this difficulty was pronounced. During 6–20 July, we expended 80 hours observing 22 arctic fox dens and 3 red fox dens, but were able to obtain complete litter counts at only 3 of the 11 arctic fox dens where litters may have been present. Observations at dens in 1996–1997 were most successful for obtaining pup counts during early morning and evening, when foxes were more active than during midday. Pups proved difficult to observe in 1997, presumably because they were young and not yet spending much time outside the den burrows at the time of our observations in late June (and even early July), but also because few dens that appeared to be good prospects early in the season had pups in July. We

Table 40. Landforms, activity status, and numbers of pups at arctic and red fox dens during the 1993 and 1995–1997 seasons on the Colville River Delta and adjacent coastal plain, Alaska.

Location/species	1997 Status[b]	No. of Pups[c] (1997)	1996 Status[d]	1995 Status[d]	1993 Status[d]
DELTA					
Arctic Fox					
dune mound	inactive?	-	inactive	inactive	-
dune ridge	inactive?	0	natal	natal	-
dune ridge	inactive	-	-	-	-
dune/cutbank	natal	4	natal	secondary	-
dune/cutbank	nd	-	inactive	inactive	-
dune/lake bank	inactive?	-	natal	inactive	natal
dune/lake bank	inactive?	nd	inactive	inactive	inactive
dune/lake bank	inactive	-	natal	natal	inactive
dune/lake bank	natal	≥3	natal	secondary?	adults only
lake bank	natal?	0?	natal	inactive	inactive
low dune ridge	natal	5	secondary	not checked	-
low mound	inactive	-	-	-	-
low ridge	active	0?	secondary?	secondary?	-
nd[a]	nd	-	-	-	-
nd[a]	active?	nd	-	-	-
nd[a]	inactive?	-			-
old dune	inactive	-	natal	inactive	natal
old dune	inactive?	-	inactive	natal	natal
Red Fox					
river cutbank	inactive	-	natal	natal	-
sand dune	active?	0	natal	natal	-
sand dunes	inactive	-	inactive	natal	-
sand dunes	active	0?	natal	secondary?	-
TRANSPORTATION CORRIDOR					
Arctic Fox					
pingo	inactive	-	natal	secondary	adults only
pingo	inactive	-	natal	natal	inactive
stream bank	inactive?	-	natal	natal	natal
lake bank	inactive?	-	natal	-	-
terrace bank	active	0	secondary	-	-
low mound	active	0	natal	-	-
terrace bank	inactive	-	natal	-	-
lake bank	inactive	-	natal	-	-
old lake bank	inactive?	-	active	-	-
low mounds	active	0	-	-	-
old lake island	inactive	-	-	-	-
old lake bank	active	0	inactive	inactive	-
old lake bank	inactive	-	inactive	inactive	secondary
pingo	inactive	-	inactive	inactive	inactive
lake bank	inactive?	-	natal	natal	secondary
lake bank	inactive	-	natal	inactive?	secondary
low ridge	inactive	-	inactive	inactive	secondary
low ridge	inactive	-	inactive	inactive	secondary
NORTH/SOUTH OF TRANSPORTATION CORRIDOR					
Arctic Fox					
lake bank	inactive	-	natal?	inactive?	-
old gravel pad	nd	-	inactive	inactive	inactive
old lake bank	natal	6	natal	inactive?	secondary
old lake bank	nd	-	natal	natal	-
old lake bank	inactive	-	natal?	-	-
old lake bank	inactive	-	secondary	-	-
old lake bank	inactive	-	inactive	inactive	inactive
pingo	inactive	-	natal	inactive	inactive
pingo	nd	-	inactive	natal	secondary
pingo	inactive	-	natal	inactive	inactive
stream bank	inactive	-	inactive	natal	-
stream bank	inactive	-	inactive	inactive	-
stream bank	natal	≥4	natal	inactive	-
stream bank	nd	-	natal	inactive	natal

[a] Sites added after the 1997 field season, based on information from S. Earnst (pers. comm., 1998), but were not visited.
[b] Based on observations between 23 June and 20 July (23–25 June and 6–10 July for most dens); question mark indicates uncertainty regarding status ("active" means natal vs. secondary status could not be determined); nd = no data (site not checked).
[c] Minimal number of pups counted; ≥ sign or question mark indicates count suspected to be incomplete; nd = no data on litter size.
[d] Sources: 1996—Johnson et al. (1997); 1995—Johnson et al. (1996); 1993—Smith et al. (1994).

Table 41. Densities of arctic fox dens in the Delta and Transportation Corridor survey areas, compared with data from other tundra areas. Table was modified from Burgess et al. (1993: Table 3). Russian sources were cited in Macpherson (1969) and Garrott (1980); sizes of study areas were not stated for all references.

Location	Den Density[a] (1 den/x km^2)	Source
COLVILLE WILDLIFE STUDY		
Colville Delta survey area	29	This study
Transportation Corridor survey area	19	This study
OTHER STUDIES		
Colville Delta and adjacent areas	42	Garrott 1980
Colville Delta and 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, Alaska	25	Burgess and Stickney 1992
Okpilak River (ANWR), Alaska	13	Spindler 1978
Yukon–Kuskokwim Delta, Alaska	1	Anthony et al. 1985
Yukon Territory coastal plain	22	Smith et al. 1992
Herschel Island, Yukon Territory	3	Smith et al. 1992
Banks Island, Northwest Territories	22–141	Urquhart 1973
Keewatin, Northwest Territories	36	Macpherson 1969
Taimyr Peninsula, Russia	0.5	Sdobnikov 1958
Bol’shezemel’sk tundra, Russia	2	Danilov 1958
Bol’shezemel’sk tundra, Russia	16	Dementyiev 1958
Siberia ("tundra zone")	32	Boitzov 1937
Turukhansk region, Russia	50	Boitzov 1937

[a] x = number listed in column; e.g., den density is 1 den/29 km^2 in the Colville Delta survey area.

counted 22 pups at the 11 arctic fox dens that we judged to be natal sites or otherwise active (Table 40). At the three dens where we thought we obtained complete counts, the litter size averaged 5.0 pups (range = 4–6). No pups were seen at the red fox dens we checked, although only one den was thought to be active.

In some years, estimates of pup production are confounded by the use of secondary dens, which may result in splitting of litters among several dens by one family (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. We were aware of no such movements in 1997, although several litters were seen early in the season but not subsequently.

The mean litter size for arctic foxes calculated in 1993 and 1995 was 3.1 pups each year (Smith et al. 1994, Johnson et al. 1996), and the mean in the high-production year of 1996 was 6.1 pups per litter (Johnson et al. 1997). These figures were identical with those reported by Garrott (1980) for low and high years of pup production in his Colville study area. In 1978, when small mammals were abundant on the delta, Garrott (1980) closely observed seven litters (from a total of 23 active dens), which averaged 6.1 pups (range = 2–8). In contrast, he observed only one litter the year before (from two active dens), when small mammals were scarce, and was unable to obtain a reliable litter count. This comparison confirms that both the occupancy rate of dens and the number of pups produced by arctic foxes were low in 1997.

Several possibilities explain the low number of pups in 1997: litters were not produced, litters were born but lost, or pups simply were not spending much time above ground during our observations. Most of the dens we checked on 23–25 June had been visited by adult foxes, judging from fresh tracks, scats, shed fur in burrows, fresh digging, and some prey remains, which suggests that the number of adults was not unusually low in 1997. *In utero* litter sizes of arctic foxes normally do not vary significantly among years, although the number of pups surviving to weaning fluctuates directly in relation to food abundance (Macpherson 1969). Macpherson observed a high rate of den abandonment during a year of low lemming abundance, so it is possible that pups died and adults abandoned dens early in the 1997 season, which could account for the low number of pups seen on our visits. The pups we saw on 21 June (Den 58) and even 9 July (Den 34) were smaller than expected for those dates, suggesting that whelping occurred later in the season or that growth rates were lower than normal; these smaller pups may not have been as active above ground as the pups observed in previous years. Although we conducted our den status checks and observations about five days earlier in 1997 than in 1996, it seems unlikely that this time difference would account for the size difference in pups between the two years.

The low occupancy rate and small number of arctic fox litters in 1997 led us to conclude that the density of small mammals (primarily brown lemmings) in the Colville study area was low, although we have no population data to evaluate support this conclusion. Our observers reported relatively few sightings of lemmings and lemming predators (e.g., snowy owls and jaegers) while searching for bird nests in the study area. Although J. Helmericks (pers. comm.) reported that lemmings were abundant around his homestead on Anachlik Island near the mouth of the East Channel, that abundance apparently was a local phenomenon. Given that den occupancy can vary substantially among years and regions in relation to population level and food abundance (Macpherson 1969, Chesemore 1975, Garrott 1980, Eberhardt et al. 1983), the low occupancy rate of dens and the general lack of pups in 1997 are strong circumstantial evidence of low abundance of small mammals.

SELECTION OF DENNING HABITAT

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).

Delta Area

Because both arctic and red foxes have similar denning requirements and will use the same den sites in different years, we included both in our analysis of habitat selection. Fifteen arctic fox dens and four red fox dens constituted our habitat selection sample for the Delta survey area. We have not been able to visit four arctic fox dens reported by other researchers, so we could not assign a habitat type to them and excluded them from the sample. Dens were located in four of the 13 available habitats (Table 42). Fourteen dens (74% of the total) were in the Riverine or Upland Shrub type (all were in upland shrub rather than riverine shrub), the only denning habitat that was preferred. The other habitats used by denning foxes on the delta were Wet Sedge–Willow Meadow (three dens), Moist Sedge–Shrub Meadow (one den), and Nonpatterned Wet Meadow (one den). The Barrens type was avoided on the delta.

Transportation Corridor

We included all 18 arctic fox dens in the Transportation Corridor in our analysis (Table 43); to date, we have found no red fox dens in the corridor. Dens were located in four of the 10 available habitats. As on the delta, Riverine or Upland Shrub was the only preferred habitat; in the Transportation Corridor, this type constitutes only 2.7% of the area of terrestrial habitats. The most dens in a single type (nine) were located in Moist Sedge–Shrub Meadow. Fewer dens were located in Moist Tussock Tundra (four dens), Riverine or Upland Shrub (three dens, all in upland shrub), and Old Basin Wetland Complex (two dens). 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%). No habitats were significantly avoided by denning foxes in the Transportation Corridor.

In both the Delta and Transportation Corridor survey areas, foxes preferred Riverine or Upland Shrub for denning (Tables 42 and 43). Dens in other habitats actually were located in small patches of higher microrelief that were below the minimal

Table 42. Habitat selection by arctic and red foxes for denning in the Delta survey area, Colville River Delta, Alaska. The sample analyzed included all active and inactive dens of arctic foxes (*n* = 15 dens) and red foxes (*n* = 4 dens) found during 1992–1997, because both species may use the same dens in different years.

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability[a] (%)	Selection Index (Ivlev's E)[b]	Monte Carlo Results[c]
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	-	-
Salt Marsh	16.35	0	0	4.3	–1.00	ns
Tidal Flat	56.05	0	0	14.8	–1.00	ns
Salt-killed Tundra	25.63	0	0	6.8	–1.00	ns
Deep Open Water w/o Islands	0	-	-	0	-	-
Deep Open Water w/Islands or Polygonized Margins	0	-	-	0	-	-
Shallow Open Water w/o Islands	0	-	-	0	-	-
Shallow Open Water w/Islands or Polygonized Margins	0	-	-	0	-	-
River or Stream	0	-	-	0	-	-
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	13.60	0	0	3.6	–1.00	ns
Aquatic Grass Marsh	0	-	-	0	-	-
Young Basin Wetland Complex	<0.01	0	0	<0.1	–1.00	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	–1.00	ns
Nonpatterned Wet Meadow	41.92	1	5.3	11.1	–0.36	ns
Wet Sedge–Willow Meadow	102.36	3	15.8	27.1	–0.26	ns
Moist Sedge–Shrub Meadow	13.36	1	5.3	3.5	0.20	ns
Moist Tussock Tundra	2.52	0	0	0.7	–1.00	ns
Riverine or Upland Shrub	27.40	14	73.7	7.2	0.82	prefer
Barrens (riverine, eolian, lacustrine)	78.90	0	0	20.9	–1.00	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	–1.00	ns
Total	378.11	19	100	100		

[a] Aquatic habitats were assigned zero availability for fox dens.
[b] Ivlev's E = (use – availability)/(use + availability).
[c] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

mapping size of habitat areas. On the Colville Delta and Transportation Corridor, the landforms used most are banks of streams and lakes (including banks of drained-lake basins), dunes, ridges, and pingos (Table 40; Garrott 1980, Eberhardt et al. 1983). Those landforms are usually vegetated with upland shrubs and less commonly with riverine shrubs. Pingos commonly were 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 west of the Colville Delta, low mounds are used most often for den sites (Chesemore 1969). These observations all confirm that the primary habitat requirement for den construction is well-drained soil with a texture conducive to burrowing, conditions that occur at elevated microsites within a variety of larger habitat types.

POLAR BEAR

BACKGROUND

Polar bears have a circumpolar distribution and occur in low densities on the sea ice within 300 km of the arctic coast of Alaska (Amstrup and DeMaster 1988). Polar bears occur annually in the coastal zone around 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 polar bears are marine mammals (protected under the Marine

Table 43. Habitat selection by arctic foxes for denning in the Transportation Corridor survey area, Colville River Delta, Alaska. The sample analyzed included all active and inactive dens found during 1992–1997.

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability[a] (%)	Selection Index (Ivlev's E)[b]	Monte Carlo Results[c]
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	-	-
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	0	-	-	0	-	-
Deep Open Water w/Islands or Polygonized Margins	0	-	-	0	-	-
Shallow Open Water w/o Islands	0	-	-	0	-	-
Shallow Open Water w/Islands or Polygonized Margins	0	-	-	0	-	-
River or Stream	0	-	-	0	-	-
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	0.03	0	0	<0.1	–1.00	ns
Aquatic Grass Marsh	0	-	-	0	-	-
Young Basin Wetland Complex	14.23	0	0	5.0	–1.00	ns
Old Basin Wetland Complex	35.60	2	11.1	12.5	–0.06	ns
Nonpatterned Wet Meadow	24.47	0	0	8.6	–1.00	ns
Wet Sedge–Willow Meadow	19.87	0	0	7.0	–1.00	ns
Moist Sedge–Shrub Meadow	84.67	9	50.0	29.9	0.25	ns
Moist Tussock Tundra	94.62	4	22.2	33.4	–0.20	ns
Riverine or Upland Shrub	7.74	3	16.7	2.7	0.72	prefer
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.7	–1.00	ns
Artificial (water, fill, peat road)	0.47	0	0	0.2	–1.00	ns
Total	283.64	18	100	100		

[a] Aquatic habitats were assigned zero availability for fox dens.
[b] Ivlev's E = (use – availability)/(use + availability).
[c] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Mammal Protection Act of 1972, as amended), a portion of the females use terrestrial habitats for dens.

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 coast of the Beaufort Sea in October (Lentfer 1972). Polar bears are most numerous along the coast in years when multi-year pack ice moves near the shoreline. 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). Females do not return to the same den sites annually, although they tend to return to the same general area and den in the same type of habitat in subsequent years (Amstrup and Gardner 1994). Cubs are born in dens in December or January (Lentfer and Hensel 1980); litter size ranges from one to three cubs.

Of 90 dens occupied by pregnant female polar bears (tracked by telemetry) from the Beaufort Sea population, 42% were on land, 53% were on drifting pack ice, and 4% were on shorefast ice (Amstrup and Gardner 1994). The proportion of bears denning on land in the Beaufort Sea region has been increasing in recent years, probably as a result of population recovery following prohibition of sport hunting in 1972 (Stirling and Andriashek 1992, Amstrup and Gardner 1994). The Beaufort Sea population stock increased at an average rate of 2.4% over the last two decades, and currently is thought to be increasing slightly or stabilizing near carrying capacity (USFWS 1995). The increasing population and the increasing proportion of terrestrial denning suggest that the number of females denning on land in the Colville Delta region may increase accordingly.

DEN NUMBERS AND DISTRIBUTION

Information on the distribution of polar bear maternity dens in the Beaufort Sea region has accumulated slowly from reports over several decades (few systematic surveys have been conducted specifically to locate polar bear dens), and has been supplemented by tracking of marked females through telemetry. Records obtained from various sources (S. Amstrup, pers. comm.; S. Schliebe, pers. comm.; USFWS 1995) indicate a low frequency of occurrence of maternity dens in the vicinity of the Colville Delta (Figure 37). These records include locations for dens in the immediate vicintity of the delta (some dating from the 1920s, 1940s, and 1950s), as recorded in interviews with hunters from Nuiqsut (USFWS 1995: Appendix A). It should be noted that the locations mapped from the accumulated records over many years cover a wide range of accuracy, and generally should be considered approximate locations.

Of particular interest is a den that was occupied in the winter of 1996–1997 on the Colville Delta, in the northeastern Development Area, as reported to USFWS by I. Helmericks; that den is the most recent one discovered in the study area. Lower Kalubik Creek has been used repeatedly by denning females over the years, as indicated by three additional records (undated) from the USFWS database (Figure 37). Additional literature records of dens were reported by Seaman et al. (1981: Figure 7), who 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. 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. All of the den locations reported by Seaman et al. (1981) and Lentfer and Hensel (1980) presumably are included in the USFWS database.

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, 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. Therefore, dunes and bluffs along the Colville River channels and bluffs along Kalubik Creek and the Miluveach and Kachemach rivers provide the habitats most likely to be used by denning polar bears.

GRIZZLY BEAR

BACKGROUND

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. ADFG biologists estimate that 40–45 bears inhabit an area of approximately 17,500 km^2 between the Colville River on the west and the Kavik River on the east, and extending inland 80 km to the White Hills (Shideler and Hechtel 1995b; R. Shideler, pers. comm.). Since 1991, ADFG has captured and marked 51 bears in this region (37 were radio-collared as of winter 1997–98) in an ongoing study of use of the oilfields by bears, and additional unmarked bears also occur there.

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. Cubs are born in dens during December and January, and litters in northern Alaska range from one to three cubs, averaging two (Reynolds 1979).

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 dependent young 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, pers. comm.). Most of the bears tracked by ADFG denned within 50 km of the oilfields,

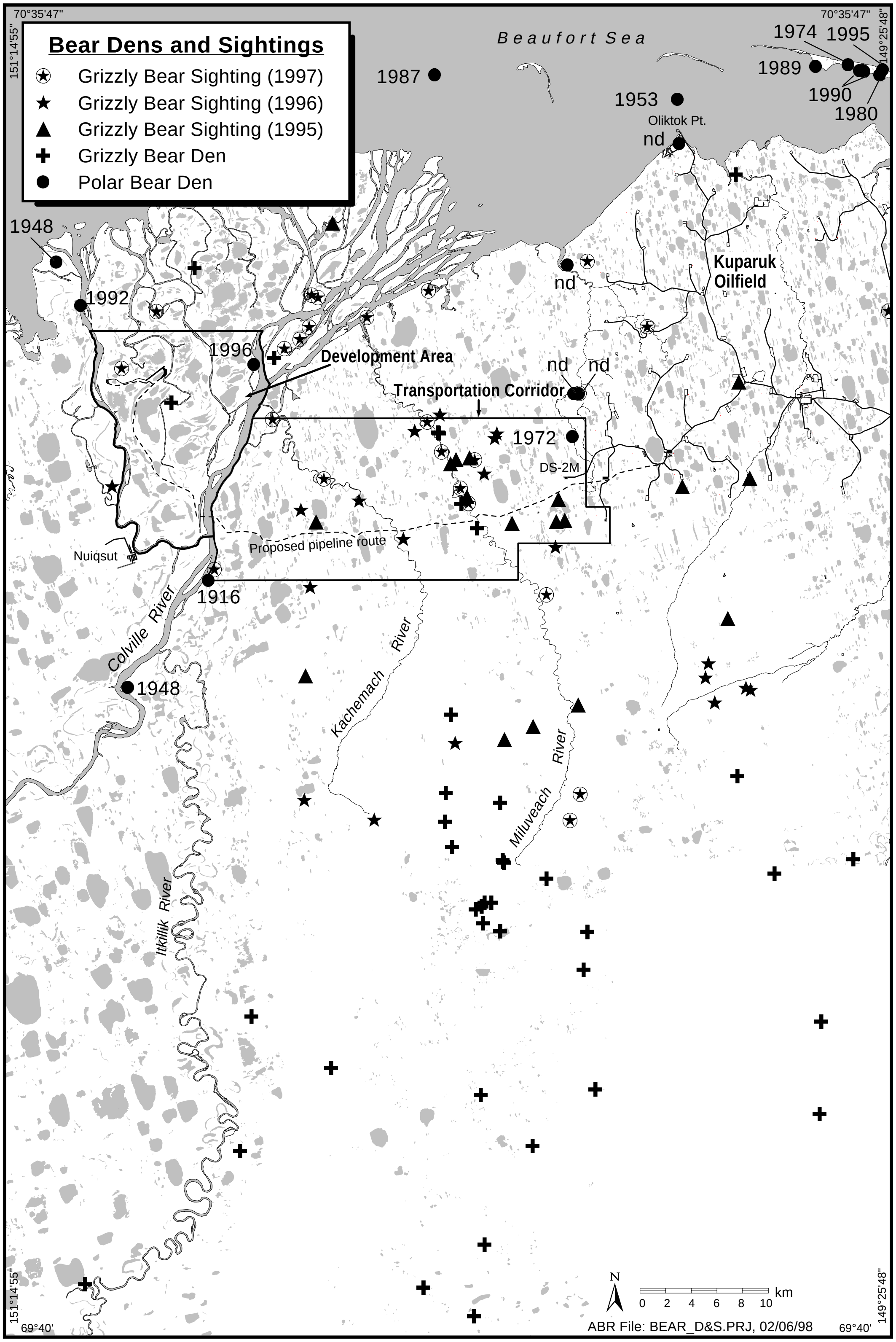

Figure 37. Distribution of winter dens of polar and grizzly bears (records from USFWS and ADFG databases) and incidental sightings of grizzly bears during aerial surveys in June–September 1995–1997 near the Colville River Delta, Alaska. Observation effort was greatest in the Development Area and Transportation Corridor during June–August.

although several have denned 100–160 km inland (Shideler and Hechtel 1995a; R. Shideler, pers. comm.).

DISTRIBUTION AND ABUNDANCE

In summer 1997, we observed grizzly bears opportunistically during our surveys for waterbirds and caribou; some additional locations were obtained in August during a telemetry survey conducted for ADFG. We recorded 31 sightings in 1997 (23 sightings occurred in the map view in Figure 37). At least 10 different bears, including 2 females with dependent young (one with a yearling and the other with 2 cubs of the year), were seen in the study area between June and September 1997. As in 1993, 1995, and 1996, we saw several grizzly bears during the first half of June on the caribou calving grounds south of the Kuparuk Oilfield. Most of the later sightings were clumped in the Transportation Corridor near the Miluveach River, probably because of the frequency of overflights of that area of favorable riverine habitat, which has been used consistently in past years. In 1997, we saw a female grizzly with two cubs of the year repeatedly on the delta (particularly “Ptarmigan Island,” a large island in the East Channel of the Colville River [Figure 37]) throughout the summer. A radio-collared subadult male bear also remained on or near the delta for much of the summer.

In the summers of 1995 and 1996, we saw grizzly bears more commonly in the Transportation Corridor and the uplands south of it than on the delta (Figure 37). During our 1996 surveys, we recorded only one bear sighting (a female with two dependent young) on the Colville Delta. In all, five of our 1996 sightings involved females with dependent young. Half of the 1995 sightings involved more than one bear, and five were of females with dependent young. At least 14 different bears (including dependent young) were seen in the vicinity of the Colville Delta during the 1995 season. Grizzly bears were observed in the vicinity of the Colville Delta five times in 1993 (Smith et al. 1994) and once in 1992 (Smith et al. 1993). The increase in sightings over this time period represents our increased observation effort from 1992 to 1996–1997. Nevertheless, use of the delta region by grizzlies can be expected to increase as the population in the vicinity of the oilfields continues to expand.

Forty-five of the grizzly bear dens located by ADFG were found between the Kuparuk Oilfield and the Colville River, south to 69º 40' N (i.e., the area shown in Figure 37). Twenty-nine of these dens were used by 12 different marked bears from the 1992–1993 to the 1997–1998 denning seasons; the other dens were older or were used by unmarked bears. In winter 1996–1997, marked bears denned on the Colville Delta for the first time in ADFG’s study: one den, containing two subadult males, was located along the Sakoonang Channel approximately 1.5 km south of the Facility Area, and another den, occupied by a pregnant female that gave birth to a litter of three cubs, was located in a sand dune at the south end of Ptarmigan Island, in the East Channel (R. Shideler, pers. comm.). That female with cubs and one of the subadult males spent much of the summer on or near the delta. One of the two subadult males also denned farther north on the delta in winter 1997–1998. In the Transportation Corridor, four different dens have been occupied by marked bears along the Miluveach River in recent years: two dens (one containing the female with cubs seen on the delta in summer 1997) during winter 1997–1998, and one each in 1995–1996 and 1996–1997. Most grizzly bear dens in the Colville–Kuparuk area, however, were clustered in the uplands >15 km south of the Transportation Corridor, in the headwaters of the Miluveach and Kachemach rivers and a western tributary of the Kuparuk River.

MUSKOX

BACKGROUND

Muskoxen were native to Alaska but were extirpated by humans 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 introductions 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 introduced near Cape Thompson in northwestern Alaska in 1970 and 1977 (Smith 1989b); that population also has expanded, albeit more slowly than the ANWR population. 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). Muskoxen that inhabit the Arctic Coastal Plain south of the Kuparuk and Prudhoe Bay oilfields probably originated from the ANWR population. This conclusion was corroborated by our observation of a tagged bull on the lower Kachemach River in July 1997, whose tag fit the description of those applied to a few bulls in ANWR by the USFWS in the 1980s (P. Reynolds, pers. comm.). By the mid-1980s, shed muskox fur (qiviut) 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 approximately 165 muskoxen inhabited the region west of ANWR to the Colville River, but gave no estimate of the number of animals west of the Sagavanirktok River. On 16 April 1997, ADFG conducted a winter survey west of the Sagavanirktok River (Game Management Unit [GMU] 26B 'West'; James 1997) for the first time and located 92 muskoxen, primarily in the general vicinity of the Itkillik uplands, where we have found the largest numbers in our surveys during late May and early June (see below); a few muskoxen also were found in the White Hills on that survey. At the same time, USFWS biologists found 187 muskoxen east of the Sagavanirktok River (GMU 26B 'East'; James 1997).

DISTRIBUTION AND ABUNDANCE

During the summers of 1992–1993 and 1995–1997, we saw most muskoxen south and east of the Colville Delta, although a few muskoxen (mostly lone bulls) have been seen on the delta (Figure 38). We first found relatively large numbers of muskoxen in the uplands east of the Itkillik River, 40–50 km south of the Transportation Corridor, during a caribou calving survey in late May 1993, and have returned each year since then because the largest numbers of muskoxen have occurred consistently in that general location and at that time of year. The number seen there has increased each year, indicating an expanding population. On 4 June 1997, we found 99 muskoxen, including 19 calves, in 7 groups in the Itkillik uplands. On 5 June 1996, we found 84 muskoxen, including 22 calves, in 7 groups in the same vicinity. On 5 June 1995, we found 61 muskoxen, including 7 calves, in four groups. The calf numbers in these counts are probably lower than the actual numbers produced each year because calving continues after early June (Reynolds et al. 1986). Although we have not conducted systematic surveys of this species in the lower Colville and Itkillik drainages, the similarity of the numbers we observed with those found by ADFG in April 1997 (Hicks 1997) indicates that we probably have found the majority of the population west of the Sagavanirktok River in the last few years.

Despite comprehensive coverage of the Colville Delta and Colville East caribou calving survey areas during early and mid-June each year, 1997 was the first year in which we saw muskoxen north of the Itkillik uplands during our calving surveys: a group of three adults was found on Kalubik Creek, north of the Transportation Corridor, on 2 June. In past years, groups of muskoxen have been seen in the vicinity of the Delta and Transportation Corridor only during July and August.

We observed several groups of muskoxen repeatedly during July and August 1997 in the vicinity of the delta and Transportation Corridor. A mixed-sex group of 24 muskoxen, including 3 calves, used riverine shrub habitat along the Kachemach River during 7–15 July, then evidently separated into smaller groups; one group of 13 muskoxen, including 2 calves, remained along the lower Kachemach River at least until 22 August. A group of four bulls used the lower Kachemach River and habitats nearby along the East Channel between 16 July and 2 August, and we saw solitary bulls on the lower Kachemach and Itkillik rivers in late July and August. We saw a single cow with a calf once on 27 July on an island in the East Channel. The last sighting of the 1997 season was a mixed-sex group of 30 muskoxen in the southwestern corner of the Transportation Corridor on 28 September (J. S. Hamilton, pers. comm.).

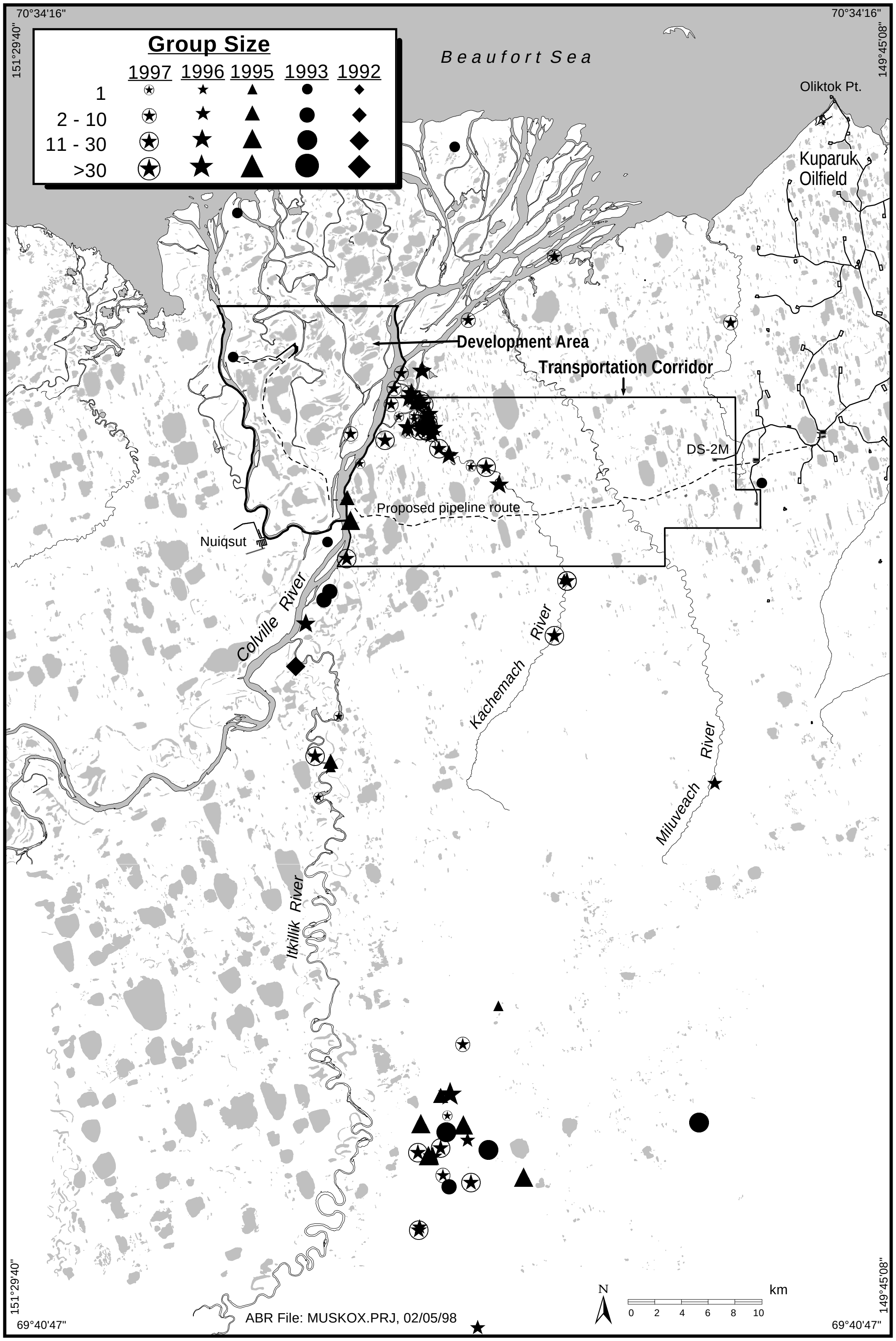

Figure 38. Distribution of muskoxen seen during aerial surveys in May–September 1992–1993, and 1995–1997 near the Colville River Delta, Alaska. Observation effort was greatest in the Development Area and Transportation Corridor during June–August.

These observations are similar to those from past years, although the number of muskoxen observed in the study area has increased in parallel with the regional population. In July 1996, a mixed-sex group of 20–21 muskoxen, including 7 calves, moved down the Kachemach River, then south toward the Itkillik River. Mixed-sex groups containing calves were seen each summer in 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 comprised 14 animals in 1992, four in 1993, and ≥13 (incomplete count) in 1995.

Muskox home ranges in ANWR are larger, and activity and movement rates are much higher, during summer than winter (Reynolds et al. 1986). Long-distance movements from winter to summer range are common in mid-late June, after 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 in summer (Reynolds et al. 1986, Reynolds 1992b). Our limited observations suggest that most of the muskox population that resides in the Itkillik–Colville region follows a similar pattern of seasonal movements and group dynamics: muskoxen winter in the uplands east of the Itkillik River, then disperse during summer into smaller groups, some of which move northward along the Itkillik and Kachemach rivers to the Colville Delta vicinity, returning south later in the summer and fall.

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, and sedges (Robus 1984, O'Brien 1988). Thus, Riverine or Upland Shrub and Moist Sedge–Shrub Meadows likely are the most important habitats for muskoxen using the Colville Delta and Transportation Corridor.

SPOTTED SEAL

BACKGROUND

In Alaska waters, the spotted seal occurs from Bristol Bay north to the Chukchi Sea and east to the Beaufort Sea (Frost et al. 1982, 1983). Although little is known of the winter habits of this species, they are known to whelp, breed, and molt from March through April while they inhabit the pack ice-front in the Bering Sea (Quakenbush 1988). As the pack ice recedes and shorefast ice melts, spotted seals disperse to nearshore habitat; from mid-summer to late fall, they commonly haul out on land throughout their range. Favored haul-out sites are small islands, sand spits, and shoals adjacent to deep water (Seaman et al. 1981, Frost et al. 1993, ABR, Inc., unpubl. data). In the Chukchi and Beaufort seas, spotted seals haul out on land from mid-July through late October (Seaman et al. 1981; Frost et al. 1993; ABR, Inc., unpubl. data). The most northerly documented major summer/autumn concentration of spotted seals is in Kasegaluk Lagoon, where up to 2,200 seals have been seen hauled-out (Frost et al. 1993). As nearshore waters begin to freeze in early winter, spotted seals move away from the coast because they are incapable of maintaining breathing holes in the thickening shorefast ice (Quakenbush 1988).

Although the distribution and abundance of spotted seals from Pt. Barrow eastward along the Beaufort Sea coast is poorly documented, the Colville River Delta is known to be used by seals in summer and autumn. Seaman et al. (1981) reported an estimate from J. Helmericks of 150–200 seals used the Colville Delta from late July through autumn. Satellite tracking of spotted seals outfitted with transmitters has revealed that movements of individuals from Kasegaluk Lagoon to the Colville Delta may be initiated as late as August (Frost et al. 1993).

DISTRIBUTION AND ABUNDANCE

During eight aerial surveys in 1997, we saw small groups of spotted seals on four occasions, hauled out on sand spits or in adjacent shoals in two locations (Figure 39). Seals were not seen elsewhere on the delta, and none were seen on or around the Jones Islands or Pingok Island. Seaman et al. (1981)

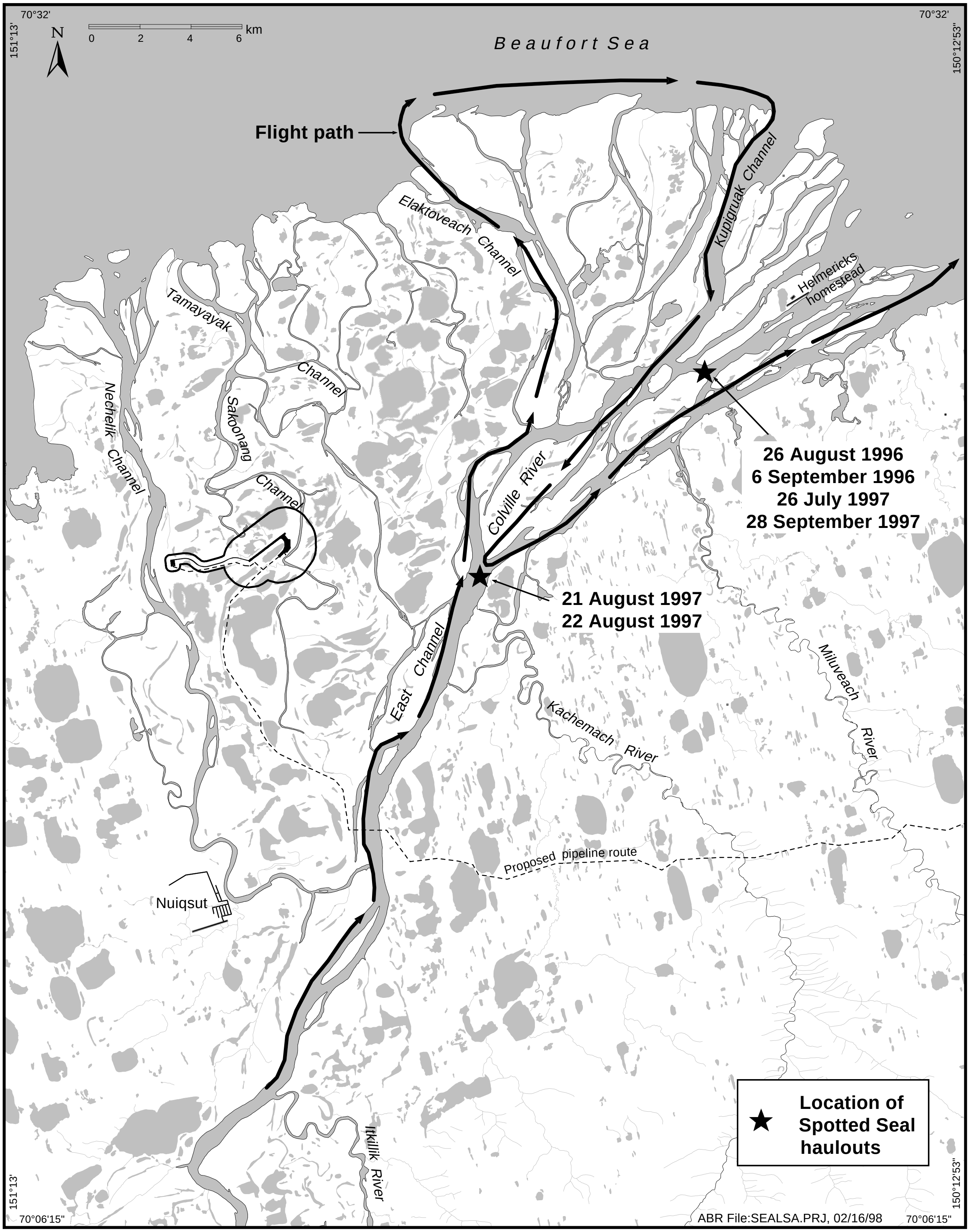

Figure 39. Locations and dates of Spotted Seal observations on the Colville River Delta, Alaska, 1996 and 1997.

speculated that adequate haulout sites on the delta are limited in number. The two locations where we observed seals in 1997 probably represent "traditionally" used sites.

We did not observe any initial response (i.e., hauled-out seals did not flee into nearby deep water) to the approach of our aircraft during our surveys, which were sometimes flown as low as 90 m agl and as close as 500 m horizontally from the seals. In one instance, however, seals entered the water when we began circling above them to obtain an accurate count. Our limited observations of haulout seals on the Colville Delta are contrary to reports by other investigators about the sensitivity of this species to aircraft. In Kasegaluk Lagoon, Frost et al. (1993) found that seals began responding to survey aircraft at ≥1 km and at flight altitudes of 760 meters; furthermore, they suggest that spotted seals may be more sensitive to disturbance than most other pinnipeds. Seaman et al. (1981), citing discussion with J. J. Burns, also mentions that spotted seals are exceptionally sensitive to disturbance.

OTHER MAMMALS

We saw three mammal species—snowshoe hare, gray wolf, and moose—in the Delta and Transportation Corridor survey areas in 1997 that we had not seen during previous years of study (1992–1996). On 16 June, we saw a Snowy Owl feeding on the carcass of a small, white-haired mammal in the Facility Area. Two days later during ground surveys in the same area, we found and collected the hindquarters of a snowshoe hare (identity confirmed by G. Jarrell, University of Alaska Museum, Fairbanks, pers. comm.). On 19 June, we spotted an unidentified hare from the helicopter in a drained lake basin in the north-central part of the Transportation Corridor. Snowshoe hares were abundant along the Colville River upstream near Umiat in mid-June 1997 (D. R. Klein, pers. comm.), but their occurrence along the lower Colville River and on the delta is rare.

We saw moose on three occasions during aerial surveys in 1997. On 16 July, we saw two female moose together close to Pikonik Mound, near the East Channel north of the Transportation Corridor. On 20 July, we saw one moose on an island southwest of Anachlik Island and another in the southwestern part of the Transportation Corridor. We do not know if the two individuals we saw on 20 July were the same ones seen on 16 July. Similar to snowshoe hares, moose occur at much higher densities upstream along the Colville River, and are rare on the delta (Coady 1979); our observers saw no moose on the delta during 1992–1996, although we found two sets of tracks one year. USFWS biologists saw 1–4 moose per year during summer field work on the delta in the early 1980s (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983).

On 29 July 1997, we saw a gray wolf on the Kachemach River 11 km south of the Transportation Corridor while flying muskox surveys in a small airplane ("super cub"). Shortly after we spotted it, the wolf began pursuing a lone caribou, which it succeeded in bringing down for about 30 seconds before the caribou escaped. The wolf continued to chase the caribou for more than a kilometer before it gave up and sat down in the creek. Five and a half hours later, we saw the wolf resting along the Kachemach River <1 km south of the Transportation Corridor. On 20 July 1995, other biologists saw a wolf north of the Transportation Corridor on the Miluveach River, 5 km upstream from the mouth (S. Earnst, pers. comm.). The population of wolves on the outer coastal plain was depressed for many years following federal predator control in the 1950s and subsequent aerial hunting (R. Stephenson, pers. comm.). Increased sightings and harvest by Nuiqsut residents in recent years indicate that the population has rebounded (G. Carroll, pers. comm.), and wolves have been seen occasionally in the Kuparuk Oilfield since winter 1993–1994 (A. Schuyler, pers. comm.).

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Appendix A. Common and scientific names of birds and mammals seen during the Colville River Delta Wildlife Study, May–October 1992–1997.

BIRDS

Red-throated Loon	*Gavia stellata*	American Golden-Plover	*Pluvialis dominica*
Pacific Loon	*Gavia pacifica*	Upland Sandpiper	*Bartramia longicauda*
Yellow-billed Loon	*Gavia adamsii*	Whimbrel	*Numenius phaeopus*
Red-necked Grebe	*Podiceps grisegena*	Bar-tailed Godwit	*Limosa lapponica*
Tundra Swan	*Cygnus columbianus*	Ruddy Turnstone	*Arenaria interpres*
Greater White-fronted Goose	*Anser albifrons*	Semipalmated Sandpiper	*Calidris pusilla*
Snow Goose	*Chen caerulescens*	Least Sandpiper	*Calidris minutilla*
Brant	*Branta bernicla*	White-rumped Sandpiper	*Calidris fuscicollis*
Canada Goose	*Branta canadensis*	Baird's Sandpiper	*Calidris bairdii*
Green-winged Teal	*Anas crecca*	Pectoral Sandpiper	*Calidris melanotos*
Mallard	*Anas platyrhynchos*	Dunlin	*Calidris alpina*
Northern Pintail	*Anas acuta*	Stilt Sandpiper	*Calidris himantopus*
Northern Shoveler	*Anas clypeata*	Long-billed Dowitcher	*Limnodromus scolopaceus*
American Wigeon	*Anas americana*	Common Snipe	*Gallinago gallinago*
Greater Scaup	*Aythya marila*	Red-necked Phalarope	*Phalaropus lobatus*
Lesser Scaup	*Aythya affinis*	Red Phalarope	*Phalaropus fulicaria*
Common Eider	*Somateria mollissima*	Pomarine Jaeger	*Stercorarius pomarinus*
King Eider	*Somateria spectabilis*	Parasitic Jaeger	*Stercorarius parasiticus*
Spectacled Eider	*Somateria fischeri*	Long-tailed Jaeger	*Stercorarius longicaudus*
Steller's Eider	*Polysticta stelleri*	Glaucous Gull	*Larus hyperboreus*
Oldsquaw	*Clangula hyemalis*	Sabine's Gull	*Xema sabini*
Black Scoter	*Melanitta nigra*	Arctic Tern	*Sterna paradisaea*
Surf Scoter	*Melanitta perspicillata*	Snowy Owl	*Nyctea scandiaca*
White-winged Scoter	*Melanitta fusca*	Short-eared Owl	*Asio flammeus*
Red-breasted Merganser	*Mergus serrator*	Horned Lark	*Eremophila alpestris*
Bald Eagle	*Haliaeetus leucocephalus*	Common Raven	*Corvus corax*
Northern Harrier	*Circus cyaneus*	American Robin	*Turdus migratorius*
Rough-legged Hawk	*Buteo lagopus*	Yellow Wagtail	*Motacilla flava*
Golden Eagle	*Aquila chrysaetos*	Wilson's Warbler	*Wilsonia pusilla*
Merlin	*Falco columbarius*	American Tree Sparrow	*Spizella arborea*
Peregrine Falcon	*Falco peregrinus*	Savannah Sparrow	*Passerculus sandwichensis*
Willow Ptarmigan	*Lagopus lagopus*	Lapland Longspur	*Calcarius lapponicus*
Rock Ptarmigan	*Lagopus mutus*	Snow Bunting	*Plectrophenax nivalis*
Sandhill Crane	*Grus canadensis*	Common Redpoll	*Carduelis flammea*
Black-bellied Plover	*Pluvialis squatarola*		

MAMMALS

Snowshoe Hare	*Lepus americanus*	Grizzly Bear	*Ursus arctos*
Arctic Ground Squirrel	*Spermophilus parryii*	Ermine	*Mustela erminea*
Brown Lemming	*Lemmus sibiricus*	Wolverine	*Gulo gulo*
Collared Lemming	*Dicrostonyx rubricatus*	Spotted Seal	*Phoca largha*
Gray Wolf	*Canis lupus*	Moose	*Alces alces*
Arctic Fox	*Alopex lagopus*	Caribou	*Rangifer tarandus*
Red Fox	*Vulpes vulpes*	Muskox	*Ovibos moschatus*

Appendix B. Descriptions of wildlife habitat types found in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1997.

Habitat	Description
Open Nearshore Water (Marine)	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 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 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 has little microrelief, and 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. These areas are often polygonized, with the rims less salt-affected than the centers of the polygons.
Deep Open Water 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.

Appendix B. (Cont.)

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 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 or margins of 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 Marsh. 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.

Appendix B. (Cont.)

Habitat	Description
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 Meadow, Moist Sedge–Shrub Meadow, 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.
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	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 (S*alix 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.

Appendix B. (Cont.)

Habitat	Description
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.

Appendix C1. Habitat selection by Spectacled Eiders and King Eiders during pre-nesting on the Delta survey area, Colville River Delta, Alaska, 1997.

Species/Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
SPECTACLED EIDER							
Open Nearshore Water (marine)	8.32	0	0	0	1.6	-1.00	11
Brackish Water	6.42	5	9	19.2	1.2	0.88	1
Tapped Lake w/Low-water Connection	21.42	1	2	3.8	4.1	-0.03	8
Tapped Lake w/High-water Connection	20.29	0	0	0	3.9	-1.00	11
Salt Marsh	16.68	1	3	3.8	3.2	0.09	7
Tidal Flat	37.37	0	0	0	7.1	-1.00	11
Salt-killed Tundra	25.63	2	3	7.7	4.9	0.22	6
Deep Open Water w/o Islands	23.31	0	0	0	4.5	-1.00	11
Deep Open Water w/Islands or Polygonized Margins	5.15	1	2	3.8	1.0	0.59	4
Shallow Open Water w/o Islands	2.30	0	0	0	0.4	-1.00	11
Shallow Open Water w/Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	11
River or Stream	75.43	2	2	7.7	14.4	-0.30	9
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	13.60	8	13	30.8	2.6	0.84	3
Aquatic Grass Marsh	1.37	1	1	3.8	0.3	0.87	2
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	11
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	11
Nonpatterned Wet Meadow	41.92	4	4	15.4	8.0	0.31	5
Wet Sedge–Willow Meadow w/Low-relief Polygons	101.83	1	2	3.8	19.5	-0.67	10
Moist Sedge–Shrub Meadow	13.10	0	0	0	2.5	-1.00	11
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	11
Riverine or Upland Shrub	27.10	0	0	0	5.2	-1.00	11
Barrens (riverine, eolian, lacustrine)	78.67	0	0	0	15.0	-1.00	11
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	11
Total	522.97	26	41	100	100		
KING EIDER							
Open Nearshore Water (marine)	8.32	1	1	5.0	1.6	0.52	3
Brackish Water	6.42	2	3	10.0	1.2	0.78	1
Tapped Lake w/Low-water Connection	21.42	1	2	5.0	4.1	0.10	5
Tapped Lake w/High-water Connection	20.29	1	2	5.0	3.9	0.13	4
Salt Marsh	16.68	0	0	0	3.2	-1.00	8
Tidal Flat	37.37	0	0	0	7.1	-1.00	8
Salt-killed Tundra	25.63	0	0	0	4.9	-1.00	8
Deep Open Water w/o Islands	23.31	0	0	0	4.5	-1.00	8
Deep Open Water w/Islands or Polygonized Margins	5.15	0	0	0	1.0	-1.00	8
Shallow Open Water w/o Islands	2.30	0	0	0	0.4	-1.00	8
Shallow Open Water w/Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	8
River or Stream	75.43	12	29	60.0	14.4	0.61	2
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	13.60	0	0	0	2.6	-1.00	8
Aquatic Grass Marsh	1.37	0	0	0	0.3	-1.00	8
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	8
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	8
Nonpatterned Wet Meadow	41.92	0	0	0	8.0	-1.00	8
Wet Sedge–Willow Meadow w/Low-relief Polygons	101.83	2	3	10.0	19.5	-0.32	7
Moist Sedge–Shrub Meadow	13.10	0	0	0	2.5	-1.00	8
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	8
Riverine or Upland Shrub	27.10	1	2	5.0	5.2	-0.02	6
Barrens (riverine, eolian, lacustrine)	78.67	0	0	0	15.0	-1.00	8
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	8
Total	522.97	20	42	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Lower numbers indicate higher preference.

Appendix C2. Habitat selection by Spectacled Eiders and King Eiders during pre-nesting on the Transportation Corridor survey area, Colville River Delta, Alaska, 1997.

Species/Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
SPECTACLED EIDER							
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	30.76	1	2	20.0	9.0	0.38	4
Deep Open Water w/Islands or Polygonized Margins	6.52	0	0	0	1.9	-1.00	5
Shallow Open Water w/o Islands	10.84	2	7	40.0	3.2	0.85	1
Shallow Open Water w/Islands or Polygonized Margins	7.36	1	1	20.0	2.1	0.81	2
River or Stream	2.30	0	0	0	0.7	-1.00	5
Aquatic Sedge Marsh	0.97	0	0	0	0.3	-1.00	5
Aquatic Sedge w/Deep Polygons	0.03	0	0	0	<0.1	-1.00	5
Aquatic Grass Marsh	0.65	0	0	0	0.2	-1.00	5
Young Basin Wetland Complex	14.23	0	0	0	4.1	-1.00	5
Old Basin Wetland Complex	35.59	0	0	0	10.4	-1.00	5
Nonpatterned Wet Meadow	24.47	1	8	20.0	7.1	0.47	3
Wet Sedge–Willow Meadow w/Low-relief Polygons	19.87	0	0	0	5.8	-1.00	5
Moist Sedge–Shrub Meadow	84.66	0	0	0	24.7	-1.00	5
Moist Tussock Tundra	94.60	0	0	0	27.6	-1.00	5
Riverine or Upland Shrub	7.74	0	0	0	2.3	-1.00	5
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0	0.6	-1.00	5
Artificial (water, fill, peat road)	0.47	0	0	0	0.1	-1.00	5
Total	343.11	5	18	100	100		
KING EIDER							
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	30.76	8	33	17.4	9.0	0.32	7
Deep Open Water w/Islands or Polygonized Margins	6.52	2	6	4.3	1.9	0.39	5
Shallow Open Water w/o Islands	10.84	8	35	17.4	3.2	0.69	2
Shallow Open Water w/Islands or Polygonized Margins	7.36	6	18	13.0	2.1	0.72	1
River or Stream	2.30	1	2	2.2	0.7	0.53	3
Aquatic Sedge Marsh	0.97	0	0	0	0.3	-1.00	10
Aquatic Sedge w/Deep Polygons	0.03	0	0	0	<0.1	-1.00	10
Aquatic Grass Marsh	0.65	0	0	0	0.2	-1.00	10
Young Basin Wetland Complex	14.23	4	10	8.7	4.1	0.35	6
Old Basin Wetland Complex	35.59	6	21	13.0	10.4	0.11	8
Nonpatterned Wet Meadow	24.47	10	23	21.7	7.1	0.51	4
Wet Sedge–Willow Meadow w/Low-relief Polygons	19.87	1	2	2.2	5.8	-0.45	9
Moist Sedge–Shrub Meadow	84.66	0	0	0	24.7	-1.00	10
Moist Tussock Tundra	94.60	0	0	0	27.6	-1.00	10
Riverine or Upland Shrub	7.74	0	0	0	2.3	-1.00	10
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0	0.6	-1.00	10
Artificial (water, fill, peat road)	0.47	0	0	0	0.1	-1.00	10
Total	343.11	46	150	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Lower numbers indicate higher preference.

Appendix C3. Habitat selection by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1997.

Season/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	3.1	3.7	-0.08	10
Salt Marsh	16.35	1	3.1	3.0	0.03	9
Tidal Flat	56.05	0	0	10.2	-1.00	12
Salt-killed Tundra	25.63	4	12.5	4.6	0.34	7
Deep Open Water w/o Islands	23.31	0	0	4.2	-1.00	12
Deep Open Water w/Islands or Polygonized Margins	5.15	1	3.1	0.9	0.54	4
Shallow Open Water w/o Islands	2.30	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	13.60	2	6.3	2.5	0.43	5
Aquatic Grass Marsh	1.37	2	6.3	0.2	0.92	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	41.92	2	6.3	7.6	0.10	8
Wet Sedge–Willow Meadow	102.36	12	37.5	18.6	0.34	6
Moist Sedge–Shrub Meadow	13.36	5	15.6	2.4	0.73	3
Moist Tussock Tundra	2.52	1	3.1	0.5	0.74	2
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	12
Barrens (riverine, eolian, lacustrine)	78.90	1	3.1	14.3	-0.64	11
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	12
Total	551.29	32	100	100		
BROOD-REARING						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	11
Brackish Water	6.50	0	0	1.2	-1.00	11
Tapped Lake w/Low-water Connection	21.42	4	16.7	3.9	0.62	2
Tapped Lake w/High-water Connection	20.36	0	0	3.7	-1.00	11
Salt Marsh	16.35	1	4.2	3.0	0.17	7
Tidal Flat	56.05	0	0	10.2	-1.00	11
Salt-killed Tundra	25.63	2	8.3	4.6	0.28	5
Deep Open Water w/o Islands	23.31	4	16.7	4.2	0.60	3
Deep Open Water w/Islands or Polygonized Margins	5.15	1	4.2	0.9	0.63	1
Shallow Open Water w/o Islands	2.30	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	2	8.3	14.8	-0.28	10
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	13.60	2	8.3	2.5	0.54	4
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	41.92	2	8.3	7.6	0.05	9
Wet Sedge–Willow Meadow	102.36	5	20.8	18.6	0.06	8
Moist Sedge–Shrub Meadow	13.36	1	4.2	2.4	0.26	6
Moist Tussock Tundra	2.52	0	0	0.5	-1.00	11
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	11
Barrens (riverine, eolian, lacustrine)	78.90	0	0	14.3	-1.00	11
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	11
Total	551.29	24	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Lower numbers indicate higher preference.

Appendix C4. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1997.

Season/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	9.1	1.9	0.65	2
Shallow Open Water w/o Islands	10.84	0	0	3.2	-1.00	9
Shallow Open Water w/Islands or Polygonized Margins	7.37	2	18.2	2.1	0.79	1
River or Stream	2.31	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	18.2	4.1	0.63	3
Old Basin Wetland Complex	35.60	2	18.2	10.4	0.27	4
Nonpatterned Wet Meadow	24.47	1	9.1	7.1	0.12	6
Wet Sedge–Willow Meadow	19.87	1	9.1	5.8	0.22	5
Moist Sedge–Shrub Meadow	84.67	1	9.1	24.7	-0.46	7
Moist Tussock Tundra	94.62	1	9.1	27.6	-0.50	8
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	9
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	9
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	9
Total	343.16	11	100	100		
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	63.6	9.0	0.75	2
Deep Open Water w/Islands or Polygonized Margins	6.52	2	18.2	1.9	0.81	1
Shallow Open Water w/o Islands	10.84	1	9.1	3.2	0.48	3
Shallow Open Water w/Islands or Polygonized Margins	7.37	0	0	2.1	-1.00	5
River or Stream	2.31	0	0	0.7	-1.00	5
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	5
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	0	0	4.1	-1.00	5
Old Basin Wetland Complex	35.60	1	9.1	10.4	-0.07	4
Nonpatterned Wet Meadow	24.47	0	0	7.1	-1.00	5
Wet Sedge–Willow Meadow	19.87	0	0	5.8	-1.00	5
Moist Sedge–Shrub Meadow	84.67	0	0	24.7	-1.00	5
Moist Tussock Tundra	94.62	0	0	27.6	-1.00	5
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	5
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	5
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	5
Total	343.16	11	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Lower numbers indicate higher preference.

Appendix C5. Habitat selection by Yellow-billed Loons during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1997.

Season/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	1.22	0	0	0.4	-1.00	6
Tapped Lake w/Low-water Connection	19.38	0	0	6.0	-1.00	6
Tapped Lake w/High-water Connection	19.57	1	7.1	6.1	0.08	4
Salt Marsh	5.64	0	0	1.7	-1.00	6
Tide Flat	0.06	0	0	<0.1	-1.00	6
Salt-killed Tundra	7.48	0	0	2.3	-1.00	6
Deep Open Water w/o Islands	21.09	1	7.1	6.5	0.05	5
Deep Open Water w/Islands or Polygonized Margins	3.58	1	7.1	1.1	0.73	1
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	6
Shallow Open Water w/Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	6
River or Stream	38.33	0	0	11.9	-1.00	6
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	10.00	0	14.3	3.1	-1.00	6
Aquatic Grass Marsh	1.20	0	5.9	0.4	-1.00	6
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	2	5.9	9.2	0.22	3
Wet Sedge–Willow Meadow	80.84	9	35.3	25.0	0.44	2
Moist Sedge–Shrub Meadow	9.10	0	0	2.8	-1.00	6
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	6
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	6
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	6
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	14	100	100		
BROOD-REARING						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	3
Tapped Lake w/Low-water Connection	19.38	0	0	6.0	-1.00	3
Tapped Lake w/High-water Connection	19.57	1	20.0	6.1	0.53	2
Salt Marsh	5.64	0	0	1.7	-1.00	3
Tide Flat	0.06	0	0	<0.1	-1.00	3
Salt-killed Tundra	7.48	0	0	2.3	-1.00	3
Deep Open Water w/o Islands	21.09	4	80.0	6.5	0.85	1
Deep Open Water w/Islands or Polygonized Margins	3.58	0	0	1.1	-1.00	3
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	3
Shallow Open Water w/Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	3
River or Stream	38.33	0	0	11.9	-1.00	3
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	10.00	0	0	3.1	-1.00	3
Aquatic Grass Marsh	1.20	0	0	0.4	-1.00	3
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	0	0	9.2	-1.00	3
Wet Sedge–Willow Meadow	80.84	0	0	25.0	-1.00	3
Moist Sedge–Shrub Meadow	9.10	0	0	2.8	-1.00	3
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	3
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	3
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	3
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	5	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from groups.
[b] Lower numbers indicate higher preference.