WILDLIFE STUDIES IN THE CD SOUTH STUDY AREA, 2000

FINAL REPORT

Prepared for

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EXECUTIVE SUMMARY

In spring 2000, ARCO Alaska, Inc. (now PHILLIPS Alaska, Inc.) contracted with ABR to conduct wildlife studies in two new study areas, CD North and CD South (known during the exploration phase as Fiord and Nanuq), on the Colville River Delta, in support of permit applications for oil development. In this annual report on the 2000 field season, we present the results from the first year of study of the wildlife resources in the CD South study area. The proposed CD South Development Project is located on the Colville River Delta, 8.8 km north and east of the village of Nuiqsut and 5.5 km south and west of the Alpine Development.

The primary goal of ecological investigations on the Colville Delta since 1992 has been to describe the distribution and abundance of selected species before, during, and after development-related construction. The species-specific approach was developed in consultation with the U.S. Fish and Wildlife Service (USFWS) and the following criteria were used to identify the species of interest: 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 selected for study. Other species were monitored opportunistically, including Red-throated and Pacific loons, Greater White-fronted Geese, red foxes, muskoxen, and brown bears. Specific objectives of the CD South ecological investigations were to 1) monitor the distribution, abundance, and habitat use of selected waterbird species during pre-nesting, nesting, brood-rearing, and fall staging, 2) locate fox dens and evaluate annual productivity, and 3) monitor the distribution of other large mammals in the study area. Information on caribou in the western segment of the Central Arctic Herd is reported separately (Lawhead et al., in prep.).

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 Delta is a regionally important nesting area for waterbirds, including Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders (Rothe et al. 1983, North et al. 1984, Meehan and Jennings 1988; see Appendix A for scientific names of birds and mammals). 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 2000 breeding season was unusual among recent years, because weather and river conditions delayed the onset of nesting for birds on much of the Colville Delta. Spring temperatures were colder and snow melt was later in 2000 relative to previous years since 1992 (when many of these surveys were initiated on the delta), even more so than 1997 and 1999, 2 years that were marked by cool temperatures and late snow melt. Average daily temperatures in the Kuparuk Oilfield indicated late May 2000 as the coldest since 1992. In addition to late snow melt, the Colville River broke up relatively late on 8 June, and ice jams caused extensive flooding on the delta during the second week of June, which made some nesting areas unavailable for several days. The late season had direct impacts on waterbirds, particularly swans and loons, whose young probably lacked adequate time to fledge (i.e., become flight capable) during the short ice-free season in 2000.

Both aerial and ground surveys of wildlife were conducted. Between the CD North (Johnson et al. 2000a) and CD South study areas, aerial surveys in 2000 covered most of the delta. Ground surveys of nesting birds were conducted on a smaller scale, focusing on a study plot that encompassed proposed CD South facility footprints. A wildlife habitat map, previously developed for the Colville River Delta, was used to assess wildlife distributions. Wildlife observations were plotted on the habitat map for analysis of

habitat selection. For each species, habitat use (% of observations in each identified habitat) was determined separately for various seasons (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. Habitat selection analyses (i.e., preference and avoidance) were conducted on combined data sets over the entire Colville River Delta (including CD North data in 2000, reported in Johnson et al. 2000a) and over all previous years of wildlife observations in the delta.

A ground-based nest search was conducted to determine the composition and abundance of waterbirds in the proposed development area and to estimate nesting success, with particular attention to eiders and geese. Nests of waterbirds were revisited after hatch to determine nest fate. In addition to nest checks during these visits, the study area was searched for broods. Nests of 12 species of birds were located during ground searches in the CD South study plot. The most common nesting birds were Greater White-fronted Geese, Willow Ptarmigan, and Northern Pintails (surveys excluded nests of shorebirds and passerines). Seventy of 80 nests in the CD South ground-search area were located in two habitat types: Wet Sedge–Willow Meadow and Moist Sedge–shrub Meadow.

Broods or brood groups of 8 species were observed during ground searches in the CD South study plot. Of 16 brood groups observed, eight were Greater White-fronted Geese. Several broods were observed of species that were not known from the nest search, including Greater Scaup, Green-winged Teal, Red-breasted Merganser, and Red-throated Loon. Unlike during nesting, when only two habitats were extensively used, broods were found in a variety of habitats in the CD South ground-survey area in 2000. Nine habitats were used. The most used habitat was Tapped Lakes with High-water Connections, used by 5 of 16 broods.

One Spectacled Eider nest was located in the CD South ground-search area. The nest was determined to have failed, as it contained no egg remnants when checked in July. No other eider nests were found in the ground-search area. Two Spectacled Eider nests are known in the CD South study area from previous years, one each in 1998 and 1999 (Johnson et al. 2000b). Both were located on the east side of the Sakoonang Channel and were located during ground-searches of the Alpine project area. Spectacled Eider broods were not observed in the CD South study area in 2000. From all the years in our database (1983, 1984, 1992–2000), we have records of only three eider broods from the CD South study area, and all were on the east side of the Sakoonang Channel.

Aerial surveys for eiders were conducted during the pre-nesting period. Methods were similar to previous years (1992–1998). We counted two Spectacled Eiders and six King Eiders. In 1993, 1994, and 1996, no Spectacled Eiders were sighted in the CD South study area. Pre-nesting Spectacled and King eiders occur in much lower densities in the CD South study area than nearby areas. During pre-nesting, Spectacled and King eiders on the Colville Delta were closely associated with coastal areas in all years.

In 9 years of nest searching in various locations on the entire delta, 45 nests of Spectacled Eiders have been found in 11 habitats. The coastal portion of the delta, where Spectacled Eiders concentrate during pre-nesting, also is where eiders nest most commonly. We have not found any documented nest locations that were farther than 13 km from the coast. Over all years of data on the delta, the mean distance of Spectacled Eider nests from the coast was 3.5 km (n = 49). Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 2.8 m from permanent water. The results of pre-nesting and nesting habitat analyses emphasize the importance to breeding Spectacled Eiders of habitats that are more prevalent on the outer delta than farther inland. The absence or scarcity of these habitats may explain the low numbers of Spectacled Eiders in the CD South study area during pre-nesting and nesting.

We did not observe any broods of Spectacled or King Eiders during 2000 in the CD South study area. Since our surveys began on the delta in 1992, we have sighted one Spectacled Eider brood in the CD South study area. On the entire delta, only 20 Spectacled Eider broods have been seen since 1992. Broods appear to be attracted to coastal lakes; for most broods (35%) the nearest waterbody type was Brackish Water ($\bar{x}$ = 0.03 km, n = 7), and the mean distance to the coast was 3.3 km (n = 20).

Aerial surveys for Tundra Swans were conducted during nesting, brood-rearing, and fall staging. During nesting surveys, 179 swans were observed in the CD South study area in 2000. Only 10% of swans observed appeared to be breeding. Prior to 1996, fewer than 90 swans were observed during nesting surveys; since 1996, more than 170 swans have been observed. Between 4 and 15% of swans observed annually during surveys appeared to be breeding. In the CD South study area, we found 12 swan nests in 2000 (including two nests found by ground observers). The number of Tundra Swan nests found in the CD South study area has varied from 3 (1992, 1993) to 17 (1996). Nest densities appear to have been relatively stable since 1997. Annually, since 1992, between 15-38% of swans nesting on the delta have been located within the CD South study area. The 12 swan nests in the CD South study area were located in five habitat types. Across the entire Colville River Delta, Tundra Swans used a wide range of habitats for nesting. During seven years of surveys on the delta, swan nests (n = 212) were located in 17 of 24 available habitats. Nearly 40% of nests were located in Wet Sedge–Willow Meadow, a preferred habitat.

During brood-rearing in 2000, 85 Tundra Swans were observed in the CD South study area, 60 adults and 25 young. Since 1992, the total number of swans observed in the CD South study area during brood-rearing surveys has ranged from 65 (1992) to 98 (1996). The number of young swans observed has varied from 10 (1993) to 35 (1996), and the number observed in 2000 was the second highest in seven years of surveys. In 2000, 25% of adults were accompanied by broods, larger proportion than in any previous year. Similarly, the total number of broods was highest in 2000. Twelve broods were observed, with a mean brood size of 2.1. Estimates of apparent nesting success have ranged from 64 to 100% in the CD South study area. Although apparent nesting success was high in 2000 (100%), the mean brood size was the lowest that has been observed since 1992. Low brood sizes may be attributable to the late initiation of nesting in 2000 due to prolonged snow cover in nesting habitats followed by widespread flooding of the delta. The 12 Tundra Swan broods observed in the CD South study area were found in all but one of the 9 available habitats.

Across the entire delta and all seven years of surveys, the number of Tundra Swan broods has varied from 14 (1993) to 32 (1996). Estimated nesting success for the whole delta in 2000 was 66% (21 of 32 nests), the lowest value recorded since 1992. Nest and brood densities in 2000 were similar to recent seasons, but mean brood size for the whole delta was the lowest value observed since 1992. Across the entire delta, Tundra Swans with broods used a wide range of habitats, occurring in 19 of 24 available habitats.

The fall-staging survey in 2000 covered the Colville River Delta and documented staging areas adjacent to the delta on both the east and west sides. On the CD South study area, 19 tundra swans in 10 groups were observed. In general, large numbers of swans have not been found on the CD South study area during fall-staging. Across the entire delta during fall staging in 2000, 89 Tundra Swans were observed, 66 adults and 23 young. The largest flock observed was a flock of 6 without young and all other swans were in pairs with or without broods. The lack of large staging flocks and the lack of broods in 2000 are attributable to the lateness of the spring and the resulting late hatch of swan nests and late fledging of young; many young still appeared flightless at the time of the fall-staging survey. Tundra Swans have been widely distributed on the delta during our fall-staging surveys; however, most swans generally occur in several large flocks that occupy river channels on the outer Delta.

Aerial surveys for Yellow-billed Loons were conducted during nesting and brood-rearing. Similar surveys have been conducted on the Colville River Delta in 1993, and 1995–1998. In 2000, we counted 21 Yellow-billed Loons and 7 nests in the CD South study area during the aerial nesting survey. The number of loons was similar to counts made in 1996, and greater than the number recorded in all other survey years. The count of seven nests in 2000 was within the range of values (2–10 nests) we have observed in the five previous years of surveys. All seven nests found in 2000 were on lakes where we have recorded nesting by Yellow-billed Loons in previous years.

During six years (1993, 1995–1998, 2000) of aerial surveys on the Colville Delta, 90 Yellow-billed Loon nests were found in 7 of 24 available habitats. 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. Nests found in the CD South study area occurred most commonly near Deep Open Water without Islands (57% of all nests), Tapped Lake with High-water Connection (29%), and Deep Open Water with Islands or Polygonized Margins (14%). Measurements of the distance from the nest to the nearest waterbody were not recorded during aerial surveys, but all nests were close (≤1m) to water.

We counted 13 adult Yellow-billed Loons and 2 broods during the brood-rearing survey in the CD South study area in 2000. In previous years, the number of loons has ranged 8 to 27 and the number of broods has ranged from 1 to 5. Most adult loons seen on the brood-rearing survey in 2000 were found on lakes where nesting occurred either in 2000 or in a previous year. During aerial surveys in 1995–1998, 2000, we found 36 Yellow-billed Loon broods in three habitats on the delta (Tapped Lake with High-water Connection and both types of Deep Open Water), all of which were preferred. No shallow-water habitats were used during brood-rearing. The concurrence of habitats preferred during nesting and brood-rearing reaffirms the importance of large, deep waterbodies to breeding Yellow-billed Loons.

Surveys for geese were conducted during brood-rearing and fall staging. Similar surveys have been conducted in the Colville River Delta since 1996. Only White-fronted Geese were observed in the CD South study area during brood-rearing in 2000: 425 White-fronted Geese in 4 groups. (In previous surveys of the delta, Brant and Canada Geese were observed only in 1997. Slightly fewer White-fronted Geese were seen in 2000 than in 1998 (528 birds in 9 groups), but we recorded more geese in these two years than in either 1997 (263 geese in 7 groups; 50% coverage) or 1996 (33 geese in 2 groups; 25% coverage). Goslings comprised only 21% of the total number of White-fronted Geese (91of 425) seen during the aerial survey in 2000. In previous years (1996–1998), goslings comprised 9–50% of total White-fronted Geese seen during the systematic surveys. Brood-rearing White-fronted Geese in 2000 were generally distributed in the southern half of the study area and typically occurred in or near water.

Two species of geese were recorded in the CD South study area during fall-staging surveys in 2000: Greater White-fronted Geese and Canada Geese. Brant have never been recorded in the CD South study area during fall-staging surveys. During fall staging in 2000, 307 White-fronted Geese were observed in the CD South study area in 14 groups that averaged <22 birds. Forty-five Canada Geese in 2 groups also were observed. Canada Geese occurred in small numbers in the CD South study area relative to coastal areas, including the CD North study area (Johnson et al. 2000a). The number of White-fronted Geese and Canada Geese observed during fall-staging surveys has varied considerably, but this variability in numbers among years is probably attributable mainly to differences in the intensity and timing of aerial surveys. During fall-staging, White-fronted Geese were distributed throughout the CD South study area in a variety of habitats. As in the brood-rearing period, staging White-fronted Geese were found primarily in lake habitats or in Barrens or Wet Sedge–Willow Meadow associated either with Tapped Lakes or the Colville River.

We used aerial and ground-based surveys to evaluate the distribution and status of arctic and red fox dens on the Colville River Delta in 2000, continuing the annual monitoring effort begun in 1992. We assessed den status and pup presence at known dens in an initial visit and then returned to active dens to count pups. The eight fox dens in the CD South study area included active and inactive sites of both species. Half of the dens were arctic fox sites and half were red fox sites in 2000; one of the red fox sites was an arctic fox den before 1998. In marked contrast to other areas on the outer coastal plain, red fox dens are more common than arctic fox dens in the CD South study area. The total density (active and inactive) of fox dens in the CD South study area (156 km^2) was 1 den/19 km^2. The densities of arctic and red fox dens were identical at 1 den/39 km^2.

The red fox dens in the CD South study area had higher occupancy rates (natal, secondary, and active categories combined) each year than did the arctic fox dens. Two to four red fox dens (50–100%) were active each year since 1995 (no red fox dens had yet been found in 1993). Since

1993, no more than one den has ever been occupied by arctic foxes in the CD South study area. In 2000, pups were present at a minimum of two dens of red foxes, but not at the arctic fox den. Pup production by red foxes in the CD South study area was moderate in 2000; the 5 pups we observed were close to the mean annual total of 5.3 pups we counted in the study area during 1995–2000; the highest production we observed for this species was 8 pups in 1996 and 1998.

Foxes locate dens on raised landforms with well-drained soil and relatively deep thaw layers; typical locations on the Arctic Coastal Plain include ridges, dunes, lake and stream shorelines, pingos, and low mounds (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993). In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville Delta, the latter species dens almost exclusively in sand dunes. In the CD South study area, the habitat type used most often for denning was Riverine or Upland Shrub (6 of 8 dens, or 75%); only one other habitat type was used—Wet Sedge–Willow Meadow (2 dens). Across the entire delta, fifteen dens (71% of the total) were located in the Riverine or Upland Shrub type, the only denning habitat that was preferred. Dens in the other habitats used— Barrens (eolian subtype), Moist Sedge–Shrub Meadow, Wet Sedge–Willow Meadow, and Nonpatterned Wet Meadow —actually were located in small patches of higher microrelief that are smaller than the minimal mapping size of habitat areas. Foxes avoided the extensive river bars and mudflats on the delta as denning sites.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

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INTRODUCTION

In spring 2000, ARCO Alaska, Inc. (now PHILLIPS Alaska, Inc.) contracted with ABR to conduct wildlife studies in two new study areas, CD North and CD South (known during the exploration phase as Fiord and Nanuq), on the Colville River Delta, in support of permit applications for oil development. In this annual report on the 2000 field season, we present the results from the first year of study of the wildlife resources in the CD South study area. The proposed CD South Development Project is located on the Colville River Delta, 8.8 km north and east of the village of Nuiqsut and 5.5 km south and west of the Alpine Development. Similar investigations for the proposed CD North Development Project, which lies 10.1 km to the north and east of the Alpine Development, are reported under a separate cover (Johnson et al. 2000a). Earlier investigations on the delta were initiated in 1992 by ARCO Alaska, Inc., as part of the long-range planning process for oil development (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b). These studies examined the biological, physical, and cultural resources of the delta. The Alpine Development Project, on the central delta, was the first on the Colville Delta, receiving its federal permits on 13 February 1998. Project construction began that spring and the Alpine Oilfield became operational during 2000.

The primary goal of ecological investigations on the Colville Delta since 1992 has been to describe the distribution and abundance of selected species before, during, and after development-related construction. The species-specific approach was developed in consultation with the U.S. Fish and Wildlife Service (USFWS) and the following criteria were used to identify the species of interest: 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 selected for study (Smith et al. 1993). Other species were monitored opportunistically, including Red-throated and Pacific loons, Greater White-fronted Geese, red foxes, muskoxen, and brown bears.

In addition to wildlife surveys, an ecological land survey (ELS) was conducted on the Colville River Delta to allow integration of ecological information with project engineering approaches (Jorgenson et al. 1997). The ELS described terrain units (surficial geology, geomorphology), surface forms (primarily ice-related features), and vegetation throughout the delta, and was used to develop a GIS (Geographic Information System) map of wildlife habitats, in which regions are identified by the presence of habitat features that are important to various wildlife species. The ELS and derived habitat maps also were used in this investigation to assess wildlife distributions and potential ecological impacts of the proposed CD South development. This ELS approach provides great flexibility for extracting information or developing classifications for specific engineering and ecological applications (e.g., maps of ice contents, flooding regimes, wildlife habitat, or fish habitat could all be derived from these maps). A particular advantage of a habitat-based approach is that information on wildlife habitat use (specifically, relative densities in each identified habitat type) and on the availability of various habitats can be used to directly compare development options and facility configurations, allowing project managers to minimize negative impacts on wildlife by design. ELS methodologies and the derivation of the habitat map are presented in previous reports (Johnson et al. 1996, Jorgenson et al. 1997) and the map products have been used extensively in previous ecological investigations in the Colville River Delta region (e.g., Johnson et al. 1996, 1997, 1998, 1999a, 1999b, 2000a). The reader is referred to these reports for a complete outline of mapping methods and techniques.

Specific objectives of the CD South ecological investigations were to 1) monitor the distribution, abundance, and habitat use of selected waterbird species during pre-nesting, nesting, brood-rearing, and fall staging, 2) locate fox dens and evaluate annual productivity, and 3) monitor the distribution of other large mammals in the study area.

STUDY AREA

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. There are two permanent human settlements on the Colville Delta, the Iñupiaq village of Nuiqsut and the Helmericks family homestead, both of which rely heavily on these fish and wildlife resources.

The Colville River drains a watershed of ~53,000 km², or ~29% of the Arctic Coastal Plain of Alaska (Walker 1976). The high-volume flow and heavy sediment load of the Colville River have created a large (551 km²), dynamic delta system, which includes a diversity of lakes, wetlands, and terrestrial habitats. The Colville River has two main distributaries in the delta: the Nechelik (Nigliq) Channel and the East Channel. These two channels together carry ~90% of the water flowing 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. The East Channel is deep and flows under ice during winter, whereas the Nechelik and other channels are shallow and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta's channels, with the depth of the river at freeze-up being the main factor determining the inland extent of this intrusion (Walker 1983). For its entire length, the Colville River flows through lands that are underlain by continuous permafrost. 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 waterbodies on the delta are shallow (e. g., polygon ponds ≤2 m deep), freezing to the bottom during winter and thawing by June. Deep ponds (>2 m deep), with steep, vertical sides, are more common on the delta than elsewhere on the Arctic Coastal Plain, where deep waterbodies are much less common. Lakes >5 ha in size cover 16% of the delta's surface (Walker 1978) and some of these lakes are deep (to 10 m), freezing only in the upper 2 m during winter and retaining floating ice until the first half of July (Walker 1978). Several other types of lakes occur on the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes (Walker 1983).

Many lakes on the delta are "tapped" (Walker 1978), meaning that they are connected to the river by narrow channels which result from thermokarst of ice wedges 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 and often salt-affected shorelines. River sediments gradually fill these narrow channels and adjacent lake bottoms, eventually limiting the flow of river water or restricting it to only 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).

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, predominantly northeast winds. The rarer westerly winds usually bring storms that often are accompanied by high wind-driven tides and rain (Walker and Morgan 1964).

The Colville Delta supports a wide array of wildlife, providing breeding habitat for passerines, shorebirds, gulls, and predatory birds such as jaegers and owls. It is a regionally important nesting area for waterbirds, including

Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders (Rothe et al. 1983, North et al. 1984, Meehan and Jennings 1988; see Appendix A for scientific names of birds and mammals). 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).

METHODS

HABITAT USE AND SELECTION

As described above, habitat analyses utilized a GIS map of wildlife habitats that was developed for previous investigations of the Colville River Delta by Jorgenson et al. (1997) (Appendix B1, Appendix B2, Table 1). Wildlife observations from aerial surveys (described below) of the CD South study area (Figure 1) were plotted on this map for analysis of habitat use. Ground-based observations also were included for analysis of fox denning habitat. For each species, habitat use (% of observations in each identified habitat) was determined separately for various seasons (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. For each species/season, we calculated 1) the number of adults, flocks, nests, young, broods, or dens in each habitat, 2) the percent of total observations in each habitat (habitat use), 3) the percent availability of each habitat in the study area, and 4) a habitat selection index, described below. Habitat use was calculated from group locations for species or seasons when birds were in flocks or broods, because we could not reasonably assume independence of selection among individuals in these groups. For fox dens (active and inactive combined), which are static in location, habitat use was calculated from the cumulative number of dens over all years. For all other species, the parameters were calculated for each year of survey. Habitat availability did differ between seasons, because survey areas often differed (as described below).

Habitat selection (i.e., preference and avoidance) was tested for observations combined for all years over the entire Colville River Delta, including wildlife observations in both the CD South and CD North study areas (data reported in Johnson et al. 2000a) in 2000. Combining the 2000 data sets with previous data over the larger region yields a more robust analysis of habitat selection. We used Monte Carlo simulations (1,000 iterations) to calculate a frequency distribution of random habitat selection and used this to calculate an index to habitat selection as the percentile scores of observed habitat use (Haefner 1996, Manly 1997). Random habitat selection was based on the percent availability of each habitat (rounded to the nearest 1%) and the sample sizes in each simulation equaled the number of observed nests, dens, or groups of birds in that season. We defined habitat preference (i.e., use > availability) as observations of habitat use greater than the 97.5 percentile of simulated random use, which represents an alpha level of 5% (two-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observations below the 2.5 percentile of simulated random use. The simulations and calculations of percentiles were conducted in a Microsoft® Excel spreadsheet on a personal computer.

WILDLIFE SURVEYS

Both aerial and ground surveys of wildlife were conducted. Aerial surveys were conducted in both fixed-wing aircraft and helicopters (as described below for each survey) and, between the CD North (Johnson et al. 2000a) and CD South study areas, covered much of the delta. Ground surveys of nesting birds were conducted on a smaller scale, focusing on a study plot that encompassed proposed CD South facility footprints. Avian studies focused on Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, and geese, but information on other waterbirds, such as Pacific and Red-throated loons, also was collected opportunistically. Mammalian studies focused on arctic foxes, but information on

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

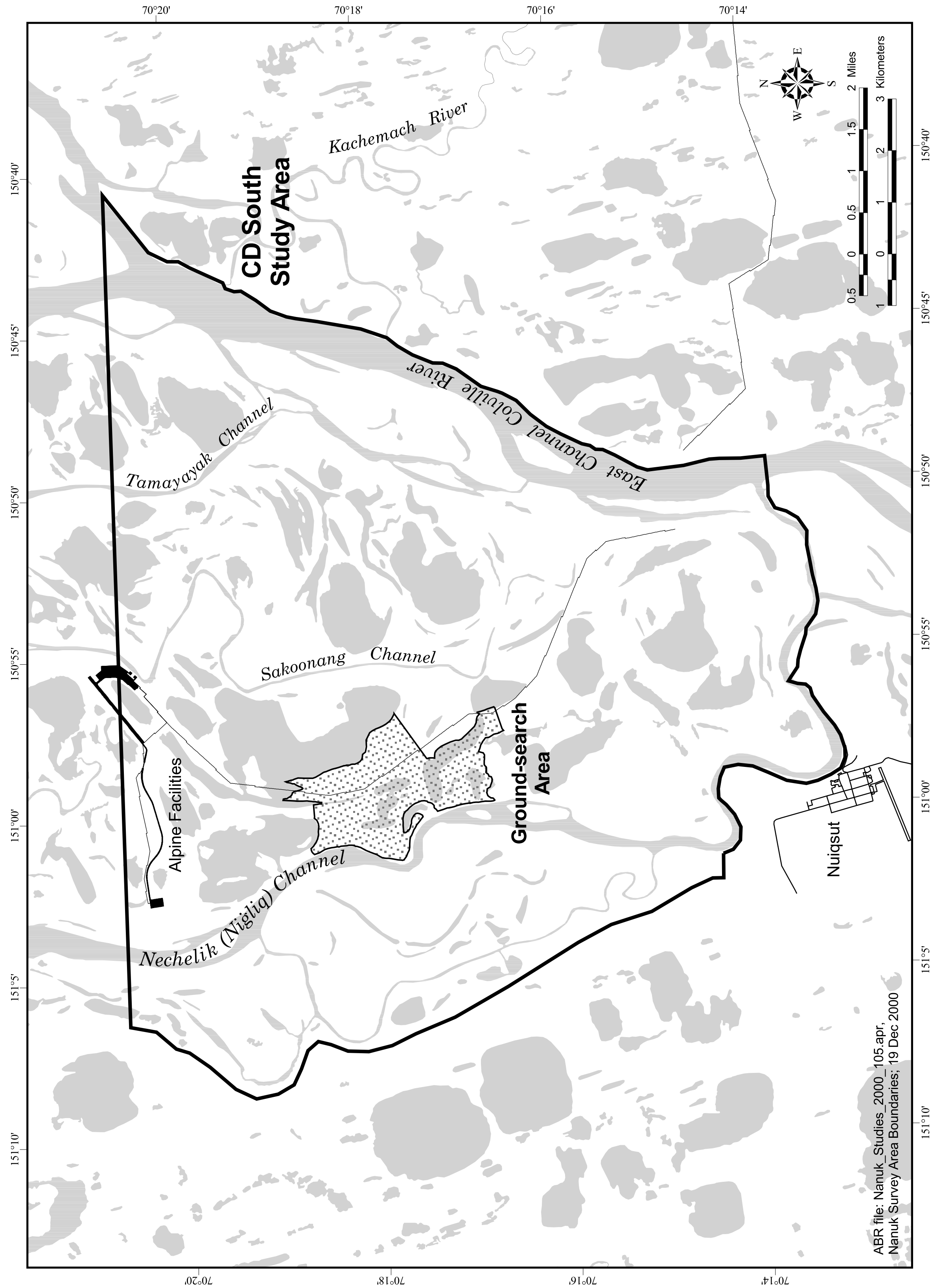


Figure 1. Survey area boundaries for wildlife studies in the CD South study area on the Colville River Delta, Alaska, 2000.

other species, such as brown bears, moose, and muskoxen, also was collected opportunistically. Information on caribou in the western segment of the Central Arctic Herd is reported separately (Lawhead et al., in prep.).

GROUND SEARCHES FOR WATERBIRD NESTS AND BROODS

A ground-based nest search was conducted to determine the composition and abundance of waterbirds in the proposed development area and to estimate nesting success, with particular attention to eiders and geese. Ground-based nest searches were conducted in a study plot that encompassed the proposed project facilities (Figure 1). Nest searches were conducted between 15 and 25 June 2000. Nests were located by a 5 or 6 person team that systematically searched the study plot by walking more or less abreast and about 10 m apart. Members of the team each thoroughly searched all dry ground between observers. All bird nests located during the search were mapped on aerial photos and nest locations that were difficult to map were determined with a GPS (Global Positioning System). Observers attempted not to flush incubating birds from nests but, when a bird was flushed, the observer counted the eggs and covered them with down before leaving the site. If the species of bird could not be determined, a small amount of down was collected and the length and width of one or two eggs was recorded. Unidentified nests were later assigned to a species based on this information. Habitat information was recorded at each waterbird nest, including the distance to nearest waterbody, distance and waterbody class of the nearest permanent waterbody, the terrestrial habitat in the area, and the landform and vegetation at the nest site.

Nests of waterbirds were revisited after hatch to determine nest fate (on 15 July for waterfowl and 27 August for loons). Waterfowl nests were classified as successful if thickened egg membranes that had detached from the shell were found in the nest bowl. For loons, nests were considered successful if a brood was later associated with the nest site. Evidence of predation, such as odor of fox urine, crushed egg remnants, etc., also was recorded. Fate was not determined for ptarmigan nests. In addition to nest checks during these visits, the study area was searched for broods. Observers scanned the area with binoculars and searched on foot all shorelines of waterbodies greater than about 25 meters long on their long axis (approximately the minimal waterbody size to support nesting Red-throated Loons). We recorded the number of adults and young of each brood and plotted the locations on aerial photos of the study area.

EIDER SURVEYS

Aerial surveys for eiders were conducted during the pre-nesting period, on 16 June 2000 (Table 2). Methods were similar to previous years (1992–1998), although the survey areas differed among years. The aerial survey employed two observers (in addition to the pilot) in a fixed-wing aircraft (Cessna 185). During the survey, the pilot navigated along transect lines using a GPS and topographic maps. Flight altitude for each survey was 30–50 m above ground level (agl) and flight speed was approximately 145 km/h. We counted eiders in a fixed–width strip (200 m on each side of the aircraft) along east-west transects spaced 400 m (0.25 mi) apart, for 100% coverage of the study area. For each observation, we recorded on a tape recorder the species, number of each sex, number of identifiable pairs, perpendicular distance from the transect, transect number, and whether the birds were flying or on the ground. Each observer also recorded their observations on 1:63,360 USGS maps of the study area. All eider locations were digitized and added to a GIS database that contains all aerial survey observations in the Kuparuk and Colville River areas since 1992. The habitat present at each eider location (singles, pairs, or flocks) was determined by plotting locations on the habitat map (Figure 2, Appendix B2).

From 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 the CD South study area (Figure 1). We calculated the total indicated birds following the procedures of the USFWS survey protocol (in which the number of lone males is doubled, USFWS 1987a), and we calculated unadjusted densities (i.e., without a visibility correction factor) for birds based on the total area covered during the survey.

Table 2. Descriptions of wildlife surveys conducted in the CD South study area, Colville River Delta, Alaska, 2000.

Species	Survey Type	Phenological Season	Date	Aircraft[a]	Transect[b] Width (km)	Transect[b] Spacing (km)	Aircraft Altitude (m)	Area Surveyed
BIRDS								
Eiders	Aerial	Pre-nesting	16 June	C185	0.4	0.4	30–35	Delta
Tundra Swans	Aerial	Nesting	22–24 June	C185	1.6	1.6	150	Delta
	Aerial	Brood-rearing	17–19 August	C185	1.6	1.6	150	Delta
	Aerial	Fall staging	16 September	C185	1.6	1.6	150	Delta
Loons	Aerial	Nesting	27, 30 June	206L	n/a	n/a	30–40	Delta
	Aerial	Brood-rearing	25, 27 August	206L	n/a	n/a	30–70	Delta
	Ground	Nesting	15 July	-	-	-	-	CD South Ground-search Area
	Ground	Brood-rearing	27 August	-	-	-	-	CD South Ground-search Area
Geese	Aerial	Brood-rearing	31 July	PA18	0.8	1.6	90	Delta
	Aerial	Fall staging	20 August	C185	0.4	1.6	90	Delta
Large Waterbirds	Ground	Nesting	15–25 June	-	-	-	-	CD South Ground-search Area
	Ground	Brood-rearing	15 July	-	-	-	-	CD South Ground-search Area
MAMMALS								
Foxes	Aerial	Denning	30 June–1 July	206L	n/a	n/a	30–90	Delta (den status checks)
	Ground	Denning	11–13 July	-	-	-	-	Delta (den observations to count pups)

[a] C185 = Cessna 185 fixed-wing airplane; PA18 = Piper "Super Cub" fixed-wing airplane; 206L = Bell "Long Ranger" helicopter.
[b] n/a = not applicable.

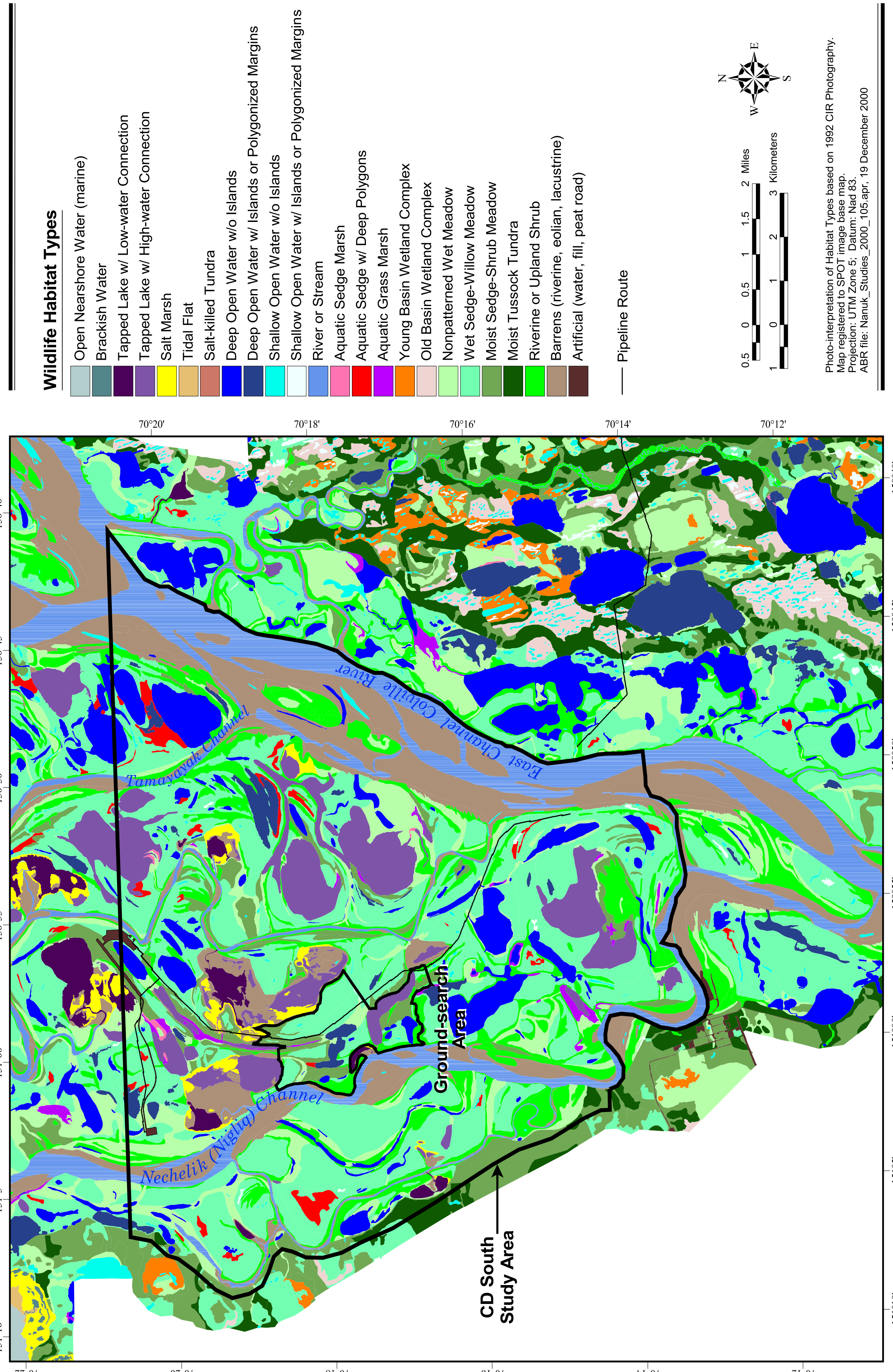


Figure 2. Habitat map of the CD South study area, Colville River Delta, Alaska.

Habitat selection was evaluated from all aerial survey locations across the entire delta 1993–1998 (including both the CD South and CD North areas in 2000). The pre-nesting survey in 1993 was flown at 50% coverage and habitat availability for that year was determined from the strips that were surveyed. The 2000 survey did not go east of the Elaktoveach Channel, so those areas were deleted from the habitat availability estimate in that year. A weighted average of habitat availability was used to combine years and was computed by summing availability for each year and dividing by the number of years.

TUNDRA SWAN SURVEYS

Aerial surveys for Tundra Swans were conducted during nesting (22–24 June 2000), brood-rearing (17–19 August 2000) and fall staging (16 September 2000) (Table 2). Aerial survey methods during nesting and brood-rearing followed the USFWS Tundra Swan Survey Protocol (USFWS 1987b, 1991) and were identical to those used for the Kuparuk Avian Studies program and previous swan surveys in the area (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993, 1994; Anderson et al. 1995, 1996, 1997, 1998a, 1999, 2000a; Smith et al. 1994; Johnson et al. 1996, 1997), with the exception of 1992 (Smith et al. 1993) when transect configurations differed (but yielded otherwise comparable results). The CD South study area was surveyed in 2000 in conjunction with similar surveys in the Kuparuk Oilfield (Anderson et al., in prep.) and in the CD North study area (Johnson et al. 2000a).

Surveys for nesting and brood-rearing Tundra Swans were flown in a Cessna 185 aircraft along fixed-width, east-west, 1.6–km wide transects. Navigation of transects was aided with a GPS. Transects were oriented along township and section lines, and swan observations were mapped on 1:63,360 USGS maps. During transects, the pilot maintained a speed of 145 km/h at an altitude of 150 m agl. Each of the two observers scanned a transect approximately 800 m wide on his/her side of the aircraft, while the pilot navigated and scanned ahead of the aircraft. This transect spacing provided 100% coverage of the study area. When any observer identified a swan nest, the aircraft left the transect line and circled the nest so that we could accurately plot the location and photograph the nest with a 35-mm camera. During the brood-rearing survey, we used an identical procedure but did not photograph broods and attempted to limit disturbance by circling only when necessary.

Fall-staging Tundra Swan surveys were flown in a Cessna 185 aircraft in mid-September. In addition to the transects described above, we flew non-transect paths over areas on and near the delta that have been previously identified as fall-staging grounds for Tundra Swans (Johnson et al. 1999a). Fall-staging surveys were flown by a single observer and a pilot-observer scanning opposite sides of the aircraft.

After the survey, we entered all location data into digital GIS maps (developed from 1:63,360 USGS maps by AeroMap, U.S., Inc.). Summary statistics for nesting surveys followed the format established in 1988 and modified in 1990 (Ritchie et al. 1989, 1991), which categorize adults as either with nests (or broods) or without nests (or broods). The latter category includes nonbreeding subadults, as well as failed or nonbreeding adults. These individuals will be referred to collectively as "nonbreeders."

From the survey data we calculated the number of swans, nests, and broods, and calculated densities for the CD South study area (Figure 1). No corrections were made for sightability. Nesting success was estimated from the ratio of broods to nests, although that estimate is affected by a number of factors, including differential sightability of broods and nests, brood loss to predation, and movements of broods into and out of the survey area. Thus, estimates of nesting success are only approximations for annual comparisons.

Habitat selection was evaluated from swan nest and brood locations across the entire delta 1992, 1993, 1995–1998, and 2000. None of the nest sites were reused in all years, and previous investigators have determined that nests at previously used sites are more successful (Monda et al. 1994). Therefore, to avoid biasing results toward less successful (perhaps less experienced) pairs, all swan nest locations were used, although reused sites were statistically non-independent observations.

LOON SURVEYS

Aerial surveys for Yellow-billed Loons were conducted during nesting (27 and 30 June 2000) and brood-rearing (25 and 27 August 2000). Similar surveys have been conducted on the Colville River Delta in 1993, and 1995–1998 (Smith et al. 1994; Johnson et al. 1996, 1997, 1998, 1999a). In 2000, all surveys were conducted using a helicopter, whereas in previous years, surveys were conducted by either fixed-wing aircraft or helicopter. In all years since their initiation, an initial nesting loon survey was conducted in a lake-to-lake pattern, concentrating on lakes ≥10 ha in size (typical nesting lakes for Yellow-billed Loons [Sjolander and Agren 1976, North and Ryan 1989]) and adjacent smaller lakes. In 1996–1998 and in 2000, a second nesting survey was conducted with a helicopter to visit lakes where Yellow-billed Loons were observed but no nest was found. Coastal lakes and tapped lakes with low-water connections to river channels were excluded, as Yellow-billed Loons are known not to use such lakes for nesting (North 1986, Johnson et al. 1999a). Observations of Pacific and Red-throated loons were recorded incidentally. Loon locations were recorded on 1:63,360-scale USGS maps.

From the survey data, we calculated the total number of adults, nests, broods, and young by season for all species of loon. Density was calculated only for Yellow-billed Loons because our coverage for Pacific and Red-throated loons was inadequate for estimating density. Habitat use and proximity to nearest waterbody were calculated for Yellow-billed Loon nests and broods found in 2000. Habitat selection was evaluated for Yellow-billed Loon nests and broods that were found on aerial surveys of the entire delta. Selection indices were calculated for nest locations in 1993, 1995–1998, and 2000, and for brood locations in 1995–1998 and 2000.

GOOSE SURVEYS

Surveys for geese were conducted during brood-rearing (31 July) and fall staging (20 August) in 2000 (Table 2). The surveys were developed originally to count White-fronted Geese (although we also counted Brant, and Canada and Snow geese) and have been conducted in the Colville River Delta since 1996.

Surveys were flown by fixed-wing aircraft at 90 m agl on east–west flight lines that were 1.6 km apart (Table 2). Two observers (including the pilot) searched a 400-m-wide strip on either side of the plane, thereby achieving 50% coverage of the study area (in 1996, only one observer was used and coverage was equivalent to 25%). We recorded species, numbers, and locations on 1:63,360-scale USGS maps.

FOX SURVEYS

We used aerial and ground-based surveys to evaluate the distribution and status of arctic and red fox dens on the Colville River Delta in 2000, continuing the annual monitoring effort begun in 1992 for baseline wildlife studies across the entire delta and adjacent coastal plain. We assessed den status and pup presence at known dens on helicopter-supported ground visits during 30 June–1 July, and then returned to active dens during 11–13 July to count pups. Most survey effort in 2000 focused on checking dens found in previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a), although we also searched opportunistically for dens in suitable habitats while transiting between known dens. Soil disturbance by burrowing adults or pups and soil fertilization by fox feces and food remains result in a characteristic, lush flora that makes perennially used sites easily visible from the air after "green-up" of vegetation (Chesemore 1969, Garrott et al. 1983a). Green-up occurs earlier on these traditionally used den sites than on surrounding tundra, a difference that is helpful in locating dens as early as the third week of June.

During ground visits, we evaluated evidence of use by foxes and confirmed the species using the den. We examined fox sign to assess den status (following Garrott 1980): presence or absence of adult or pup foxes; presence and appearance of droppings, diggings, and tracks; trampled vegetation (play areas or beds); shed fur; prey remains; and signs of predation (e.g., pup remains). We classified dens into four categories (following Burgess et al. 1993), the first three of which are considered to be "occupied" dens:

1. *natal*—dens at which young were whelped, characterized by abundant adult and pup sign early in the current season;

2. *secondary*—dens 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);
3. *active*—dens showing evidence of consistent, heavy use, and suspected to be natal or secondary dens, but at which pups were not seen; or
4. *inactive*—dens 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 are needed to classify den status with confidence. As we have annually since 1996, we made a concerted effort to confirm den occupancy and to count pups. Based on our initial assessment of den activity, our observations during 11–13 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 2½–4 hours. Observations usually were conducted early and late in the day, when foxes tend to be more active.

Denning habitat selection indices were calculated based on the total number of dens located for both arctic and red foxes during 1992–2000 on the Colville River Delta survey areas (updating the analyses presented by Johnson et al. [1999a]). We used the total area of all terrestrial habitats as the measure of habitat availability, excluding waterbodies and other aquatic habitats that obviously could not be used for denning. In the selection analysis, no distinction was made between species or between active (including natal and secondary) and inactive dens, because den status can change annually. Only sites that we visited, confirmed, and mapped on aerial photographs were included in the habitat selection analysis.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

The habitat map identified 24 wildlife habitat types in the delta (Appendix B1, Appendix B2), of which 20 occur in the CD South study area (the delta south of the Alpine Development Project, Figure 2; Table 3). Wildlife habitats are described in Appendix B1. The most abundant wildlife habitat in the CD South study area was Wet Sedge–Willow Meadow, which comprised 31% of the total area (Table 3). Other habitats comprising more than 10% of the total area were Barrens, Riverine or Upland Shrub, and River or Stream. Several habitats occurred only in trace amounts (≤1% of total area): Tapped Lake w/ Low-water Connection, Salt Marsh, Shallow Open Water without Islands, Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, Aquatic Grass Marsh, Young Basin Wetland Complex, Old Basin Wetland Complex, Moist Tussock Tundra, and Artificial. Because of its more inland location, the CD South study area has lower cover by Nonpatterned Wet Meadows, Tapped Lakes with Low-water Connections, and coastal habitats, such as Open Nearshore Water, Brackish Water, Salt Marsh, and Salt-killed Tundra than either the more northerly CD North area (Johnson et al. 2000a) or the entire delta as a whole.

The CD South ground-search area (Figure 2) included 14 wildlife habitat types (Table 4). Wet Sedge–Willow Meadow with Low-Relief Polygons also dominated in the ground-search area, comprising 38% of the total area. Moist Sedge–shrub Meadow and Riverine or Upland Shrub were the only other habitats comprising >10% of the total area. Seven habitats occurred in only trace amounts (>1% of total area): Tapped Lake w/ Low-water Connection, Salt Marsh, Shallow Open Water without Islands, Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, Aquatic Grass Marsh, and Barrens.

Table 3. Availability of wildlife habitat types in the CD South study area, Colville River Delta, Alaska, 2000.

Habitat	CD South Study Area Area (km^2)	CD South Study Area Availability (%)	Colville Delta Area (km^2)	Colville Delta Availability (%)
Open Nearshore Water (marine)	-	0.0	10.02	1.8
Brackish Water	-	0.0	6.53	1.2
Tapped Lake w/ Low-water Connection	1.61	1.0	21.62	3.9
Tapped Lake w/ High-water Connection	13.56	8.7	20.77	3.8
Salt Marsh	1.59	1.0	16.55	3.0
Tidal Flat	-	0.0	56.01	10.2
Salt-killed Tundra	-	0.0	25.64	4.7
Deep Open Water w/o Islands	10.02	6.4	20.77	3.8
Deep Open Water w/ Islands or Polygonized Margins	2.43	1.6	7.76	1.4
Shallow Open Water w/o Islands	0.39	0.3	2.02	0.4
Shallow Open Water w/ Islands or Polygonized Margins	0.10	0.1	0.54	0.1
River or Stream	16.64	10.7	82.07	14.9
Aquatic Sedge Marsh	0.13	0.1	0.13	<0.1
Aquatic Sedge w/ Deep Polygons	1.78	1.1	13.22	2.4
Aquatic Grass Marsh	0.86	0.6	1.45	0.3
Young Basin Wetland Complex	<0.01	<0.1	<0.01	<0.1
Old Basin Wetland Complex	<0.01	<0.1	0.01	<0.1
Nonpatterned Wet Meadow	9.99	6.4	41.54	7.5
Wet Sedge–Willow Meadow	47.45	30.5	102.63	18.6
Moist Sedge–Shrub Meadow	8.20	5.3	13.20	2.4
Moist Tussock Tundra	0.85	0.6	2.55	0.5
Riverine or Upland Shrub	18.22	11.7	27.58	5.0
Barrens (riverine, eolian, lacustrine)	21.80	14.0	78.67	14.3
Artificial (water, fill, peat road)	0.22	0.1	0.39	<0.1
Total	155.86	100	551.67	100

Table 4. Availability of wildlife habitat types in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Habitat	Area (km^2)	Availability (%)
Tapped Lake w/ Low-water Connection	<0.01	<0.1
Tapped Lake w/ High-water Connection	0.54	9.4
Salt Marsh	<0.01	<0.1
Deep Open Water w/o Islands	0.22	3.8
Deep Open Water with Islands or Polygonized Margins	0.39	6.7
Shallow Open Water w/o Islands	0.01	0.2
Shallow Open Water with Islands or Polygonized Margins	0.01	0.1
Aquatic Sedge w/ Deep Polygons	0.02	0.3
Aquatic Grass Marsh	0.02	0.4
Nonpatterned Wet Meadow	0.28	4.8
Wet Sedge–Willow Meadow	2.20	37.6
Moist Sedge–shrub Meadow	1.27	21.8
Riverine or Upland Shrub	0.85	14.6
Barrens (riverine, eolian, lacustrine)	0.03	0.5
Total	5.85	100

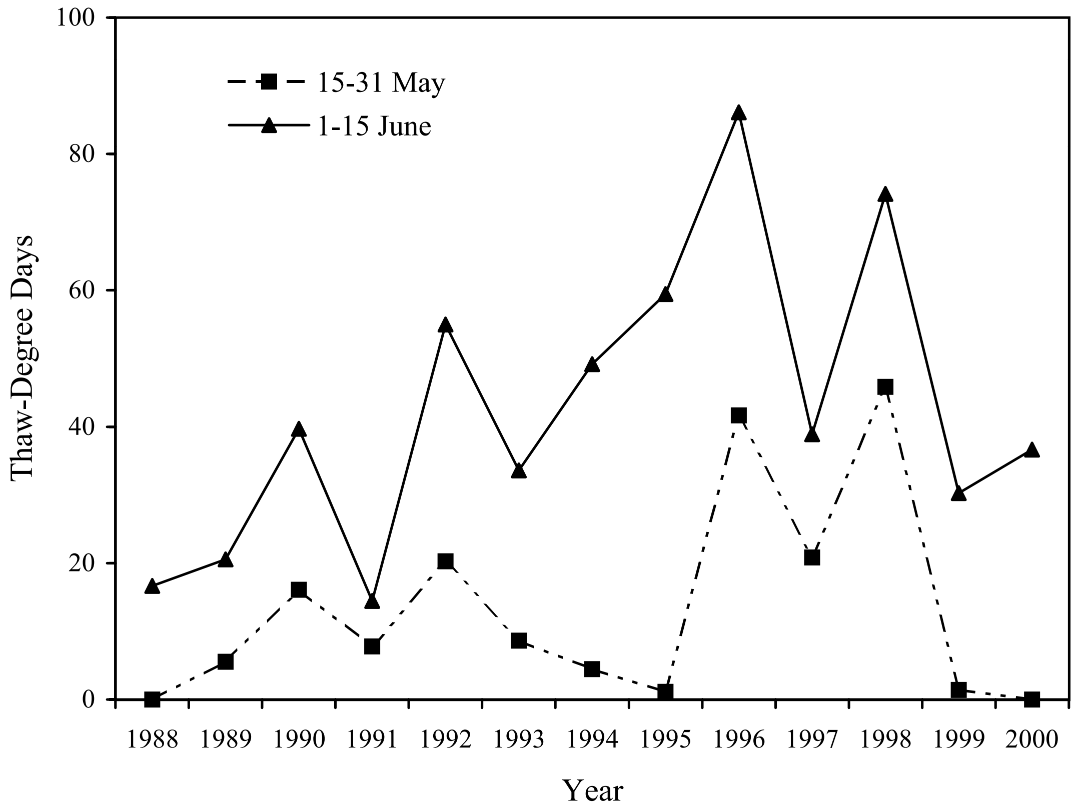


Figure 3. Number of thaw-degree days recorded for 15–31 May and 1–15 June in the Kuparuk Oilfield, Alaska, 1988–2000. Thaw-degree days are calculated by summing the number of degrees above 0° C for daily mean temperature.

CONDITIONS IN THE STUDY AREA

The 2000 breeding season was unusual among recent years, because weather and river conditions delayed the onset of nesting for birds on much of the Colville Delta. Spring temperatures were colder and snow melt was later in 2000 relative to previous years since 1992 (when many of these surveys were initiated on the delta), even more so than 1997 and 1999, 2 years that were marked by cool temperatures and late snow melt. Average daily temperatures in the Kuparuk Oilfield (~25 km east of the delta) did not rise above freezing during 15–31 May 2000, making it the coldest year during this period since 1992 (Figure 3).

During 11–15 June 2000, mean snow cover was 40% and 54% in two areas west and south of the Kuparuk Oilfield and 14% within the Kuparuk Oilfield survey area (Lawhead et al., in prep), which is an area of accelerated thawing due to dust blown from gravel roads and pads. During the same period in 1999, the Kuparuk survey area had ~20% snow cover and the two other areas had <15% snow cover (Lawhead and Johnson 2000). In addition to late snow melt, the Colville River broke up relatively late on 8 June, and ice jams caused extensive flooding on the delta during the second week of June, which made some nesting areas unavailable for several days. Another index to the lateness of the nesting season was the delayed development of young Tundra Swans and loons, two species that require more time to become capable of flight than other nesting birds in the region. Swan young were judged to be unusually small during our brood-rearing survey on 17–19 August and, during the fall-staging survey on 16 September, family groups were still on nesting territories. No young were observed in

Table 5. Nests located in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Species	Number of Nests				Nesting Success (%)	Nest Density (no./km^2)
	Failed	Successful	Unknown Fate	Total		
Pacific Loon	0	0	3	3	0	0.52
Greater White-fronted Goose	15	18	3	36	50	6.19
Tundra Swan	1	0	0	1	0	0.17
Northern Pintail	11	1	0	12	8	2.06
Spectacled Eider	1	0	0	1	0	0.17
Long-tailed Duck	1	0	0	1	0	0.17
Willow Ptarmigan	0	0	17	17	0	2.92
Rock Ptarmigan	0	0	1	1	0	0.17
Whimbrel	0	0	1	1	0	0.17
Long-tailed Jaeger	0	1	1	2	50	0.34
Glaucous Gull	1	0	0	1	0	0.17
Arctic Tern	2	0	2	4	0	0.69
Total	32	20	28	80	25	13.75

flocks, which usually form by mid-September prior to migration and freeze-up. During the same survey, loon adults were observed in flight, but none were observed on lakes attending young, suggesting that young loons either were abandoned or had already perished. These observations suggest that few swan or loon young survived to migrate from the breeding area in 2000.

WILDLIFE SURVEYS AND HABITAT ANALYSES

GROUND SEARCHES FOR WATERBIRD NESTS AND BROODS

Nests of 12 species of birds were located in the CD South ground-search area (Table 5, Figure 4). The most common nesting birds were Greater White-fronted Geese, Willow Ptarmigan, and Northern Pintails (surveys excluded nests of shorebirds and passerines). All other species had fewer than five nests. Nesting success was 50% for White-fronted Geese (for 3 of 36 nests fate could not be determined) and 8% for Pintails (12 nests, including three identified from feather and down samples; only one nest was successful). Fate was not determined for ptarmigan nests.

Overall nest density in the CD South ground-search area was 13.8 nests/km² (Table 5) or, if ptarmigan are excluded, 10.7 nests/km² (Table 6). Nest densities in the CD South ground-search area were higher than were observed in the Alpine project area 1996–1999 (Table 6; Johnson et al. 2000b). The CD South ground-search area supported somewhat higher densities of nests of Greater White-fronted Geese, Northern Pintail, and ptarmigan (primarily Willow Ptarmigan) than were found in the Alpine project area 1996–1999 (Table 6; Johnson et al. 2000b). However, the CD South ground-search area was less than one-half the size of study plots searched in the Alpine project area and for most other species only one or two nests were found. Density estimates for these species are probably inaccurate (larger plots sizes would be required to calculate accurate densities for uncommon species).

Seventy of 80 nests in the CD South ground-search area were located in two habitat types: Wet Sedge–Willow Meadow and Moist Sedge–shrub Meadow (Table 7). For all species except Glaucous Gulls (with only one nest in the area, in Shallow Open Water w/o Islands), all or most nest were located in these two habitats.

Broods or brood groups of 8 species were observed during ground searches in the CD South study plot (Table 8, Figure 5). (Four broods of Greater White-fronted Geese were observed just outside the ground-search area, but these are included in totals as observers believed that they left the study plot in response to the survey.) Of 16

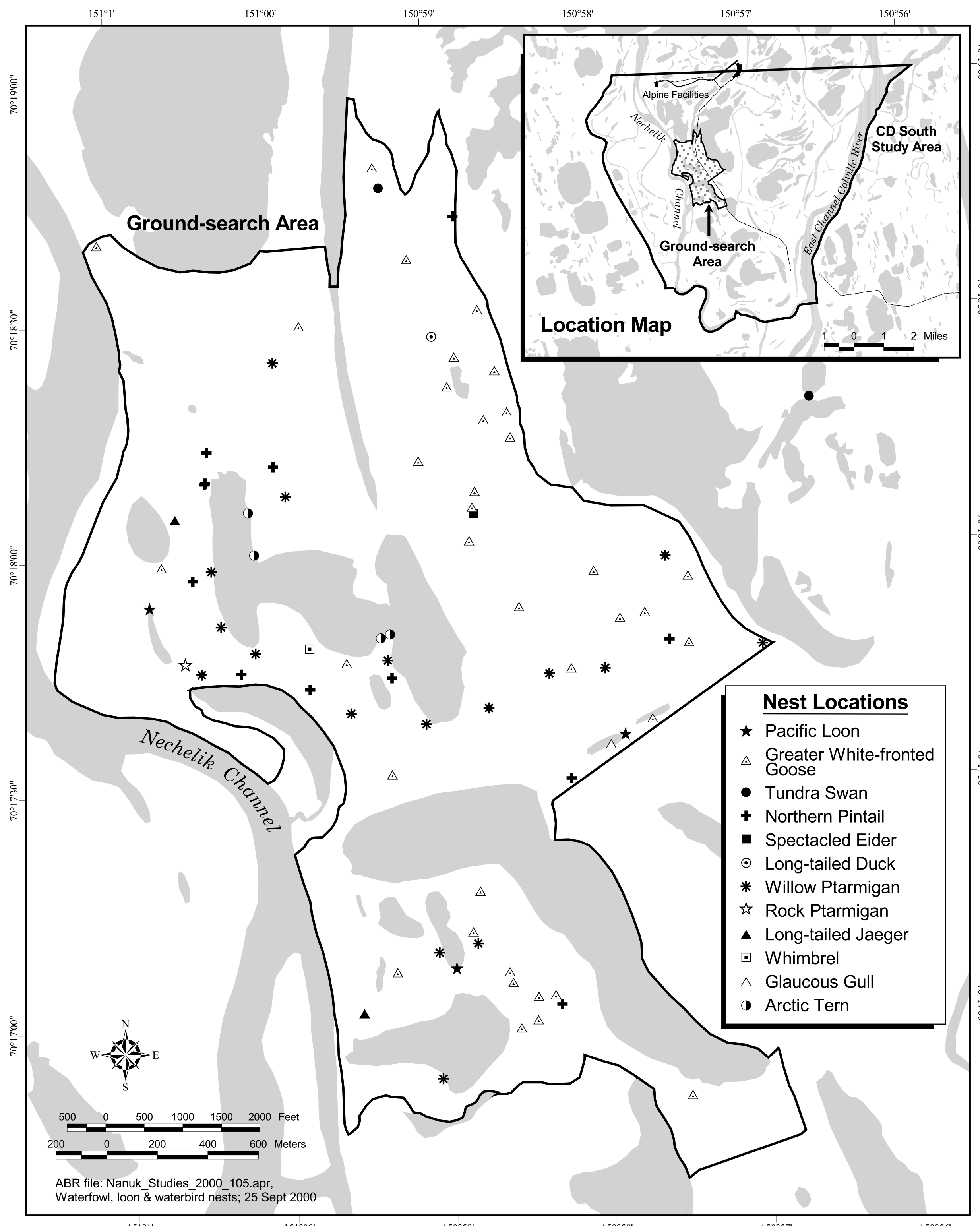


Figure 4. Distribution of waterfowl, loon, and other waterbird nests in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Table 6. Densities (nests/km²) of nests in the CD South and CD North ground-search areas, 2000, and in the Alpine project area, 1996–1999, Colville River Delta, Alaska (pre-2000 data from Johnson et al. 1999a; CD North data from Johnson et al. 2000a).

	Alpine				CD South	CD North
Species	1996	1997	1998	1999	2000	2000
Red-throated Loon	0.1	0.5	0.1	0	0	0.5
Pacific Loon	0.2	0.6	0.1	0.5	0.5	0.7
Yellow-billed Loon	0.1	0.1	0	0.1	0	0.2
Red-necked Grebe	0	0.2	0.1	0.1	0	0
Greater White-fronted Goose	2.0	3.1	3.2	5.0	6.2	9.8
Canada Goose	0	0	0.1	0.1	0	0
Brant	0.1	0.5	0.1	0.3[a]	0	2.5
Tundra Swan	0.2	0.4	0.3	0.4	0.2	0.3
Northern Shoveler	0.1	0	0.3[b]	0	0	0
Northern Pintail	0.1[b]	0.3	0.6[b]	0.6[b]	2.1[b]	0.3[b]
Green-winged Teal	0.1	0	0.1	0.3[b]	0	0
Greater Scaup	0	0.1	0.1	0.4	0	0
Lesser Scaup	0	0	0.1	0	0	0
Unidentified scaup	0	0	0.1	0.1[b]	0	0
Spectacled Eider	0	0	0.1	0.1	0.2	1.2[b]
King Eider	0.1	0	0	0	0	0.2
Long-tailed Duck	0.4[b]	0.6	0.4[b]	0.2[b]	0.2	1.5[b]
Unidentified duck	0	0	0.3	0.1	0	0.1
Willow Ptarmigan	0.1	0.8	nd	1.3	2.9	0.7
Rock Ptarmigan	0	0.1	nd	0	0.2	0
Unidentified ptarmigan	0	0	0	0.2	0	0
Sandhill Crane	0	0	0	0.1	0	0
Whimbrel	0	0	0	0	0	0
Bar-tailed Godwit	0.1	0	0.1	0.2	0	0
Common Snipe	0	0.1	0	0	0	0
Parasitic Jaeger	0.1	0.1	0.1	0.1	0	0.1
Long-tailed Jaeger	0.1	0	0.1	0.1	0.3	0
Glaucous Gull	0	0.1	0	0.1	0.2	0.8
Sabine's Gull	0.1	0	0	0	0	0.4
Arctic Tern	0	0.3	0.3	1.0	0.7	0.7
Short-eared Owl	0.1	0	0	0	0	0
Area searched (km^2)	17.2	14.3	14.8	15.7	5.8	12.2
Total nests[c]	63	102	99	154	62	233
Total densities[c]	3.7	7.1	6.7	9.8	10.7	19.1
Total species[c]	16	14	18	18	10	16

[a] Includes one nest identified by down and nest site location.
[b] Includes nests identified from feather and down samples.
[c] Total does not include ptarmigan.

Table 7. Number of nests in each habitat type in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Species	Deep Open Water with Islands	Shallow Open Water with Islands	Nonpatterned Wet Meadow	Wet Sedge-Willow Meadow	Moist Sedge–shrub Meadow	Riverine or Upland Shrub	Total
Pacific Loon				2	1		3
Greater White-fronted Goose				23	13		36
Tundra Swan					1		1
Northern Pintail			1	4	6	1	12
Spectacled Eider				1			1
Long-tailed Duck				1			1
Willow Ptarmigan			1	9	3	4	17
Rock Ptarmigan					1		1
Whimbrel				1			1
Long-tailed Jaeger				1	1		2
Glaucous Gull		1					1
Arctic Tern	2			2			4
Total	2	1	2	44	26	5	80

brood groups observed, eight were Greater White-fronted Geese. Several broods were observed of species that were not known from the nest search, including Greater Scaup, Green-winged Teal, Red-breasted Merganser, and Red-throated Loon. Unlike during nesting, when only two habitats were extensively used, broods were found in a variety of habitats in the CD South ground-survey area in 2000 (Table 9). Nine habitats were used. The most used habitat was Tapped Lakes with High-water Connections, used by 5 of 16 broods.

One Spectacled Eider nest was located in the CD South ground-search area (Figure 4). The nest was 9.6 km from the coast. The hen was not flushed, so the clutch size was not determined. The nest was determined to have failed, as it contained no egg remnants when checked in July. The nest

Table 8. Broods or brood groups located in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Species	Adults	Young	Broods or Brood Groups
Red-throated Loon	2	1	1
Pacific Loon	1	1	1
Greater White-fronted Goose	22	32	8
Northern Pintail	1	7	1
Green-winged Teal	1	6	1
Greater Scaup	2	11	2
Red-breasted Merganser	1	5	1
Long-tailed Jaeger	2	1	1
Total	32	64	16

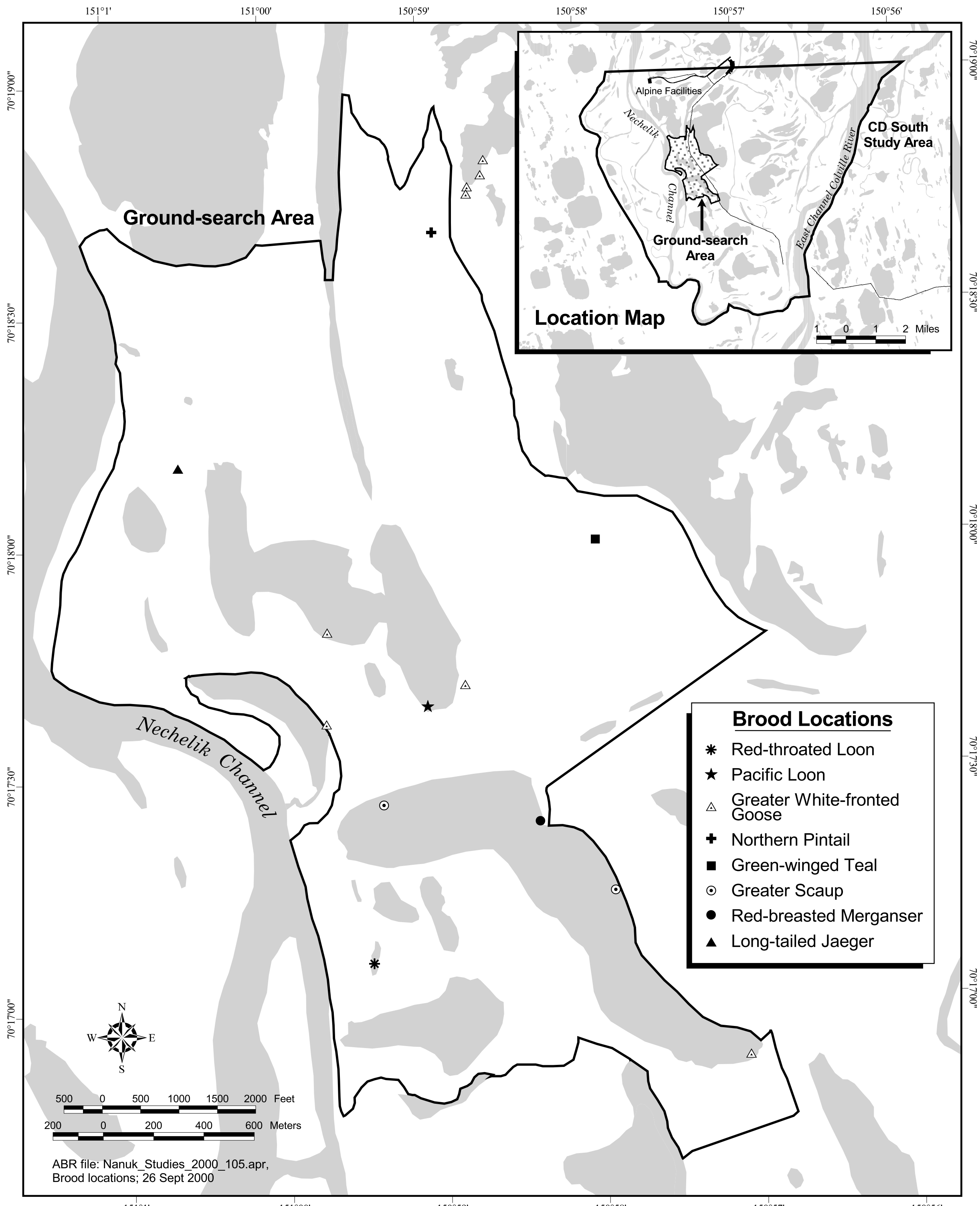


Figure 5. Distribution of broods in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Table 9. Number of broods or brood groups in each habitat type in the CD South ground-search area, Colville River Delta, Alaska, 2000.

Species	Tapped Lake w/ High-water Connection	Salt Marsh	Deep Open Water with Islands	Shallow Open Water w/o Islands	Nonpatterned Wet Meadow	Wet Sedge–Willow Meadow	Moist Sedge–shrub Meadow	Riverine or Upland Shrub	Barrens	Total
Red-throated Loon				1						1
Pacific Loon			1							1
Greater White-fronted Goose	2	2	1		1			1	1	8
Northern Pintail							1			1
Green-winged Teal						1				1
Greater Scaup	2									2
Red-breasted Merganser	1									1
Long-tailed Jaeger							1			1
Total	5	2	2	1	1	1	2	1	1	16

predator could not be determined. No nests of other eider species were found in the ground-search area. Two Spectacled Eider nests are known in the CD South study area from previous years, one each in 1998 and 1999 (Johnson et al. 2000b). Both were located on the east side of the Sakoonang Channel and were located during ground-searches of the Alpine project area (Appendix C3). During nest searches in various portions of the delta from 1992 to 2000, we have found 45 Spectacled Eider nests, 6 King Eider nests, 1 Common Eider nest, and 3 unidentified eider nests, of which most were on the outer delta (Smith et al. 1993, 1994; Johnson et al. 2000a, 2000b; this study). 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 locations of only four of these nests (M. North, unpubl. data). The earliest records we have found for Spectacled Eider nests are of two nests on the outer delta in 1958 and four in 1959 (T. Myres, unpubl. data). Four of the nests found in 1993 and 1994 were on the same lakes as the nests from these earliest records (near the Nechelik Channel, Appendix C3).

We have found few nests of other eider species on the delta, possibly because we focused our nest searches prior to 1996 on Spectacled Eiders. More probable, however, is that the delta does not support much nesting by other eider species. Similar search techniques were used in the Kuparuk Oilfield, and 53% of the 178 nests found in 6 years belonged to King Eiders (Anderson et al. 1999). In 9 years of nest searching on the delta, we found only 10 of 55 nests (18%) belonged to species other than Spectacled Eiders: one Common Eider nest, six King Eider nests (two identified by contour feathers), and three nests of unidentified eiders.

Spectacled Eider broods were not observed in the CD South study area. However, brood locations are available from previous surveys and casual observations on the Colville River Delta. The distribution of Spectacled Eider broods observed opportunistically and during eider surveys on the delta (Appendix C5) was similar to the distribution of eiders during pre-nesting and nesting surveys (Appendix C1, Appendix C2, Appendix C3, and Appendix C4); no broods were observed >13 km from the coast. From all the years in our database (1983, 1984, 1992–2000), we have records of only three eider broods from the CD South study area, and all were on the east side of the Sakoonang Channel (Appendix C5). One Spectacled Eider brood was seen in 1984 (M. North, unpubl. data), one King Eider brood was seen in 1992 (Smith et al. 1993), and one Spectacled Eider brood was seen in 1993 (Smith et al. 1994). For the entire delta we have records of 25 Spectacled Eider broods and 2 King Eider broods. Nine Spectacled Eider broods were sighted in the CD North study area during 2000 (Johnson et al. 2000a). The number of broods undoubtedly is undercounted during aerial and ground surveys.

Three Pacific Loon nests were the only loon nests identified, yielding a nest density of 0.5/km². During the ground brood search, however, we found one Pacific Loon and one Red-throated Loon brood (Figure 5), indicating that at least one Red-throated Loon also nested on the study area. Nesting and brood surveys that covered the entire CD South and CD North study areas also were conducted for loons in 2000, and further discussion of the abundance and distribution of loons can be found in those sections of results, below.

Thirty-six nests of Greater White-fronted Geese yielded a nest density of 6.2 nests/km². Similar high nest densities for Greater White-fronted Geese have been reported from previous investigations in the Colville River Delta. In the early 1980s, the USFWS recorded mean densities during June of 1.8 –6.3 birds/km² in plots across the delta, and 6.6 nests/ km² at one site on the western delta, noting that these are among the highest densities on the Arctic Coastal Plain of Alaska (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). Since then, we have recorded nest densities of 2.0–5.0 nests/km² on the delta in an area searched intensively for goose nests in the Alpine project area (Johnson et. al. 2000b). Further discussion of the abundance and distribution of White-fronted Geese during brood-rearing and fall staging on the Colville River Delta can be found in the section on aerial survey results, below.

Northern Pintails were the third most common nesting bird on the CD South ground-search area, with a nest density of 1.6/km² (Table 5). Northern Pintails (*Anas acuta*) were recorded by the USFWS as the most numerous large bird on the Colville Delta in the 1980s with mean densities of 16.6 birds/km² (Rothe et al. 1983), which were among the highest densities recorded for these ducks on the Arctic Coastal Plain of Alaska. A majority of these birds were considered to be drought-displaced nonbreeding drakes (Derksen and Eldridge 1980). In the Alpine project area 1996–1999, between 2–9 nests of Northern Pintails were located during ground-searches and Northern Pintails were one of the two most numerous nesting ducks (Johnson et al. 1997, 1998, 1999b, 2000b).

Only one nest of Long-tailed Duck (Oldsquaw) was found on the CD South ground-search area in 2000 (Table 5). In the early 1980's, the USFWS reported the Long-tailed Duck as the second most abundant large bird on the Colville Delta and the average density of 7.4 birds/km² in June was higher than that recorded for any other location on the arctic coastal plain (Rothe et al. 1983). Long-tailed Ducks also were the second most common breeding duck in the Alpine project area, with 5–9 nests recorded during nest searches (Johnson et al. 1997, 1998, 1999b, 2000b).

The second most abundant nesting bird on the CD South ground-search area was the Willow Ptarmigan, with 17 nests and nest density of 2.9/km² (Table 5). A single nest of Rock Ptarmigan also was found on the CD South ground-search area. Both species have been recorded as common in upland habitats on the Colville Delta, with densities of 0.9 birds/km² for Willow Ptarmigan and 0.3 birds/km² for Rock Ptarmigan, much higher than densities than have been recorded for other sites on the arctic coastal plain (Rothe et al. 1983). Willow Ptarmigan nest mainly on polygon rims and among shrubby willow, whereas Rock Ptarmigan are more common in dune terrains on the delta, a habitat with restricted distribution in the CD South study area.

Three of the six larid species that are known to nest on the Colville River Delta occurred in the CD South ground-search area: Long-tailed Jaegers (2 nests), Glaucous Gulls (1 nest) and Arctic Terns (4 nests) (Table 5). No Sabine's Gulls or Pomerine Jaegers were observed and no Parasitic Jaeger nests were located (although Parasitic Jaegers were observed in the area). Two of four Arctic Tern nests in the CD South ground-search area in 2000 were located on floating ice and undoubtedly failed. Glaucous Gulls are the most common larid on the delta, nesting either as single pairs or in small colonies across the delta, and their recorded densities (2.1 birds/km²) are higher than has been recorded elsewhere on the North Slope (Rothe et al. 1983). Parasitic Jaegers were the most common jaeger on the delta in June (1.1 birds/km²), followed by Pomarine (0.8/km²) and Long-tailed (0.3/km²) and the densities recorded on the delta were generally higher than those recorded for elsewhere on the North Slope (Rothe et al. 1983). In the Alpine project area, we have found 0–2

Glaucous Gull, 1–2 Parasitic Jaeger, 0–1 Long-tailed Jaeger, 0–1 Sabine's Gull and 0–15 Arctic Tern nests per year in the 4 years that we have conducted ground searches in that area (Johnson et al. 2000b).

EIDER SURVEYS

Background

Spectacled Eiders have suffered large population declines, particularly in the Yukon-Kuskokwim Delta in western Alaska (Kertell 1991, Stehn et al. 1993) and, as a result, they were listed as a threatened species under the Endangered Species Act in 1993 (58 FR 27474–27480). Spectacled Eiders nest on the arctic coast of Siberia (Bellrose 1980) and in Alaska on the Yukon-Kuskokwim Delta and along the Beaufort Sea coast from Point Barrow to Demarcation Point (Gabrielson and Lincoln 1959, Dau and Kistchinski 1977). Spectacled Eiders are uncommon nesters (i.e., they occur regularly but are not found in all suitable habitats) on Alaska's Arctic Coastal Plain, and tend to concentrate on 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 the earliest nests have been recorded to appear between 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 Spectacled Eiders on the Colville Delta is 28 August (Gerhardt et al. 1988). The entire world's population of Spectacled Eiders appears to winter in restricted openings in Bering Sea ice south of St. Lawrence Island; in 1997, 363,030 birds were estimated from photographs of 18 flocks (Larned and Tiplady 1997).

King Eiders nest in high densities in the Prudhoe Bay area (Troy 1988) and at 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 visitors but uncommon or rare 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 and/or they use the delta as a staging area before moving to nesting areas farther east.

Common Eiders have a circumpolar distribution and along the Beaufort Sea they favor barrier islands as nesting sites (Johnson and Herter 1989). Except on the barrier islands, Common Eiders are rare on the Colville Delta (Simpson et al. 1982, Renken et al. 1983, North et al. 1984, Johnson et al. 1998). During pre-nesting surveys, a pair was seen in 1992 (Smith et al. 1993) and seven were seen in the delta area in 1998 (Johnson et al. 1999a); one nest was found on an island in the outermost delta in 1994 (Johnson 1995).

The Steller's Eider was listed as threatened under the Endangered Species Act in 1997 (62 FR 31748–31757). Steller's Eiders breed primarily on the arctic coast of Siberia (Bellrose 1980). In Alaska they breed in the west and northwest with few recent records from east of Point Barrow (Johnson and Herter 1989). Five Steller's Eiders were seen briefly on the delta in June 1995 (J. Bart, Boise State University, pers. comm.), and one pair was observed on one day in June 2000 in the Kuparuk Oilfield (S. Schlentner, ABR, Inc., pers. comm.).

Distribution and Abundance

Pre-nesting

In 2000, we conducted the eider pre-nesting survey over the CD South and CD North study areas on 16 June, which is later than usual (10–14 June) but within the range of dates that surveys were flown in previous years (10–20 June; Johnson et al. 1999a). Lakes and ponds remained frozen prior to our survey, except for those connected to river channels; therefore we delayed our survey until meltwater was available across the study area. All Spectacled Eiders sighted were alone or in pairs and they appeared to be dispersed into breeding habitat. Nonetheless, the descriptions of eider locations made by aerial observers indicated that much of the tundra was flooded and not available for nesting at the time of the survey.

The pre-nesting distribution of both Spectacled and King eiders on the delta in 2000 was similar to that recorded on surveys flown in 1993–1998 (Figure 6, Appendix C1 and C2). Spectacled and King eiders on the Colville Delta were closely associated with coastal areas in all years. During pre-nesting in 2000, Spectacled Eiders were found as far as 14.3 km from the coastline, a small increase over the furthest inland sighting recorded between 1993 and 1998 (14 km). Across the entire delta in 2000, the mean distance of Spectacled Eiders from the coast was 4.3 km (n = 24 sightings), slightly farther from the coast than the mean of all sightings since 1993 ($\bar{x}$ = 4.0 km, n = 199 sightings). 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 inland 40–50 km from the sea. 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 2000 was 14.2 km, and the mean was 5.2 km (n = 112 sightings).

In 2000, King Eiders were slightly more abundant than Spectacled Eiders in the CD South study area, although neither species was abundant during the pre-nesting survey. We counted two Spectacled Eiders and six King Eiders, and the number of "indicated" birds (i.e., the number of single and paired males × 2 + the number birds in mixed sex groups ≥ 4; USFWS 1987a) was identical (Table 10).

The densities of Spectacled and King eiders in the CD South study area during pre-nesting in 2000 were similar to previous years (Table 11). In 2000, the uncorrected density (i.e., raw counts of birds that were uncorrected for sightability) of flying and non-flying Spectacled Eiders in the CD South study area was 0.01 birds/km² (Table 11). In 1993, 1994, and 1996, no Spectacled Eiders were sighted in the CD South study area. The density of King Eiders in 2000 was 0.04 birds/km², and densities have ranged from from 0 to 0.06 birds/km² (Table 11).

Pre-nesting Spectacled and King eiders occur in much lower densities in the CD South study area than nearby areas. In the adjacent CD North study area on outer Colville Delta, indicated densities of Spectacled Eiders in 1993–2000 ranged from 0.14 to 0.28 birds/km² and densities of King Eiders ranged from 0.02 to 0.11 birds/km² (Johnson et al. 2000a). East of the delta in the Kuparuk Oilfield, indicated densities of Spectacled and King eiders

Table 10. Numbers and densities (uncorrected for sightability) of eiders during pre-nesting aerial surveys (100% coverage) of the CD South study area, Colville River Delta, Alaska, 16 June 2000.

						Density (birds or pairs/km²)		
	Observed Numbers			Indicated Numbers		Observed	Indicated	
Species	Males	Females	Total	Birds[a]	Pairs[b]	Birds	Birds[a]	Pairs[b]
NON-FLYING BIRDS								
Spectacled Eider	1	1	2	2	1	0.01	0.01	0.01
King Eider	3	3	6	6	3	0.04	0.04	0.02
Unidentified Eider	0	0	0	0	0	0	0	0
FLYING BIRDS								
Spectacled Eider	0	0	0	0	0	0	0	0
King Eider	0	0	0	0	0	0	0	0
Unidentified Eider	0	0	0	0	0	0	0	0
NON-FLYING + FLYING BIRDS								
Spectacled Eider	1	1	2	2	1	0.01	0.01	0.01
King Eider	3	3	6	6	3	0.04	0.04	0.04
Unidentified Eider	0	0	0	0	0	0	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.

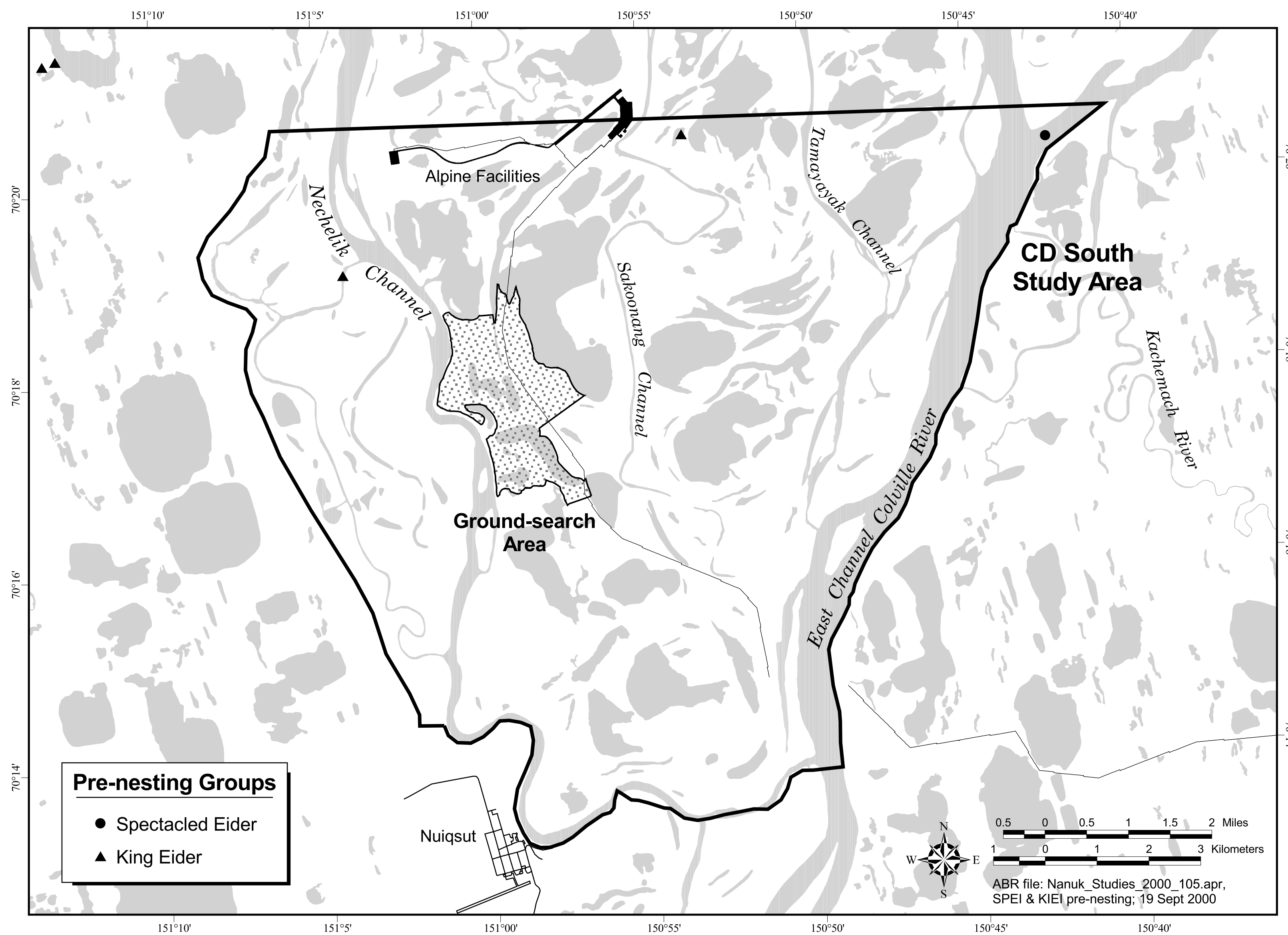


Figure 6. Distribution of Spectacled and King eider groups observed during pre-nesting aerial surveys in the CD South study area, Colville River Delta, Alaska, 2000.

Table 11. Numbers and densities (birds/km²) of eiders (flying and non-flying combined) during pre-nesting aerial surveys in the CD South study area, Colville River Delta, Alaska, 1993–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

	Number of Birds							Density						
Species	2000	1998	1997	1996	1995	1994[a]	1993[b]	2000	1998	1997	1996	1995	1994[a]	1993[b]
Spectacled Eider	2	2	2	0	2	0	0	0.01	0.01	0.01	0	0.01	0	0
King Eider	6	0	9	8	4	0	3	0.04	0	0.06	0.05	0.03	0	0.04
Unidentified eider	0	0	0	0	0	0	1	0	0	0	0	0	0	0.01
Total	8	2	11	8	6	0	4	0.05	0.01	0.07	0.05	0.04	0	0.05

[a] In 1994, 31 km² west of the Nechelik Channel were not surveyed.
[b] Coverage of survey area in 1993 was 50%.

varied over the same years from 0.06 to 0.09 birds/km² and 0.23 to 0.66 birds/km², respectively (Anderson et al., in prep.). Across the entire Arctic Coastal Plain from 1993 to 1998, indicated densities of Spectacled Eiders were 0.17–0.31 birds/km² and indicated densities of King Eiders were 0.36–0.51 birds/km² (Larned et al. 1999).

Habitat Use

Pre-nesting

During the 2000 pre-nesting season in the CD South study area, one pair of Spectacled Eiders and one pair of King Eiders were in River or Stream, and one group of two pairs of King Eiders was in Tapped Lake with High-water Connection. Since 1993, only four groups of Spectacled Eiders have been sighted on the ground during pre-nesting surveys in the CD South study area, and one pair each occupied both types of Tapped Lakes, River or Stream, and Aquatic Sedge with Deep Polygons (Appendix D1).

Over the entire delta and among all years combined, preferred habitats by Spectacled Eiders during pre-nesting included Brackish Water, Salt Marsh, and Aquatic Sedge with Deep Polygons (Appendix D2). Brackish Water did not occur in the CD South study area (Table 3). Both Tapped Lake types were used in proportion to their availability, but River or Stream was avoided by Spectacled Eiders. Elsewhere, studies have emphasized the importance of emergent vegetation for eiders using waterbodies. West of the Colville Delta 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). East of the Colville River in the Kuparuk Oilfield, most of the pre-nesting Spectacled Eiders were found in basin wetland complexes, aquatic grass (Arctophila), and aquatic sedge (Carex) habitats (Anderson et al. 2000). 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 ponds with emergent vegetation (both Arctophila and Carex) and impoundments (Warnock and Troy 1992). Lakes with emergents are not abundant on the Colville Delta; however, Aquatic Sedge with Deep Polygons, Aquatic Sedge Marsh, and Aquatic Grass Marsh are probably analogous to the Carex and Arctophila ponds described elsewhere. None of these habitats is abundant in the CD South study area, occupying <2% of the area combined (Table 3).

Since 1993, 12 groups of King Eiders have been sighted on the ground in the CD South study area during pre-nesting (Appendix D1). Most of the King Eiders (53% of the sightings) used River or Stream, one of two preferred habitats on the entire delta (Appendix D2). The other preferred habitat was Brackish Water. The preference for River or Stream and Brackish Water, the low use of typical nesting habitat (i.e., lakes and wet meadows), and the prevalence of flocks rather than pairs on the entire delta suggests that most King Eiders had not yet dispersed into breeding areas during the pre-nesting surveys (Johnson et al. 1999a). Furthermore, the low number of nests found later 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 or aquatic nonpatterned ground; aquatic strangmoor; and water with and without emergents (Warnock and Troy 1992).

Nesting

One Spectacled Eider nest was found in the CD South ground-search area in 2000. That nest occupied a polygon rim in Wet Sedge–Willow Meadow habitat 0.5 m from permanent water and 20 m from Shallow Open Water with Islands or Polygonized Margins.

Although coverage of nest searches for Spectacled Eiders has never been complete, in nine years of nest searching in various locations on the entire delta, 45 nests of Spectacled Eiders have been found in 9 habitats (Appendix D3); in two of those years, no nests were found. The coastal portion of the delta, where Spectacled Eiders concentrate during pre-nesting (Appendix C1), also is where eiders nest most commonly (Appendix C3). We have not found any documented nest locations that were farther than 13 km from the coast. The mean distances from the coast of all eider nests on the delta for which we have records are 3.6 km (n = 49) for Spectacled Eider, 3.6 km (n = 6) for King Eider, 1.4 km (n = 1) for Common Eider, and 2.4 km (n = 3) for unidentified eider.

Most Spectacled Eider nests that have been located on the Colville River Delta since 1992 were in Salt-killed Tundra (12 nests), Aquatic Sedge with Deep Polygons (9 nests), Nonpatterned Wet Meadow (7 nests), and Brackish Water (6 nests on islands) (Appendix D3). Wet Sedge–Willow Meadow, the most abundant habitat and the habitat occupied by the single nest in the CD South study area, accounted for 11% of all nests found on the delta since 1992.

Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 2.9 m from permanent water (range = 0.1–80 m, n = 45; data from Smith et al. 1994; Johnson et al. 1998, 2000b; and this study). Brackish Water was the nearest waterbody type for 47% of the nests, and Deep Open Water with Islands was the nearest for 27% of the nests (Appendix D3). The results of pre-nesting and nesting habitat analyses emphasize the importance to breeding Spectacled Eiders of habitats that are more prevalent on the outer delta than farther inland: Brackish Water, Salt-killed Tundra, Salt Marsh, and Aquatic Sedge with Polygonized Margins. The absence or scarcity of these habitats may explain the low numbers of Spectacled Eiders in the CD South study area during pre-nesting and nesting.

Similar habitat associations have been reported for Spectacled Eiders in 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 5.7 m over 7 years, and the waterbodies closest to nests were primarily basin wetland complexes, shallow and deep open lakes, and water with emergents (both *Carex* and *Arctophila*) (Anderson et al. 1999). 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 the Kuparuk Oilfield, the most common nesting habitats were basin wetland complexes, aquatic grass with islands, low-relief wet meadows, and nonpatterned wet meadows (Anderson et al. 1999). In Prudhoe Bay, nests were found in *Carex* ponds and wet, nonpatterned tundra (Warnock and Troy 1992). Waterbodies with emergent vegetation are relatively scarce on the Colville Delta: the three habitat types that comprise waterbodies with emergents (Aquatic Sedge with Deep Polygons, Aquatic Grass Marsh, and Aquatic Sedge Marsh) together comprise only 1.8% of the delta (Table 3). Therefore, Spectacled Eider nesting habitat on the delta differs somewhat from adjacent coastal tundra areas with more abundant *Carex* and *Arctophila* waterbodies.

Brood-rearing

We did not observe any broods of Spectacled or King Eiders during 2000 in the CD South study area. The one Spectacled Eider nest in the ground-search area failed to hatch. Since our surveys began on the delta in 1992, we have sighted one Spectacled Eider brood in the CD South study area, and it was using Wet Sedge–Willow Meadow. We conducted aerial surveys for eider broods on the delta only during 1995, so not much effort has been expended to locate eider broods. On the entire delta, only 20 Spectacled Eider brood-rearing groups have been seen since 1992 (Appendix D4). Because eider broods often group, or creche, the total number of actual broods is unknown; however, the average group size was only 3.9 young, suggesting that most of the groups observed on the delta comprised only one or two broods. Most brood-rearing groups were found in Salt-killed Tundra (20% of all locations), Deep Open Water with Islands or Polygonized Margins (20%), Brackish Water (15%), and Wet Sedge–Willow Meadow (15%). Broods appear to be attracted to coastal lakes; most broods (35%) were seen nearest to Brackish Water ($\bar{x}$ = 0.03 km, n = 7), and the mean distance to the coast was 3.3 km (n = 20). In the 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 (Appendix D4). One King Eider brood was seen in 1995 in Aquatic Sedge with Deep Polygons approximately 0.02 km from Brackish Water. The other King Eider brood was found in 1992 in Wet Sedge–Willow Meadow approximately 0.07 km from Deep Open Water without Islands.

TUNDRA SWAN SURVEYS

Background

Tundra Swans arrive on the Colville Delta in mid–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 use the same nest mounds in successive years (Palmer 1976, Monda et al. 1994, Anderson et al. 1999). 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 1976, 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).

Distribution And Abundance

Nesting

During nesting surveys, 179 swans were observed in the CD South study area in 2000 (Table 12, Figure 7). Only 10% of swans observed appeared to be breeding. Ten swan nests were located in the CD South study area during aerial surveys in 2000 (Table 12). Two additional nests were found during ground activities.

The total number of swans observed during nesting surveys in 2000 was somewhat lower than in 1997 and 1998, but was similar to results since 1996 (Table 12). Prior to 1996, fewer than 90 swans were observed during nesting surveys; since 1996, more than 170 swans have been observed. Between 4 and 15% of swans observed annually during surveys appeared to be breeding.

Table 12. Numbers of Tundra Swans and swan nests during nesting aerial surveys in the CD South study area, Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

	Birds		Nests	
Year	Total	Percent Nesting	Total	Density (no./km^2)
2000	179	10	10	0.06
1998	256	7	11	0.07
1997	232	8	11	0.07
1996	174	15	17	0.11
1995	87	15	7	0.04
1993	51	10	3	0.02
1992	72	4	3	0.02

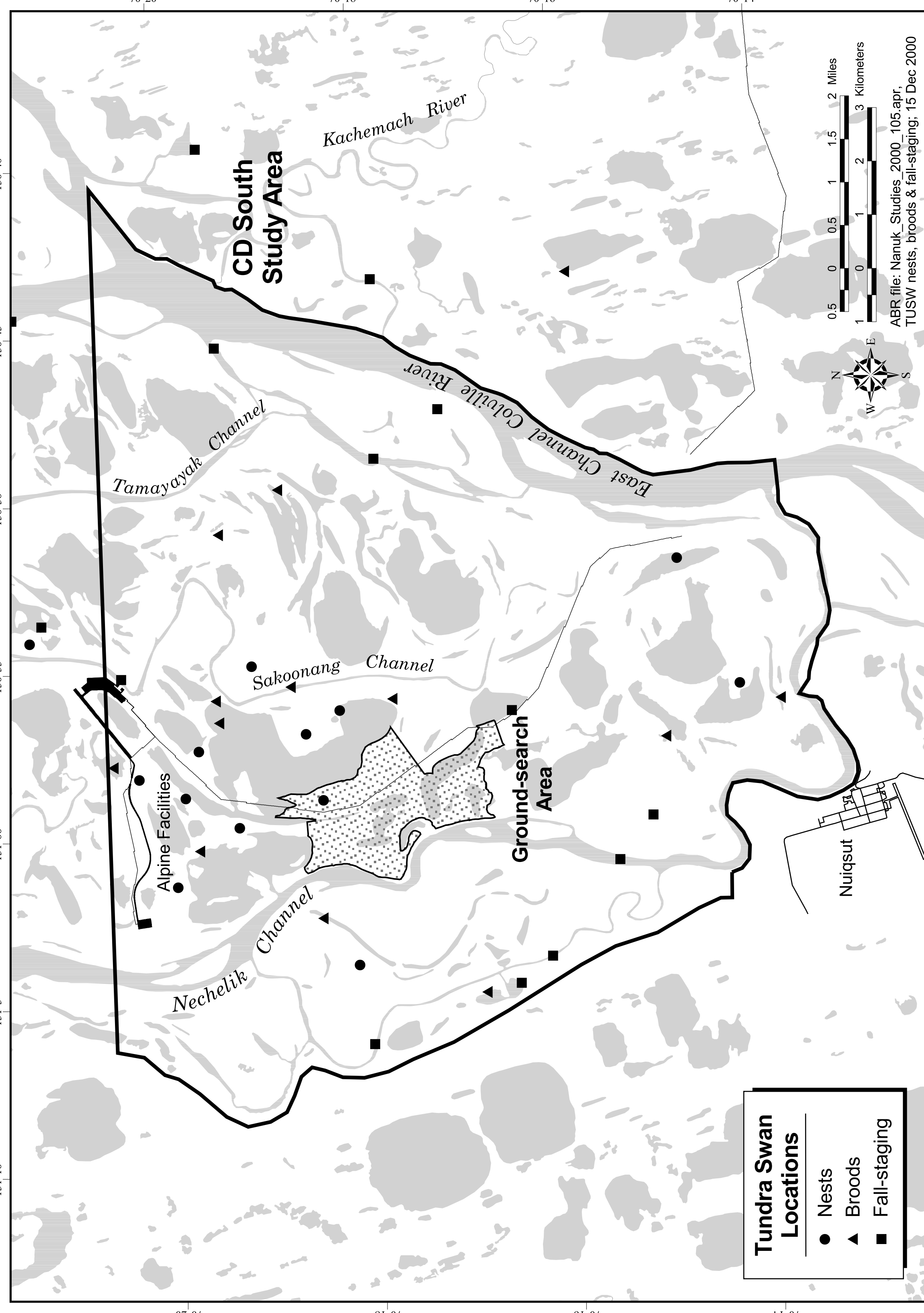


Figure 7. Distribution of Tundra Swan nests, broods, and fall-staging groups in the CD South study area, Colville River Delta, Alaska, 2000.

Table 13. Numbers of Tundra Swans and broods during brood-rearing aerial surveys in the CD South study area, Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

Year	Adults	Young	Total	Percent with Broods	Percent Young	Mean Brood Size	Broods Total	Broods Density (no./km^2)
2000	60	25	85	28	29	2.1	12	0.08
1998	78	16	94	15	17	2.3	7	0.04
1997	56	17	73	18	23	2.4	7	0.04
1996	63	35	98	21	36	3.2	11	0.07
1995	53	17	70	14	24	3.4	5	0.03
1993	57	10	67	10	15	2.5	4	0.03
1992	53	12	65	15	18	2.4	5	0.03

The number of Tundra Swan nests found in the CD South study area has varied from 3 (1992, 1993) to 17 (1996) (Table 12). The high density of nests in 1996 reflected a regional increase in nest numbers in that year (Anderson et al. 1996, Johnson et al. 1997). Nest densities appear to have been relatively stable since 1997. Aerial survey data from previous years indicate that swan nest density within the CD South study area has closely paralleled that estimated for the Colville Delta as a whole (Table 12, Appendix D5, Appendix C6). Annually, since 1992, between 15-38% of swans nesting on the delta have been located within the CD South study area.

A previous investigation on the Colville River Delta found similar densities of Tundra Swans. In 1982, 48 nests (~0.11 nests/km^2) were found on the northern 80% of the delta (Simpson et al. 1982). In other areas of the Arctic Coastal Plain, nest densities were similar to or lower than those for the CD South study area: 0.04–0.06 nests/km^2 on the eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km^2 in the Kuparuk Oilfield and adjacent areas (Anderson et al. 1999).

Brood-Rearing

During brood-rearing, 85 Tundra Swans were observed in the CD South study area, 60 adults and 25 young (Figure 7, Table 13). Twenty-five percent of adults were accompanied by broods. Twelve broods were observed, with a mean brood size of 2.1 (Table 13). The apparent nesting success was 100% (12 nests known/12 broods observed), but this estimate may be inflated by movements of broods into the study area (one nest in the ground-search area was known to have failed). Nonetheless, nesting success appeared to be high in the CD South study area in 2000.

Since 1992, the total number of swans observed in the CD South study area during brood-rearing surveys has ranged from 65 (1992) to 98 (1996) (Table 13). Numbers in 2000 were similar to those in recent seasons. The number of young swans observed has varied somewhat more, from 10 (1993) to 35 (1996), and the number observed in 2000 was the second highest in seven years of surveys. The proportion of adults with broods was higher in 2000 than in any previous year. Similarly, the total number of broods was highest in 2000 (Table 13).

Estimates of apparent nesting success have ranged from 64 to 100% in the CD South study area, although values of more than 100% in 1992 and 1993 indicate that either all nests were not located during aerial and ground surveys or broods from outside the study area moved into the area after hatching and inflated the estimates (Table 12). Although apparent nesting success was high in 2000, the mean brood size was the lowest that has been observed since 1992. Low brood sizes may be attributable to the late initiation of nesting in 2000 due to prolonged snow cover in nesting habitats followed by widespread flooding of the delta. In general, in the CD South study area in 2000, Tundra Swans were present in numbers similar to those observed in recent years but,

Table 14. Numbers of Tundra Swans during fall-staging aerial surveys in the CD South study area, Colville River Delta, Alaska, 1992–1993, 1995–1996, and 2000 (pre-2000 data from Johnson et al. 1999a).

Year	Birds	Groups	Mean Group Size	Range
2000	19	10	1.9	1–3
1998	15	3	3.0	1–5
1997	49	4	12.3	1–39
1996	90	11	8.2	1–39
1995	3	2	1.5	1–2
1993	62	11	5.6	1–20
1992	0	0	–	–

despite what appears to be relatively high nesting success, brood sizes were smaller than has been recorded previously.

Across the entire delta and all seven years of surveys, the number of broods has varied from 14 (1993) to 32 (1996) (Appendix D5, Appendix C7). Estimated nesting success for the whole delta in 2000 was 66% (21 of 32 nests), the lowest value recorded since 1992 (Appendix D5). Nest and brood densities in 2000 were similar to recent seasons, but mean brood size for the whole delta was similar to that in the CD South study area, and the lowest value observed since 1992.

Over the seven years of monitoring on the Colville River Delta and adjacent Arctic Coastal Plain, productivity (as indicated by nesting success, brood density, and mean brood size) on the Colville River Delta has generally been similar to or greater than in other areas. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995–2000) recorded mean brood sizes of 2.0–2.8 young/brood and densities of 0.02–0.04 broods/km² (Anderson et al., in prep.). In 2000, swans in other regions of the coastal plain also experienced low brood sizes, often accompanied by low nesting success. In the Kuparuk Oilfield, nesting success of swans was 64% and mean brood size was 2.0 young (n =53) in 2000, some of the lowest estimates on record there since 1988 (Anderson et al., in prep.).

Two earlier studies on the Colville Delta, both employing intensive ground surveys, also provide comparative data. Rothe et al. (1983) reported nesting success 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 mean 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). Platte and Brackney (1987) estimated 63–85% nesting success, 0.04 broods/km², and 2.5 young/brood on portions of the Arctic National Wildlife Refuge (ANWR) during 1982–1985.

Fall Staging

The fall-staging survey in 2000, was flown on 16 September and covered the Colville River Delta and documented staging areas adjacent to the delta on both the east and west sides. On the CD South study area, 19 tundra swans in 10 groups were observed (Table 14, Figure 7). In general, large numbers of swans have not been found on the CD South study area during fall staging (Table 14).

Across the entire delta during fall staging in 2000, 89 Tundra Swans were observed, 66 adults and 23 young (Appendix D6). The largest flock observed was a flock of 6 without young and all other swans were in pairs with or without broods. An additional 17 Tundra Swans were observed in the Fish Creek area (just west of the Colville River Delta), an area that has been known to be an important staging area in past years. The lack of large staging flocks is attributable to the lateness of the spring and the resulting late hatch of swan nests and late fledging of young; many young still appeared flightless at the time of the fall-staging survey.

Tundra Swans have been widely distributed on the delta during our fall-staging surveys (Appendix C8). However, most swans generally occur in several large flocks that occupy river channels on the outer delta. Wetlands immediately to the east of the delta, lying 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 (Appendix C8). In 1996, we counted 355 swans on the delta and 415 on several lakes just east of the delta. The distribution of swans in 1998 was slightly different from that in other years, in that few swans were seen in the wetlands between Kalubik Creek and the Miluveach River; rather, swans were found primarily in the East Channel of the Colville Delta (e.g., near the mouth of the Miluveach River). We expanded our fall-staging survey area in 1998, flying over the wetlands at the mouths of the Tingmeachsiovik River and Fish Creek, west of the mouth of the Nechelik Channel. We counted 231 swans there in 1998, most within a single group. We had not surveyed this area during previous years, so we do not know whether it is regularly used during fall staging. In 2000, only 17 swans were observed in this area during the fall-staging survey.

Our surveys have confirmed that in some years large numbers of swans stage on or near the Colville River Delta prior to migration, which was previously reported by Campbell et al. (1988). Departure of swans from the delta is variable and dependent on a number of factors, including the timing of nest initiation and weather conditions in the fall. In years with mild fall conditions, such as 1993, both flocks and family groups may remain until some time after our survey. However, freezing temperatures trigger the movement of swans and, in years such as 1992, when swans were able to nest and fledge young early, both nonbreeders and family groups could leave the area despite early freeze-up conditions. In years when nesting is delayed by prolonged snow conditions, such as in 1995 and 2000, and freezing temperatures occur prior to our staging surveys, only family groups may remain on the delta. Early freeze-up combined with delayed nesting may be a source of mortality for cygnets in these years (Monda 1991; R. King, USFWS, pers. comm.).

Habitat Use

Nesting

In the CD South study area, we found 12 nests in 5 habitat types (including two nests found by ground observers, Table 15). Nine were found in preferred habitats (Wet Sedge–Willow Meadow and Moist Sedge–shrub Meadow) and one in an avoided habitat (River or Upland Shrub); two nests were in habitats that were neither preferred nor avoided (Appendix D7). Most swan nests in the CD South study area were found in Wet Sedge–Willow Meadow, which is the single most available habitat (19%) in the delta (Table 3).

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. During seven years of surveys on the delta, swan nests (n = 212) were located in 16 of 24 available habitats (Appendix D7, Appendix C6). Five habitat types were preferred, and eight were avoided. Nearly 40% of nests were located in Wet Sedge–Willow Meadow, a preferred habitat. More than 10% of nests were located in Salt-killed Tundra, a preferred habitat, and Nonpatterned Wet Meadow, which was neither preferred or avoided (i.e., it was used in proportion to its availability). No other

Table 15. Habitat use by nesting and brood-rearing Tundra Swans in the CD South study area, Colville River Delta, Alaska, 2000.

	Nests		Broods	
Habitat Type	No.	Use (%)	No.	Use (%)
Tapped Lake w/ Low-water Connection	0	0	3	25.0
Salt Marsh	1	8.3	1	8.3
Deep Open Water w/o Islands	0	0	1	8.3
Deep Open Water w/ Islands or Polygonized Margins	0	0	1	8.3
River or Stream	0	0	1	8.3
Non-patterned Wet Meadow	1	8.3	0	0
Wet Sedge–Willow Meadow	6	50.0	3	25.0
Moist Sedge–shrub Meadow	3	25.0	0	0
Riverine or Upland Shrub	1	8.3	1	8.3
Barrens (riverine, eolian, lacustrine)	0	0	1	8.3
Total	12	100	12	100

habitat in the delta had more than 8% of Tundra Swan nests.

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. Monda et al. (1994) found that nesting habitat preferences differed between their two study sites, which reflected differences in habitat availability. On the Kongakut delta, 42% of 36 nests were in areas classified as saline graminoid-shrub (probably equivalent to Salt Marsh). On the Canning delta, 52% of 54 nests were in graminoid-marsh (probably equivalent to Aquatic Grass and Aquatic Sedge marshes), 26% were in graminoid-shrub-water sedge (probably equivalent to Wet Sedge–Willow Meadow).

Brood-Rearing

The 12 Tundra Swan broods observed in the CD South study area were found in eight different habitats (Table 15). Six of the 12 broods were observed in preferred habitats, three were found in avoided habitats, and the remaining three broods were found in Wet Sedge–Willow Meadow, a non-selected habitat (Appendix D7).

Across the entire delta, Tundra Swans with broods used a wide range of habitats, occurring in 18 of 24 available habitats (Appendix D7, Appendix C7). Five habitats were preferred and four were avoided. Sixty-five broods were in preferred habitats and 17 broods were in avoided habitats. Preferred habitats were Brackish Water, Tapped Lake with Low-water Connections, Salt Marsh, and Deep Open Water (either with or without islands). Avoided habitats were Tidal Flats, Rivers and Streams, Riverine or Upland Shrub, and Barrens. Avoided habitats are alike in providing few waterbodies for foraging and escape habitat.

The apparent preference for salt-affected habitats (Brackish Water, Salt Marsh, Tidal Flat, Salt-killed Tundra, and Tapped Lake with Low-water Connection) by brood-rearing swans indicates a seasonal change in distribution and habitat preference: 36% of all swan broods on the delta were in salt-affected habitats, compared with only 19% of all nests. Similarly, swan broods on the Kongakut River delta in northeast Alaska used different habitats as the brood-rearing season progressed (Monda et al. 1994), from saline graminoid marsh and aquatic-marsh habitats early in the season to aquatic-marsh habitat later in the season, where swans used both surface and sub-surface foraging. Changes in habitat and foraging methods may be related to nutritive quality of different plants or the increasing 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 river deltas of the Kobuk-Selawik lowlands. On the Colville Delta, swans also favored pondweeds 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 near the Naknek River. Monda et al. (1994) also found that pondweeds were an important component of the diet of swans of 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 suggests similar diets on the Colville Delta.

LOON SURVEYS

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

In 2000, we counted 21 Yellow-billed Loons and 7 nests in the CD South study area during the aerial nesting survey (Figure 8). The number of loons was similar to counts made in 1996, and greater than the number recorded in all other survey years (Table 16). Densities of Yellow-billed Loons ranged from 0.10 to 0.15 birds/km² during our six years of study. Similar densities have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska: Square Lake in the NPR–A (0.14 birds/km²; Derkson et al. 1981) and the Alaktak region south of Smith Bay (0.16 birds/km²; McIntyre 1990). The distribution of Yellow-billed Loons in the CD South study area in 2000 was similar to that recorded on aerial surveys in 1993 and 1995–1998 (Smith et al. 1994; Johnson et al. 1999a), and during ground studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

In 1996–1998 and 2000, we revisited lakes where we had seen Yellow-billed Loon pairs but did not find nests during the initial aerial survey. During these second visits in 1996–1998, we found an additional one to three nests in the CD South study area that either had been missed or were initiated after the first survey. In 2000, we found no additional nests during revisit surveys or during foot surveys in the CD South ground-search area. Our count of seven nests in 2000 was within the range of values (2–10 nests) we have observed in

Table 16. Numbers and densities of loons and their nests and broods during aerial surveys of the CD South study area, Colville River Delta, Alaska, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

	Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
	Number			Density (no./km²)		Number			Number		
Year	Adults	Nests/ Broods[b]	Young	Birds	Nests/ Broods[b]	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
NESTING											
2000	21	7 (7)		0.13	0.04 (0.04)	61	17		15	0	
1998	17	8 (9)		0.11	0.05 (0.06)	26	6		0	0	
1997	18	3 (3)		0.12	0.02 (0.02)	48	12		0	0	
1996	23	7 (10)		0.15	0.04 (0.06)	37	7		0	0	
1995	15	3		0.10	0.02	29	4		7	0	
1993	15	2		0.10	0.01	63	10		10	0	
BROOD-REARING											
2000	13	2	2	0.08	0.01	38	2	2	2	1	2
1998	13	5	7	0.08	0.03	66	18	21	10	5	8
1997	27	2	4	0.17	0.01	65	8	10	12	2	3
1996	20	1	1	0.13	0.01	52	13	17	10	5	8
1995	18	3	5	0.12	0.02	68	6	7	2	0	0
1993	8	1	1	0.05	0.01	13	1	1	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] 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.

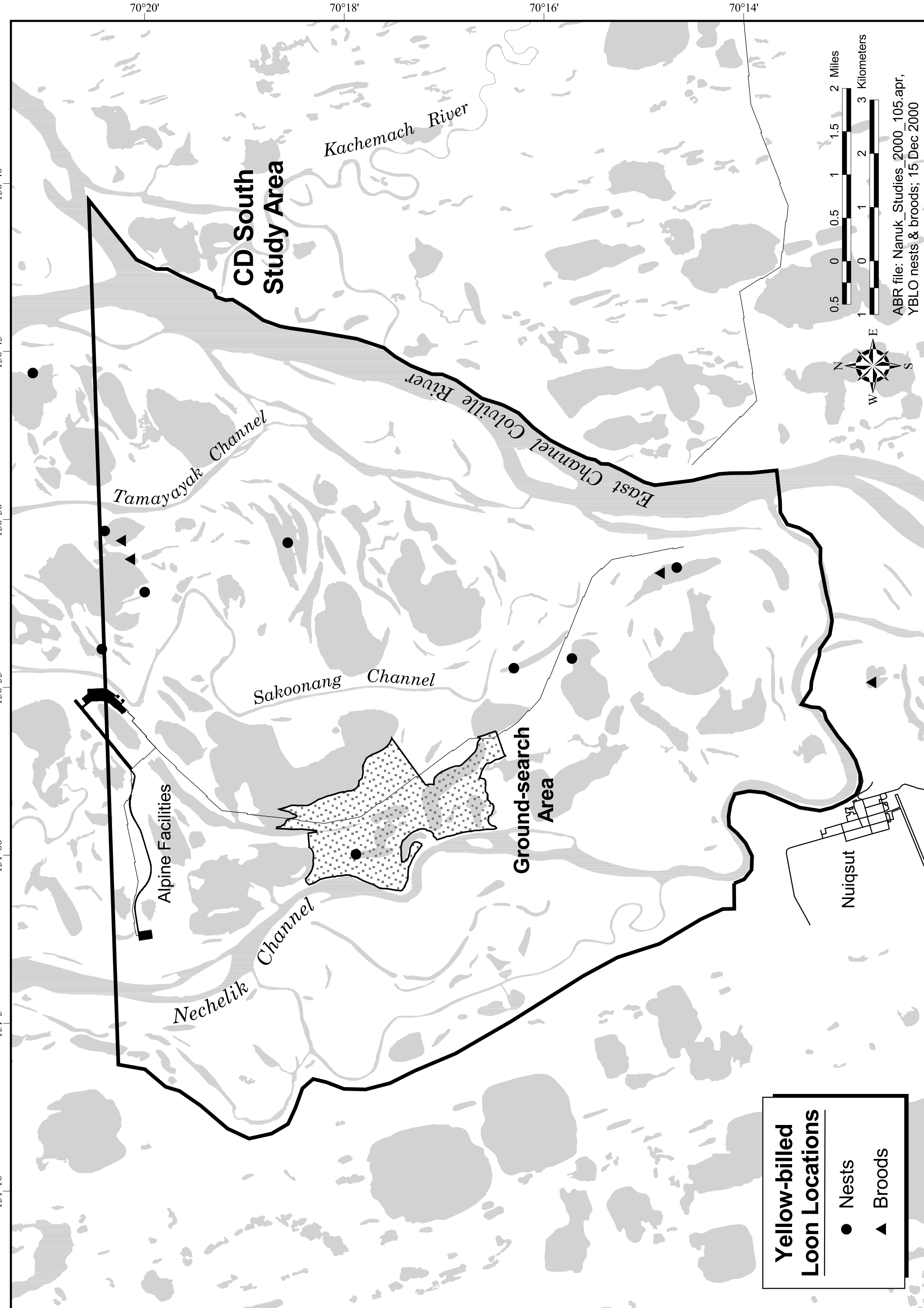


Figure 8. Distribution of Yellow-billed Loon nests and broods in the CD South study area, Colville River Delta, Alaska, 2000.

the five previous years of surveys (Table 16). During intensive ground surveys of the delta in 1983 and 1984, North (1986) found six and eight nests, respectively, in the CD South study area. All seven nests found in 2000 were on lakes where we have recorded nesting by Yellow-billed Loons in previous years (Figure 8, Appendix C9). One of the seven nests found on the aerial survey was within the CD South ground-search area; nesting also occurred in this area in 1995. With the additional nests found during revisit surveys in some years, densities ranged from 0.01–0.06 nests/km².

Seventeen nests of Pacific Loons were located opportunistically during Yellow-billed Loon surveys in 2000; no nests of Red-throated Loons were seen (however, see brood surveys, below) (Table 16). Opportunistic counts of Pacific and Red-throated loons reflect their general distribution in the CD South study area 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 9, Appendix C10). Therefore, we have not calculated densities for these two species. Although our counts are not adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon in the CD South study areas during each year of study (Table 16). 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/km² for Pacific Loons and 0.6 birds/km² for Red-throated Loon (Rothe et al. 1983).

Brood-Rearing

We counted 13 adult Yellow-billed Loons and 2 broods during the brood-rearing survey in the CD South study area in 2000 (Table 16). In previous years, the number of loons has ranged 8 to 27 and the number of broods has ranged from 1 to 5 (Table 16). The density of Yellow-billed Loons during brood-rearing in 2000 was 0.08 birds/km². In other survey years, the density ranged from 0.05 to 0.17 birds/km². North and Ryan (1988, 1989) found that adults with young remain on or near the nest lake during brood-rearing, while non-nesting and failed breeders maintain their territories throughout the summer. Most adult loons seen on the brood-rearing survey in 2000 were found on lakes where nesting occurred either in 2000 or in a previous year.

We saw two Yellow-billed Loon broods in 2000 on the aerial brood survey in the CD South study area (Figure 8). An additional brood was seen in the CD South study area during an intensive waterbird survey on 29 July in the Alpine project area (Johnson et al., in prep.). Brood density in 2000 was 0.01 broods/km² (Table 16; 0.02 broods/km², if the third brood is included). In 1993 and 1995–1998, we counted between one and five broods and densities ranged from 0.01 to 0.03 broods/km² (Table 16). The highest number of Yellow-billed Loon broods recorded in the CD South study area during our six years of surveys was in 1998 when we counted 5 broods and 7 young.

We observed two Pacific and one Red-throated loon brood in the CD South study area on the aerial survey in 2000 (Table 16). Although the numbers of Pacific and Red-throated loons and their broods counted in the CD South study area and across the Colville River Delta (Appendix C12) in 2000 were noticeably lower than in the previous four years, these surveys were not intended to be quantitative for those species. These loon species can rear their young on smaller waterbodies than were surveyed for Yellow-billed Loons so an unknown number of broods were missed. Because survey intensity for these smaller waterbodies varied among years and coverage was never complete, we cannot compare annual abundance or calculate densities for these two species.

Habitat Use

Nesting

Two of seven Yellow-billed Loon nests in the CD South study area in 2000 were located in Nonpatterned Wet Meadow and two were in Wet Sedge–Willow Meadow (Table 17). Three other habitats were used (one nest in each): Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, and Aquatic Sedge with Deep Polygons. Nests were built on peninsulas, shorelines, islands, or in emergent vegetation; the

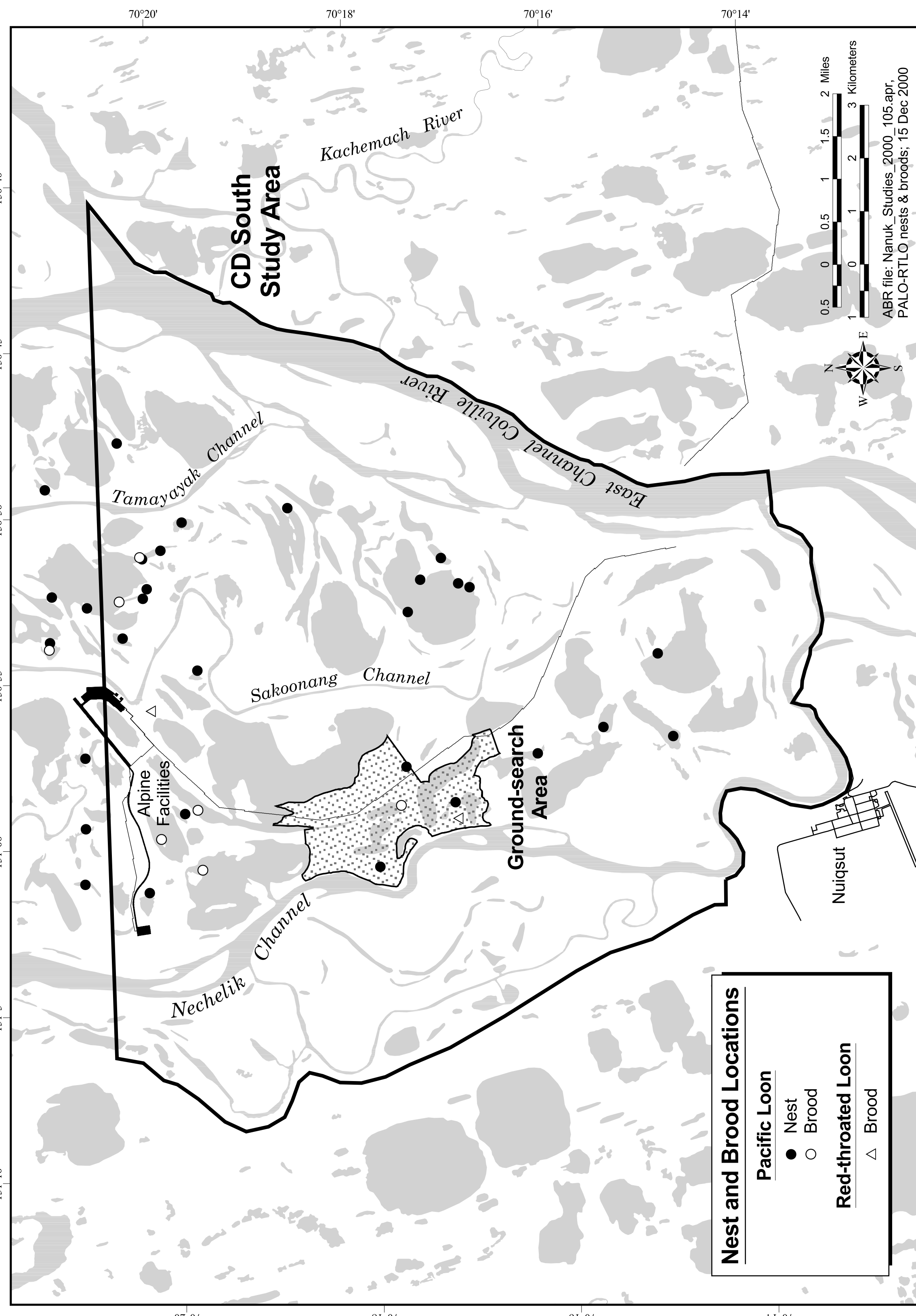


Figure 9. Distribution of Pacific and Red-throated loon nests and broods in the CD South study area, Colville River Delta, Alaska, 2000.

Table 17. Habitat use by nesting Yellow-billed Loons in the CD South study area, Colville River Delta, Alaska, 2000.

Habitat	No. Nests	Use (%)
HABITAT USED		
Deep Open Water w/ Islands or Polygonized Margins	1	14.3
Aquatic Sedge Marsh	1	14.3
Aquatic Sedge w/ Deep Polygons	1	14.3
Nonpatterned Wet Meadow	2	28.6
Wet Sedge–Willow Meadow	2	28.6
Total	7	100
NEAREST WATERBODY HABITAT		
Tapped Lake w/ High-water Connection	1	14.3
Deep Open Water w/o Islands	3	42.9
Deep Open Water w/ Islands or Polygonized Margins	2	28.6
Aquatic Sedge Marsh	1	14.3
Total	7	100

latter two types could be classified as part of a waterbody at the scale of our habitat map.

During six years (1993, 1995–1998, 2000) of aerial surveys on the Colville Delta, 85 Yellow-billed Loon nests were found in 8 of 24 available habitats (Appendix D8). Sixty-two nests (73%) were located in the four preferred habitats: Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, and Wet Sedge–Willow Meadow. Wet Sedge–Willow Meadow was the habitat most frequently used for nesting (40% of all nests), and it was the most abundant habitat on the delta (19% of total area, Table 3). Nesting Yellow-billed Loons significantly avoided five habitats—Tapped Lake with Low-water Connection, Salt-killed Tundra, River or Stream, Riverine or Upland Shrub, and Barrens—that were unused and together occupied a large portion of the delta (37%).

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. Nests found in the CD South study area occurred most commonly near Deep Open Water without Islands (43% of all nests), and Deep Open Water with Islands or Polygonized Margins (29%) (Table 17). Measurements of the distance from the nest to the nearest waterbody were not recorded during aerial surveys, but all nests were close (≤1 m) to water. Other ground-based studies of nesting Yellow-billed Loons on the Arctic Coastal Plain found nests occurring within 2 m of water (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989).

North (1986) found that similar waterbody types were used by nesting Yellow-billed Loons on the Colville Delta in 1983 and 1984. Forty-eight percent of 23 nests occurred on deep-*Arctophila* lakes, 39% were on deep-open lakes, and <1% were on ponds <0.5 ha in size, 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. 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.

Brood-Rearing

In the CD South study area in 2000, we found two Yellow-billed Loon broods in two different habitats: Tapped Lake with High-water Connection and Deep Open Water without Islands. During aerial surveys in 1995–1998, 2000, we found 34 Yellow-billed Loon broods in three habitats on the delta (Tapped Lake with High-water Connection and both types of Deep Open Water), all of which were preferred (Appendix D8, Appendix C11). Deep Open Water without Islands or Polygonized Margins was used by most broods (62%), followed by Tapped Lake with High-water Connection (24%) and Deep Open Water with Islands or Polygonized Margins (15%). 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 by loons 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).

GOOSE SURVEYS

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). Most Brant nests on the delta (>1,100; USFWS, unpubl. data) 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). 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, 1998, 1999a), north of the CD South study area.

Brood-rearing groups of Brant move from nesting areas to salt marshes along the coast from Milne Point in the east to the Tingmeachsiovik River (Smith et al. 1994) in the west, both outside 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), and 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).

Between 1992 and 1998, we conducted aerial surveys for nesting Brant that included the entire outer delta (see Johnson et al. 2000a). During these surveys we recorded 3 colonies/nesting locations in the CD South study area that had 2–4 years of occupation and ranged between 1 and 6 nests, as well as 2 solitary nest locations with only one year of use (Appendix C13). These colonies and nesting locations were all in the northern part of the CD South study area, in the vicinity of the Alpine project area. In 2000, three nests were found in the northern part of the CD South study area during the ground search in the Alpine project area (Johnson et al., in prep.). A thorough analysis of Brant distribution and abundance in the Colville River Delta during the nesting season in 2000 can be found in the report for the CD North study area (Johnson et al. 2000a).

The Colville Delta is a regionally important nesting area for White-fronted Geese (Rothe et al. 1983). In the early 1980s, the USFWS reported that densities of White-fronted Geese and their nests on the Colville River Delta were among the highest recorded on the Arctic Coastal Plain; reported densities were between 1.8–6.28 birds/km² in plots across the delta, and 6.6 nests/ km² at one site on the western delta (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). Since then, nest densities of 2.0–5.0 nests/km² have been reported on the delta in an area searched intensively for goose nests in the Alpine project area (Johnson et. al. 1999b, 2000b). Nest density in the CD South ground-search area was 6.19/km² (Table 5). White-fronted Geese also use the delta for both brood-rearing and staging and are generally distributed throughout the area, principally in lakes and along the river (Johnson et al. 1999a).

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, pers. comm.). On the Colville Delta, occasional nests and small groups of brood-rearing and staging geese have been recorded, all on the outer delta within the CD North study area (Johnson et al. 2000a).

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, although local residents have observed Canada Geese nesting in the NPR–A at least since the 1980s (J. Helmericks, pers. comm.). Since 1997, 1–2 Canada Goose nests have been recorded on the Colville Delta (Johnson et al. 1999a, 2000b; ABR unpubl. data). 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). In each year 1998–2000, one Canada Goose nest was found in the CD South study area during the nest search in the Alpine project area (Johnson et al., in prep).

Distribution And Abundance

Brood-Rearing

Systematic aerial surveys for geese were conducted only during brood-rearing and staging in 2000. Only White-fronted Geese were observed in the CD South study area during brood-rearing in 2000 (Figure 10). In previous surveys of the delta, Brant and Canada Geese were observed in the CD South study area during brood-rearing only in 1997 (Appendix C14 and Appendix C16): 16 Brant (8 adults and 8 goslings) were observed at a single location and one pair of Canada Geese with a brood was also observed. The Brant were located in a lake just southeast of the CD South ground-search area in 2000. 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 the Kuparuk River delta (Anderson et al. 1996, Martin and Nelson 1996, Martin et al. 1997), and as far west as the Tingmeachsiovik River (Smith et al. 1994). The predominant pattern for most Brant is to rear their broods along the coast (Stickney and Ritchie 1996) but many Brant that nest in inland locations rear their broods in small groups (<10 broods) on inland lakes (Stickney 1997). Such inland-breeding Brant represent only a small percentage of all brood-rearing Brant in the region.

During the brood-rearing survey of the CD South study area (50% coverage) in 2000, we saw 425 White-fronted Geese in 4 groups (Figure 10). Group sizes ranged between 16 and 220 birds (Table 18, $\bar{x}$ = 106). Slightly fewer White-fronted Geese were seen in 2000 than in 1998 (528 birds in 9 groups), but we recorded more geese in these two years than in either 1997 (263 geese in 7 groups; 50% coverage) or 1996 (33 geese in 2 groups; 25% coverage) (Table 18).

During fall staging in 2000, 307 White-fronted Geese were observed in the CD South study area in 14 groups that averaged <22 birds (Table 19, Figure 11). More geese were observed in the CD South study area in 1998 (607 geese in 17 groups) and in 1997 (686 geese in 10 groups) than in 2000 (Appendix C17). In 1996, we recorded 181 geese in 8 groups in the CD South study area, but the survey coverage was only 25%. Prior to 1996, we made observations

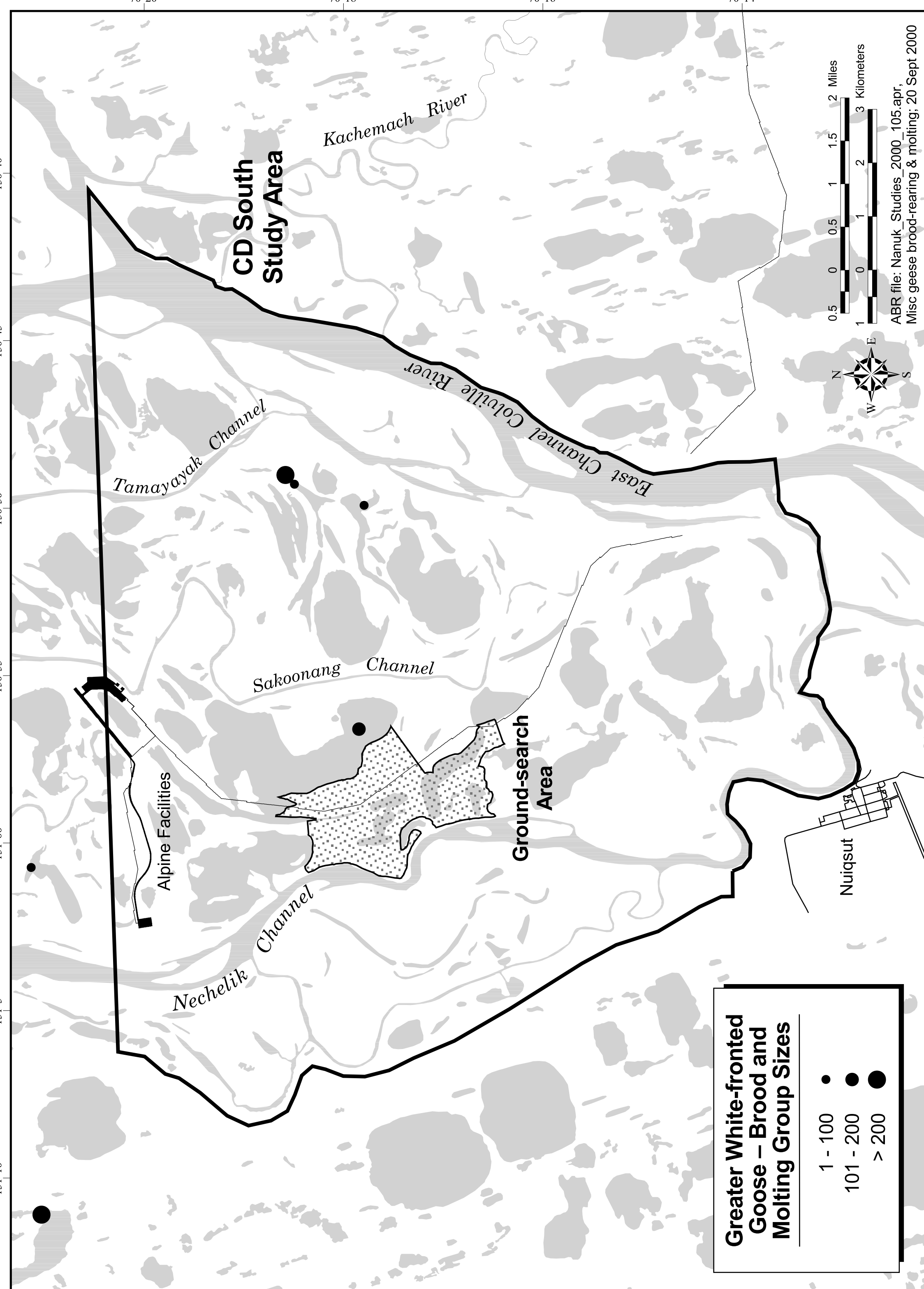


Figure 10. Distribution of brood-rearing and molting groups of Greater White-fronted Geese in the CD South study area, Colville River Delta, Alaska, July 2000.

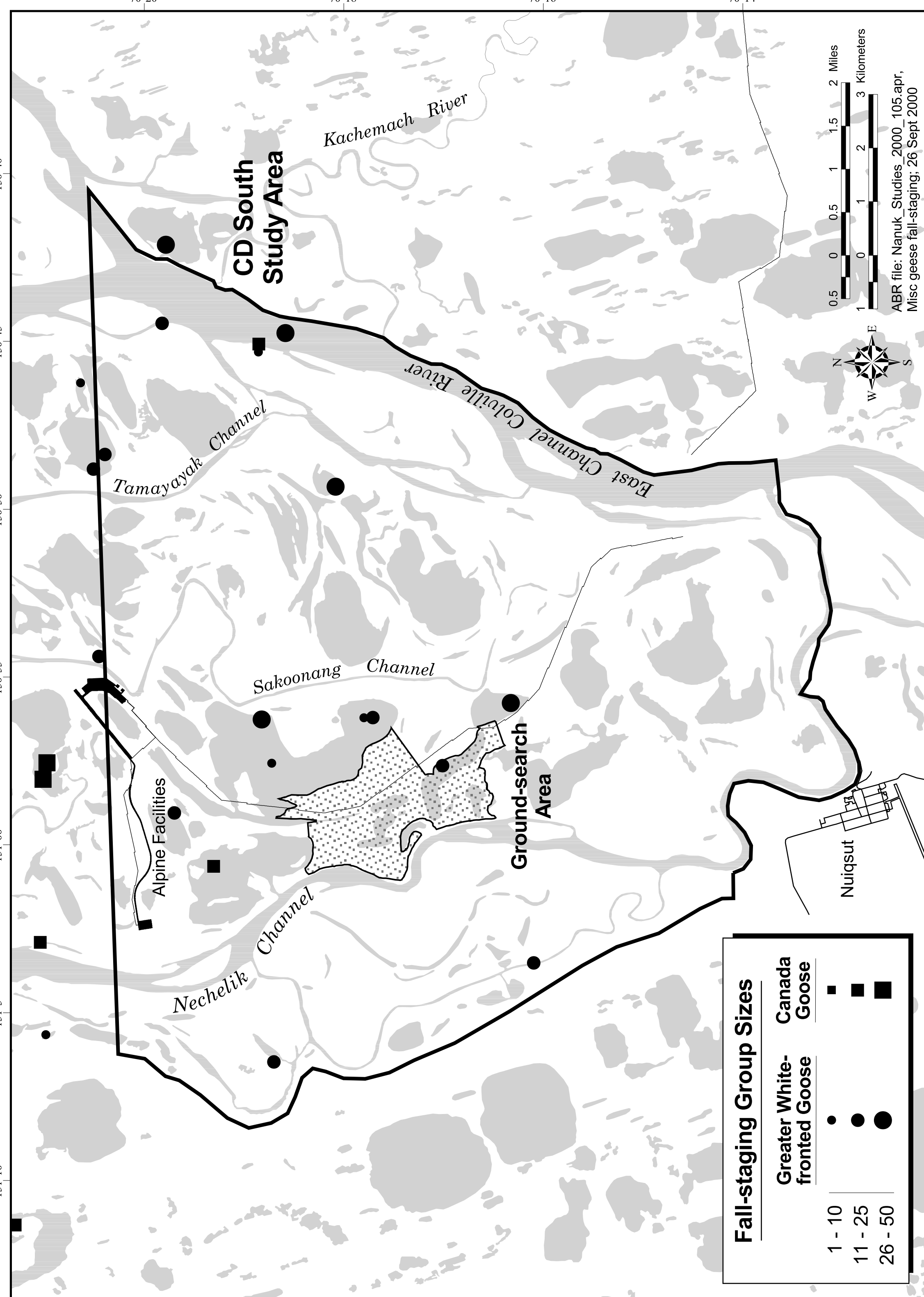


Figure 11. Distribution of fall-staging groups of Greater White-fronted and Canada geese in the CD South study area, Colville River Delta, Alaska, 2000.

Table 18. Numbers of Greater White-fronted Geese during brood-rearing aerial surveys in the CD South study area, Colville River Delta, Alaska, 1996–1998, and 2000 (pre-2000 data from Johnson et al. 1999a). In 1996, survey coverage was 25%; in all other years, coverage was 50% of the study area.

Year	Total Birds	Total Groups	Group size (Range)	Total Goslings	% Groups w/ Goslings
2000	425	4	16-220	91	75
1998	528	9	8-190	266	89
1997	263	7	11–94	24	14
1996	33	2	15–18	15	100

opportunistically during surveys for focal species. Hence, the level of effort devoted to sampling White-fronted Geese varied among years. Counts of fall-staging White-fronted Geese on the delta during 1991, 1992, and 1995, were 84, 20, and 232 geese, respectively. 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.

Goslings comprised only 21% of the total number of White-fronted Geese (91of 425) seen during the aerial survey in 2000 (Table 18). However, one group was a molting group of 220 geese with no young. In previous years (1996–1998), goslings comprised 9–50% of total White-fronted Geese seen during the systematic surveys.

Fall Staging

Two species of geese were recorded in the CD South study area during fall-staging surveys in 2000: Greater White-fronted Geese and Canada Geese. Brant have never been recorded in the CD South study area during fall-staging surveys.

Canada Geese were the only other species of goose observed in the CD South study area during fall staging in 2000; 45 Canada Geese in 2 groups were observed (Table 19, Figure 11). In previous years, we observed 94 Canada Geese in 1998 (50% coverage) and 10 Canada Geese in 1996 (25% coverage) (Table 19, Appendix C17). The only other year that we recorded Canada Geese in the CD South study area was in 1995, when we recorded one group of 6 geese during a loon survey and 75 geese in one group during a Brant staging survey. Variability in numbers among years is probably attributable mainly to differences in the intensity and timing of aerial surveys. Canada Geese occurred in small numbers in the CD South study area relative to coastal areas, including the CD North study area (Johnson et al. 2000a).

Habitat Use

Brant primarily use coastal areas during nesting, brood-rearing, and fall staging and a complete analysis of habitat selection by Brant in the Colville River Delta in 2000 can be found in

Table 19. Numbers of Greater White-fronted Geese and Canada Geese during fall-staging aerial surveys in the CD South study area, Colville River Delta, Alaska, 1996–1998, and 2000 (pre-2000 data from Johnson et al. 1999a). In 1996, survey coverage was 25%; in all other years, coverage was 50% of the study area.

	Greater White-fronted Goose				Canada Goose			
Year	Total Birds	Total Groups	Mean Group Size	Range	Total Birds	Total Groups	Mean Group Size	Range
2000	307	14	21.9	4–40	45	2	22.5	20–25
1998	607	17	35.7	5–150	94	3	31.3	10–70
1997	686	10	68.6	1–500	–	–	–	–
1996	181	8	22.6	7–35	10	1	10.0	–

Table 20. Habitat use by Greater White-fronted Geese during brood-rearing and fall staging in the CD South study area, Colville River Delta, Alaska, 2000.

Habitat Type	Brood-rearing /Molting No. Groups	Brood-rearing /Molting Use (%)	Fall Staging No. Groups	Fall Staging Use (%)
Tapped Lake w/ High-water Connection	3	75.0	4	44.4
Deep Open Water w/o Islands	0	0	1	11.1
River or Stream	0	0	1	11.1
Wet Sedge–Willow Meadow	0	0	0	0
Barrens (riverine, eolian, lacustrine)	1	25.0	3	33.3
Total	4	100.0	9	100.0

the report on the CD North wildlife studies (Johnson et al. 2000a).

Brood-rearing White-fronted Geese in 2000 were generally distributed in the southern half of the study area (Figure 11) and typically occurred in or near water (Table 20): 3 of 4 groups (75%) were observed in Tapped Lake with High-water Connection and the other group occurred in Barrens within a Tapped Lake.

During fall-staging, White-fronted Geese were distributed throughout the CD South study area in a variety of habitats (Table 20). As in the brood-rearing period, staging White-fronted Geese were found primarily in lake habitats (Tapped Lake with High-water Connection, Deep Open Water, and River or Stream) or in Barrens or Wet Sedge–Willow Meadow associated either with Tapped Lakes or the Colville River.

FOX SURVEYS

Background

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are common on the coastal plain. Red foxes are common in the foothills and mountains of the Brooks Range, but are restricted largely to major drainages on the coastal plain (such as the Colville and Sagavanirktok rivers), 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), and dens are occupied from late spring until pups disperse in mid-August (Chesemore 1975). Throughout their circumpolar 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, Johnson et al. 1997). Survival of arctic fox pups to weaning is highest in years when small mammals (primarily lemmings) 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, lemmings and voles are the most important year-round prey, supplemented by carcasses of caribou and marine mammals 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; Roderigues et al. 1994). Before our surveys in recent years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a), 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. We began recording information on fox dens on the Colville River Delta when baseline wildlife studies began there in 1992 (Smith et al. 1993). In 8 years of surveys (none were conducted in 1994) and through contacts with other observers, we have located 62 fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield (Appendix C18). In 2000, 53 dens (85%) were classified as arctic fox dens and the remaining nine dens (15%) were occupied by red foxes; three of the dens used by red foxes were former arctic fox dens. To date, eight dens have been found in the CD South study area; one was found in 1992, one in 1993, five in 1995 (with increased survey effort), and one in 1997. It is possible that additional dens are present in the CD South study area because of the abundance of arctic ground squirrel burrows in dune habitats, which make it difficult to distinguish fox dens.

Distribution and Abundance of Dens

The eight fox dens in the CD South study area (Figure 12) included active and inactive sites of both species (Table 21). Half of the dens were arctic fox sites and half were red fox sites in 2000; one of the red fox sites was an arctic fox den before 1998. In marked contrast to other areas on the outer coastal plain, red fox dens are more common than arctic fox dens in the CD South study area. The annual density of active red fox dens (2–4 dens; Table 22) ranged from 1 den/39 km² to 1 den/78 km². The density of arctic fox dens active annually (0–1 den; Table 22) was very low, at 1 den/156 km² or less. In view of the aforementioned aggressiveness of red foxes toward arctic foxes, it is possible that the relatively high density of red foxes in the CD South area suppresses denning activity by arctic foxes. The highest density of active dens in the CD South study area occurred in 1998, when all 4 red fox dens and 1 arctic fox den were active (Table 22), for a total combined density of 1 den/31 km².

The total density (active and inactive) of fox dens in the CD South study area (156 km²) was 1 den/19 km². The densities of arctic and red fox dens were identical at 1 den/39 km². In contrast, the density of red fox dens in the entire Colville Delta area was 1 den/92 km² (Johnson et al. 2000b); comparative data are unavailable for this species from other arctic tundra areas of Alaska and Canada. The density of arctic fox dens in the CD South study area is slightly higher than the regional average, which was 1 den/26 km² in the combined Colville Delta (551 km²) and Transportation Corridor (343 km²) survey areas (Johnson et al. 2000b). The overall density also was higher than the 1 den/34 km² reported by Eberhardt et al. (1983) for their 1700-km² Colville study area (which extended farther east–west than ours, but not as far inland). However, the overall density of arctic fox dens was lower than those reported for the 805-km² developed area of the Prudhoe Bay Oilfield (1 den/12–15 km²; Eberhardt et al. 1983, Burgess et al. 1993, Roderigues et al. 1994), but was within the range reported for undeveloped areas nearby the Prudhoe field (1 den/28–72 km²; Burgess et al. 1993, Roderigues et al. 1994).

Den Occupancy and Production of Young

The red fox dens in the CD South study area had higher occupancy rates (natal, secondary, and active categories combined) each year than did the arctic fox dens. Two to four red fox dens (50–100%; Table 22) were active each year since 1995 (no red fox dens had yet been found in 1993). The small number of arctic fox dens occupied in the CD South study area makes comparisons with other areas difficult. Since 1993, the occupancy rate of arctic fox dens in the study area ranged from 0 to 50% occupied, but no more than one den has ever been occupied by this species in the study area (Table 22). In their Colville study area, Eberhardt et al. (1983) reported that the percentage of arctic fox dens containing pups ranged from 6% to 55% annually over a 5-year period, whereas 56–67% showed signs of activity by adults alone. Burgess et al. (1993) estimated that between 45% and 58% of the arctic fox 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. In 1993, the occupancy rate by arctic foxes at 49 natural den sites in the Prudhoe Bay Oilfield and surrounding area was 69%, and 53% of the sites were classified as natal dens (Rodrigues et al. 1994). 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 arctic fox dens examined over 5 years were used as natal dens in any one year (Smits and Slough 1993).

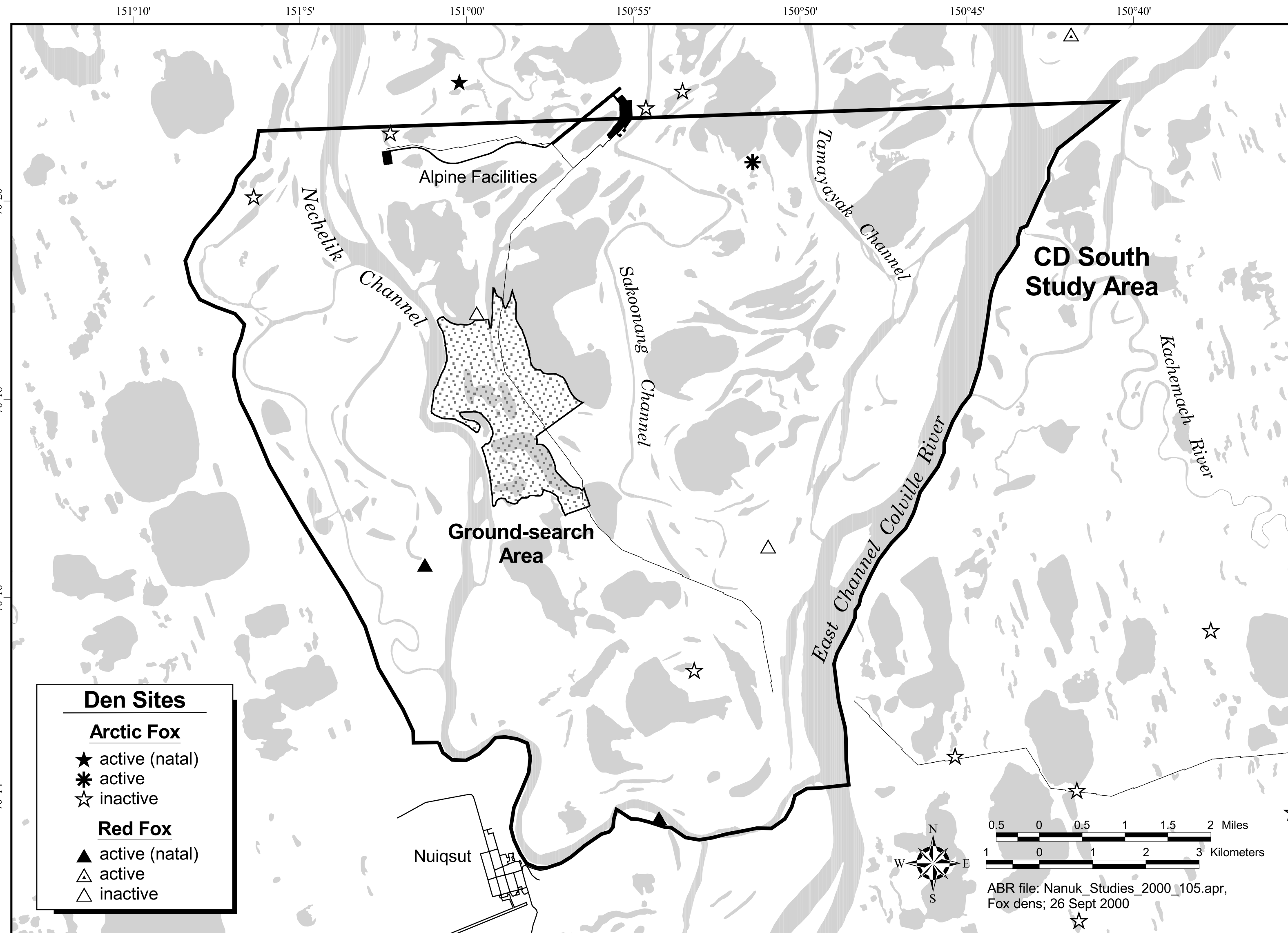


Figure 12. Distribution of arctic and red fox dens in the CD South study area, Colville River Delta, Alaska, 2000. Survey coverage was not uniform over the area portrayed.

Table 21. Annual status and productivity of four arctic fox and four red fox dens in the CD South study area, Colville River Delta, Alaska, 1993 and 1995–2000 (pre-2000 data from Johnson et al. 2000b). Zeroes indicate that dens were observed but no pups were seen; dashes indicate no data.

	2000		1999		1998		1997		1996		1995		1993	
SPECIES Landform	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups
ARCTIC FOX														
old dune	active	0	inactive?	--	inactive	--	inactive?	0	inactive	--	natal	--	natal	3
dune mound	inactive	--	inactive	--	inactive	--	inactive?	--	inactive	--	inactive	0	--	--
low ridge	inactive	--	secondary	4	natal	3	active	0	secondary?	5	secondary?	--	--	--
low mound	inactive	--	inactive	--	natal?	0	inactive	0	--	--	--	--	--	--
RED FOX														
dune/lake bank [a]	inactive?	--	inactive?	0	active	0	inactive?	--	inactive	--	inactive	--	inactive	--
sand dune	inactive	0	natal	2	natal	2	active	0	natal	2	secondary?	0	--	--
dune/river bank	natal	4	natal?	0	natal?	0	inactive	0	natal	1	natal	5	--	--
sand dune	natal	1	natal	2	natal	6	active?	0	natal	5	natal	2	--	--

[a] Arctic fox den until 1998.

Table 22. Number of arctic and red fox dens in each of four categories of occupancy status in the CD South study area, Colville River Delta, Alaska, 1993 and 1995–2000 (pre-2000 data from Johnson et al. 2000b).

SPECIES	2000		1999		1998		1997		1996		1995		1993	
Status	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ARCTIC FOX														
Active natal	0	--	0	--	1	33	0	--	0	--	1	33	1	50
Active secondary	0	--	1	33	0	--	0	--	0	--	0	--	0	--
Active[a]	1	25	0	--	0	--	0	--	0	--	0	--	0	--
Inactive[b]	3	75	2	67	2	67	3	100	3	100	2	67	1	50
Total sample	4		3		3		3		3		3		2	
RED FOX														
Active natal	2	50	2	50	2	50	0	--	3	100	2	67	0	--
Active[a]	0	--	1	25	2	50	2	67	0	--	1	33	0	--
Inactive[b]	2	50	1	25	0	--	1	33	0	--	0	--	0	--
Total sample	4		4		4		3		3		3		0	

[a] Dens showing regular use, but for which natal vs. secondary status, or presence of pups, could not be confirmed.
[b] Dens showing either no signs of activity or limited use by adults, but not pups.

Based on brief visits at all eight fox dens during 28 June–2 July and longer observations at three red fox dens and one arctic fox den during 10–13 July, we concluded that pups were present at a minimum of two dens of red foxes, but not at the arctic fox den (Table 21). We counted five red fox pups at the two natal dens, for a mean litter size of 2.5 pups. Only a single pup was counted at one of the dens, however, it was strongly suspected that more were present. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to obtain a complete count. Red fox dens are more difficult to observe than arctic fox dens because they tend to be located in sand dunes having high topographic relief and tall shrubs that obscure the den entrances and activity areas. In general, our observations at dens have been most successful in obtaining pup counts during early morning and evening, when foxes tend to be most active; litters occasionally can be counted successfully even in midday, however. Estimates of pup production also can be 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 of arctic foxes 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 found no indication that litters were moved between den sites in the CD South area in 2000, however.

Pup production by red foxes in the CD South study area was moderate in 2000; the 5 pups we observed were close to the mean annual total of 5.3 pups we counted in the study area during 1995–2000; the highest production we observed for this species was 8 pups in 1996 and 1998. The mean litter size of 2.5 pups for red foxes in 2000 was near the lower end of the range observed since 1993 (2.0–4.7 pups/litter), although one of the litter counts we obtained was probably incomplete.

Habitat Use

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have relatively deep seasonal thaw layers. Foxes locate dens on raised landforms with well-drained soil; typical locations on the Arctic Coastal Plain include ridges, dunes, lake and stream shorelines, pingos, and low mounds (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993). In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville Delta, the latter species dens almost exclusively in sand dunes. On the Colville Delta and adjacent coastal plain to the east, foxes den in sand dunes (mostly those stabilized by vegetation), banks of streams and lakes (including banks of drained-lake basins), ridges, and pingos (Table 21; Garrott 1980, Eberhardt et al. 1983). Those landforms are usually vegetated with upland shrubs and less commonly with riverine shrubs. Pingos are used commonly as den sites in the Prudhoe Bay area (Burgess et al. 1993), but account for only a small percentage of the known sites in the Colville area (Eberhardt et al. 1983). Low mounds are used most often for den sites in the Teshekpuk Lake area of NPRA west of the Colville Delta (Chesemore 1969). These observations all confirm that the primary requirement for denning habitat is well-drained soil with a texture conducive to burrowing, conditions that occur on elevated microsites within a variety of larger habitat types.

In the CD South study area, the habitat type used most often for denning was Riverine or Upland Shrub (6 of 8 dens, or 75%); only one other habitat type was used—Wet Sedge–Willow Meadow (2 dens). In the CD South area, foxes tend to den in old dunes stabilized by vegetation, occasionally cut by lakes or river channels (Table 21). Because both arctic and red foxes have similar denning requirements and will use the same den sites in different years, we included dens used by both species to analyze habitat selection across the entire Colville Delta (Appendix D9), updating the analysis by Johnson et al. (1999a). Fifteen dens (71% of the total) were located in the Riverine or Upland Shrub type (upland shrub subtype), the only denning habitat that was preferred. Dens in the other habitats used— Barrens (eolian subtype), Moist Sedge–Shrub Meadow, Wet Sedge–Willow Meadow, and Nonpatterned Wet Meadow —actually were located in small patches of higher microrelief that are smaller than the minimal mapping size of habitat areas. Foxes avoided the extensive river bars and mudflats on the delta.

LITERATURE CITED

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

Anderson, B. A., R. J. Ritchie, and A. A. Stickney. 1997. Avian studies in the Kuparuk Oilfield, Alaska, 1996. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks, AK. 93 pp.

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and A. M. Wildman. 1998. Avian studies in the Kuparuk Oilfield, Alaska, 1997. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks. 69 pp.

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and A. M. Wildman. 1999. Avian studies in the Kuparuk Oilfield, 1998. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks, AK. 100 pp.

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and A. M. Wildman. 2000. Avian studies in the Kuparuk Oilfield, 1999. Final report prepared for PHILLIPS Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks, AK. 91 pp.

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

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

Bailey, A. M. 1948. Birds of arctic Alaska. Colorado Museum of Natural History, Popular Series, No. 8. 317 pp.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Third Edition. The Stackpole Company, Harrisburg, PA. 540 pp

Bergman, R. D., and D. V. Derksen. 1977. Observations on Arctic and Red-throated loons at Storkersen Point, Alaska. Arctic 30: 41–51.

Bergman, R. D., R. L. Howard, K. F. Abraham, and M. W. Weller. 1977. Waterbirds and their wetland resources in relation to oil development at Storkersen Point, Alaska. U.S. Fish and Wildlife Service Resource Publication. No. 129. 38 pp.

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

Burgess, R. M. 2000. Arctic fox. Chapter 8. Pages 159–178 *in* J. C. Truett and S. R. Johnson, eds. The Natural History of an Arctic Oil Field: Development and the Biota. Academic Press, San Diego.

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

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

Chesemore, D. L. 1968. Notes on the food habits of arctic foxes in northern Alaska. Canadian Journal of Zoology 46: 1127–1130.

Chesemore, D. L. 1969. Den ecology of the arctic fox in northern Alaska. Canadian Journal of Zoology 47: 121–129.

Chesemore, D. L. 1975. Ecology of the arctic fox (*Alopex lagopus*) in North America—a review. Pages 143–163 *in* M. W. Fox, ed. The wild canids: their systematics, behavioral ecology, and evolution. Van Nostrand Reinhold Co., NY. 508 pp.

Dau, C. P. 1974. Nesting biology of the Spectacled Eider *Somateria fischeri* (Brandt) on the Yukon-Kuskokwim Delta. M. S. thesis, Univ. Alaska, Fairbanks. 72 pp.

Dau, C. P. and S. A. Kistchinski. 1977. Seasonal movements and distribution of the Spectacled Eider. Wildfowl 28: 65–75.

Day, R. H. 1998. Predator populations and predation intensity on tundra-nesting birds in relation to human development. Report prepared for Northern Alaska Ecological Services, U.S. Fish and Wildlife Services, Fairbanks, by ABR, Inc., Fairbanks, AK. 106 pp.

Derksen, D.V. and W. D. Eldridge. 1980. Drought-displacement of pintails to the Arctic Coastal Plain, Alaska. J. Wildl. Manage. 44:224–229.

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

Derksen, D. V., T. C. Rothe, and W. D. Eldridge. 1981. Use of wetland habitats by birds in the National Petroleum Reserve–Alaska. U.S. Fish and Wildlife Service Resour. Publ. No. 141. 25 pp.

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

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

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

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

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

Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. Stackpole Company, Harrisburg, PA. 922 pp.

Garner, G. W., and P. E. Reynolds. 1986. Birds. Pages 68–195 *in* G. W. Garner and P. E. Reynolds, eds. Arctic National Wildlife Refuge coastal plain resource assessment, final report—baseline study of fish, wildlife, and their habitats. Vol. 1. U.S. Fish and Wildlife Service, Anchorage, AK.

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

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

Garrott, R. A., L. E. Eberhardt, and W. C. Hanson. 1983a. Arctic fox den identification and characteristics in northern Alaska. Canadian Journal of Zoology 61: 423–426.

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

Garrott, R. A., L. E. Eberhardt, and W. C. Hanson. 1984. Arctic fox denning behavior in northern Alaska. Canadian Journal of Zoology 62: 1636–1640.

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

Haefner, J. W. 1996. Modeling biological systems: principles and applications. Chapman and Hall, New York, NY. 473 pp.

Hawkins, L. L. 1983. Tundra Swan study, 1983 progress report. U.S. Fish and Wildlife Service, Anchorage, AK. 6 pp.

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

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

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2000a. CD North Wildlife Studies, 2000. Draft report prepared for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks.

Johnson, C. B., M. T. Jorgenson, R. M. Burgess, B. E. Lawhead, J. R. Rose, and A. A. Stickney. 1996. Wildlife studies on the Colville River Delta, Alaska, 1995. Fourth annual report prepared for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 154 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1997. Wildlife studies on the Colville River Delta, Alaska, 1996. Fifth annual report prepared for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 139 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1998. Wildlife studies on the Colville River Delta, Alaska, 1997. Sixth annual report prepared for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 144 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, J. E. Roth, S. F. Schlentner, A. A. Stickney, and A. M. Wildman. 2000b. Alpine Avian Monitoring Program, 1999. Second annual report prepared for PHILLIPS Alaska, Inc., Anchorage, and Anadarko Petroleum Corporations by ABR, Inc., Fairbanks, AK. 86 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1999a. Wildlife studies on the Colville River Delta, Alaska, 1998. Seventh annual report prepared for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks. 102 pp.

Johnson, C. B., W. B. Lentz, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1999b. Alpine Avian Monitoring Program, 1998. First annual report prepared for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 46 pp.

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

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

Jorgenson, M. T., J. E. Roth, E. R. Pullman, R M. Burgess, M. Raynolds, A. A. Stickney, M. D. Smith, and T. Zimmer. 1997. An ecological land survey for the Colville River Delta, Alaska, 1996. Final report prepared for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 160 pp.

Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon-Kuskokwim Delta, Alaska. Arctic 44: 177–187.

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

King, J. G., and J. I. Hodges. 1980. A correlation between *Cygnus columbianus columbianus* territories and water bodies in western Alaska. Pages 26–33 *in* G. V. T. Matthews and M. Smart, eds. Proceedings of the Second International Swan Symposium, Sapporo, Japan. IWRB, Slimbridge, England.

Kistchinski, A. A., and V. E. Flint. 1974. On the biology of the Spectacled Eider. Wildfowl 24: 5–15.

Larned, W. W., and T. Tiplady. 1997. Late winter population and distribution of Spectacled Eiders (*Somateria fischeri*) in the Bering Sea. U.S. Fish and Wildlife Service, Anchorage, AK. 11 pp.

Larned, W. W., T. Tiplady, R. Platte, and R. Stehn. 1999. Eider breeding population survey, Arctic Coastal Plain, Alaska. U.S. Fish and Wildlife Service, Anchorage, AK. 22 pp.

Lawhead, B. L., and C. B. Johnson. 2000. Surveys of caribou and muskoxen in the Kuparuk-Colville region, Alaska, 1999, with a summary of caribou calving distribution since 1993. Final report prepared for PHILLIPS Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks. 30 pp.

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

Macpherson, A. H. 1969. The dynamics of Canadian arctic fox populations. Canadian Wildlife Service Report Series, No. 8. 52 pp.

Manly, B. F. J. 1997. Randomization, bootstrap and Monte Carlo methods in biology. 2nd Edition. Chapman & Hall, London. 399 pp.

Martin, P. D., and B. Nelson. 1996. Distribution and movement of Brant (*Brant bernicla nigricans*) in the central North Slope of Alaska. U.S. Fish and Wildlife Service, Fairbanks, AK. 25 pp.

Martin, P. D., and T. Obritschkewitsch, B. A. Anderson, A. A. Stickney. 1997. Site fidelity and movements of brood-rearing Brant in the oil fields of northern Alaska. Poster presented at the 7th Alaska Bird Conference, 1–3 December 1997, Anchorage, AK.

McIntyre, J. W. 1990. Surveys for Yellow-billed Loons in arctic Alaska during the breeding season 1989 following the Exxon Valdez oil spill. Report to National Geographic Society 19 pp.

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

Meehan, R., and T. W. Jennings. 1988. Characterization and value ranking of waterbird habitat on the Colville River Delta, Alaska. U.S. Fish and Wildlife Service, Anchorage, AK. 105 pp.

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

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

Monda, M. J., J. T. Ratti, and T. R. McCabe. 1994. Reproductive ecology of Tundra Swans on the Arctic National Wildlife Refuge, Alaska. Journal Wildlife Management 58: 757–773.

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

Nickles, J. R., R. Field, J. Parker, R. Lipkin, and J. Bart. 1987. Bird–habitat associations on the North Slope, Alaska. Progress report, Fiscal Year 1986. U.S. Fish and Wildlife Service, Anchorage, AK. 96 pp.

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

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

North, M. R., and M. R. Ryan. 1989. Characteristics of lakes and nest sites used by Yellow-billed Loons in Arctic Alaska. Journal of Field Ornithology 60: 296–304.

North, M. R., J. L. Schwerin, and G. A. Hiemenz. 1984. Waterbird studies on the Colville River Delta, Alaska: 1984 summary report. U.S. Fish and Wildlife Service, Anchorage, AK. 18 pp.

Palmer, R. S., ed. 1976. Handbook of North American birds. Vol. 2. Yale Univ. Press, New Haven, CT. 567 pp.

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

Renken, R., M. R. North, and S. G. Simpson. 1983. Waterbird studies on the Colville River Delta, Alaska: 1983 summary report U.S. Fish and Wildlife Service, Anchorage, AK. 19 pp.

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

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

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

Roderigues, R., R. O. Skoog, and R. H. Pollard. 1994. Inventory of arctic fox dens in the Prudhoe Bay Oilfield, Alaska. Report prepared for BP Exploration (Alaska) Inc., Anchorage, by LGL Alaska Research Associates, Anchorage. 25 pp. + appendix.

Rothe, T. C., C. J. Markon, L. L. Hawkins, and P. S. Koehl. 1983. Waterbird populations and habitat analysis of the Colville River Delta, Alaska: 1981 summary report U.S. Fish and Wildlife Service, Anchorage, AK. 131 pp.

Sage, B. L. 1971. A study of White-billed Divers in Alaska. Brit. Birds 64: 519–528.

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

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

Simpson, S. G. 1983. White-fronted Geese on the Colville River Delta, Alaska: 1983 Progress report U.S. Fish and Wildlife Service, Anchorage, AK. 3 pp.

Simpson, S. G., J. Barzen, L. Hawkins, and T. Pogson. 1982. Waterbird studies on the Colville River Delta, Alaska: 1982 summary report U.S. Fish and Wildlife Service, Anchorage, AK. 24 pp.

Simpson, S. G., and T. Pogson. 1982. White-fronted Goose nesting and productivity, Colville River Delta—1982. U.S. Fish and Wildlife Service, Anchorage, AK. 5 pp.

Sjolander, S., and G. Agren. 1976. Reproductive behavior of the Yellow-billed Loon, *Gavia adamsii*. Condor 78: 454–463.

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

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

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

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

Spindler, M. A., and K. F. Hall. 1991. Local movements and habitat use of Tundra or Whistling Swans (*Cygnus columbianus*) in the Kobuk-Selawik lowlands of northwest Alaska. Wildfowl 42: 17–32.

Stehn, R. A., C. P. Dau, B. Conant, and W. I. Butler, Jr. 1993. Decline of Spectacled Eiders nesting in western Alaska. Arctic 46: 264–277.

Stickney, A. A. 1997. Brant use of the Oliktok LRRS and movements in the Kuparuk Oilfield. Final report prepared for U. S. Air Force, 611 Civil Engineer Squadron, Elmendorf AFB, by Alaska Biological Research, Inc., Fairbanks. 30 pp.

Stickney, A. A., and R. J. Ritchie. 1996. Distribution and abundance of Brant (*Branta bernicla*) on the central Arctic Coastal Plain of Alaska. Arctic 49: 44–52.

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

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

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

Strand, O., T. Skogland, and T. Kvam. 1995. Placental scars and estimation of litter size: An experimental test in the arctic fox. Journal of Mammalogy 76: 1220–1225.

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

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

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

USFWS (U.S. Fish and Wildlife Service). 1987a. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. Migratory Bird and Habitat Res. Lab., Patuxent Wildlife Res. Center, Laurel, MD. 96 pp.

USFWS. 1987b. Trumpeter and Tundra swan survey protocol update. Office of Migratory Bird Management, Juneau, AK. 8 pp.

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

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

Walker, H. J. 1978. Lake tapping in the Colville River Delta, Alaska. Pages 233–238 *in* Proceedings of the 3rd International Conference on Permafrost, Vol. 1. Nat. Res. Council Canada, Edmonton, AB.

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

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

Warnock, N. D., and D. M. Troy. 1992. Distribution and abundance of Spectacled Eiders at Prudhoe Bay, Alaska: 1991. Prepared for BP Exploration (Alaska) Inc., Anchorage by Troy Ecological Research Associates, Anchorage, AK.

Wilk, R. J. 1988. Distribution, abundance, population structure, and productivity of Tundra Swans in Bristol Bay, Alaska. Arctic 41:288–292.

Appendix A. Common and scientific names of birds and mammals observed on the Colville River Delta, Alaska, 1992–2000.

BIRDS

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

MAMMALS

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

Appendix B1. Descriptions of wildlife habitat types found on the Colville River Delta, Alaska, 2000.

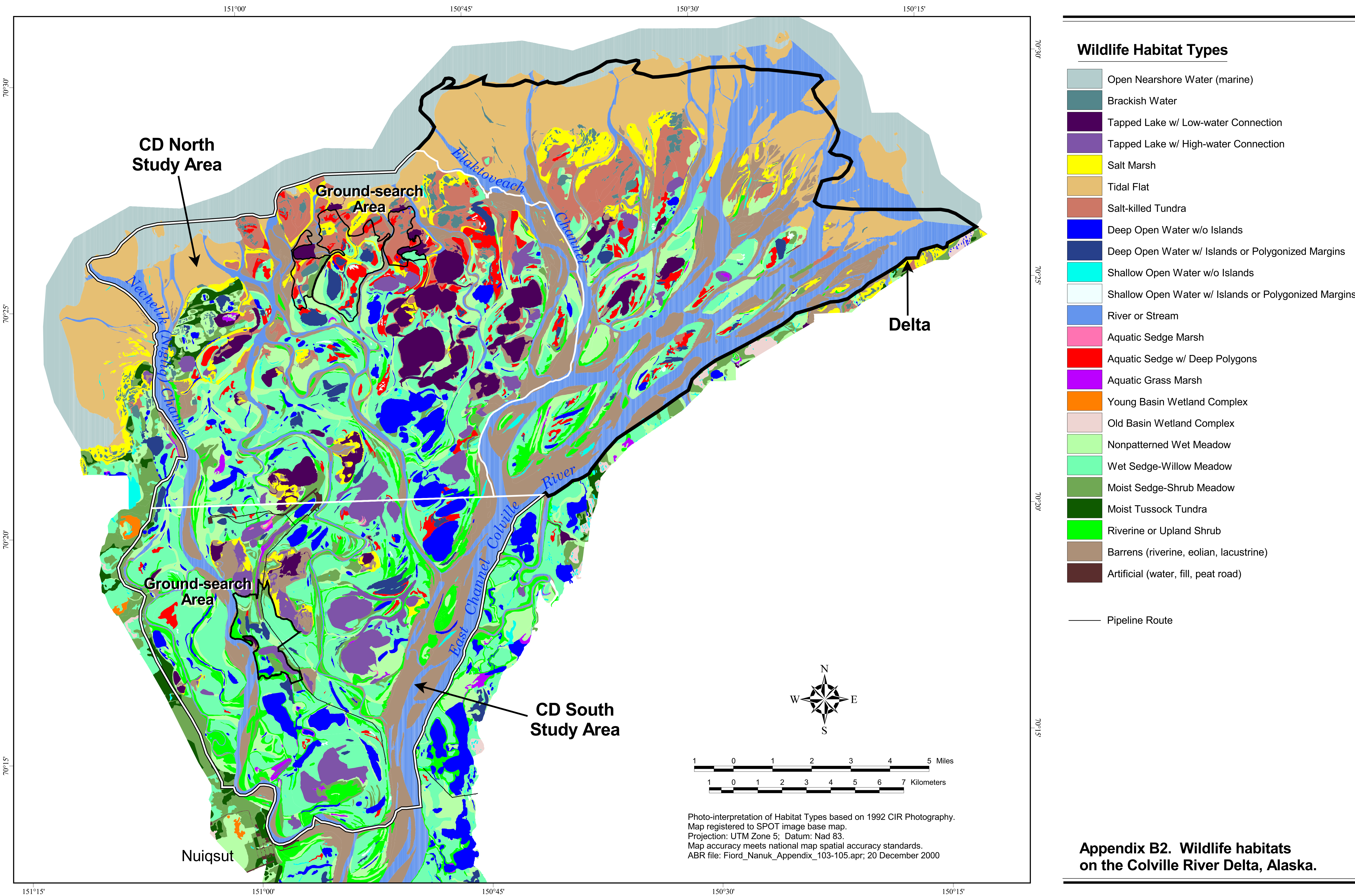
Habitat	Description
Open Nearshore Water (Marine)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced 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 C*arex 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 B1. (Continued)

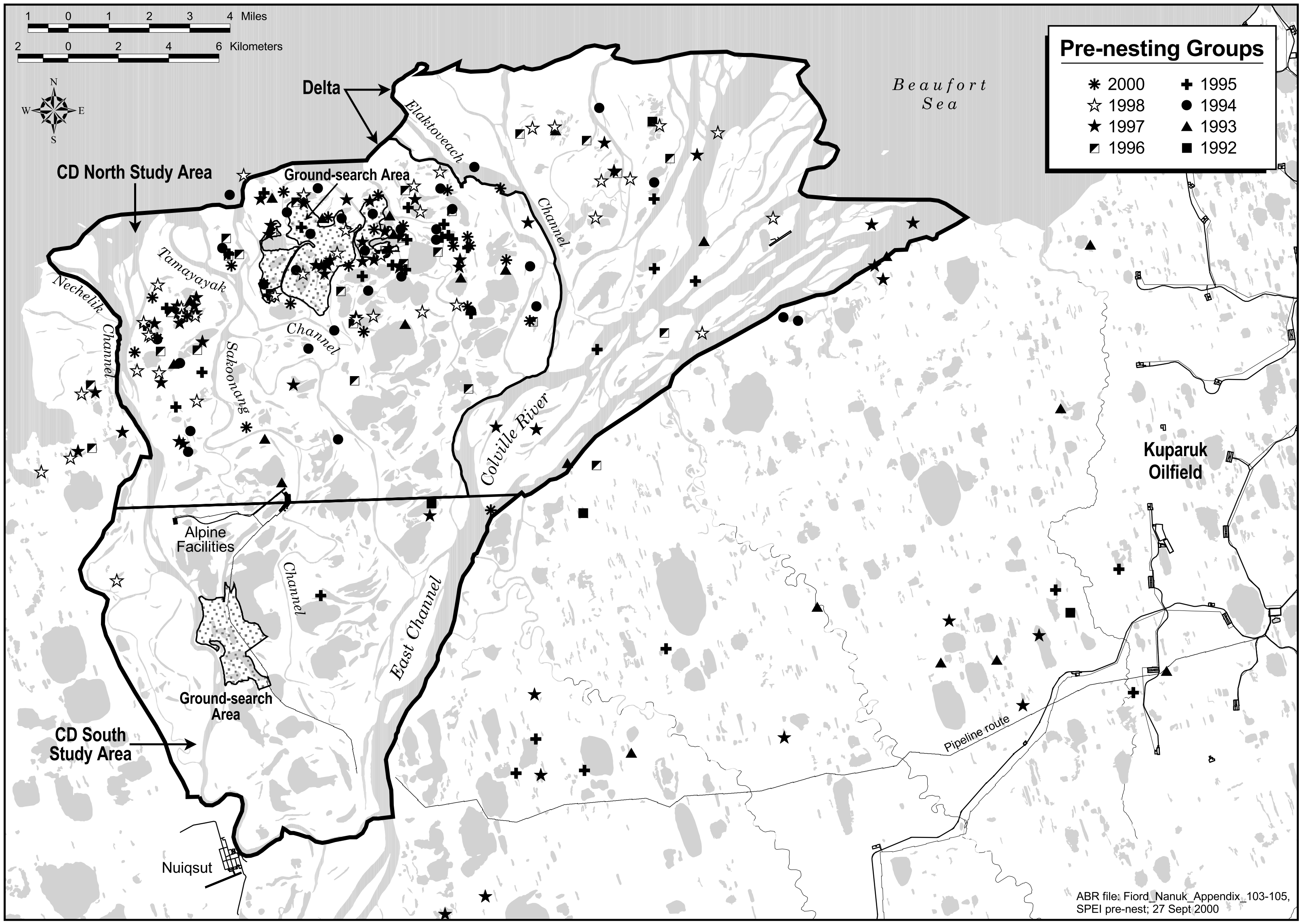
Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many species of waterbirds.
Shallow Open Water 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.
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.

Appendix B1. (Continued)

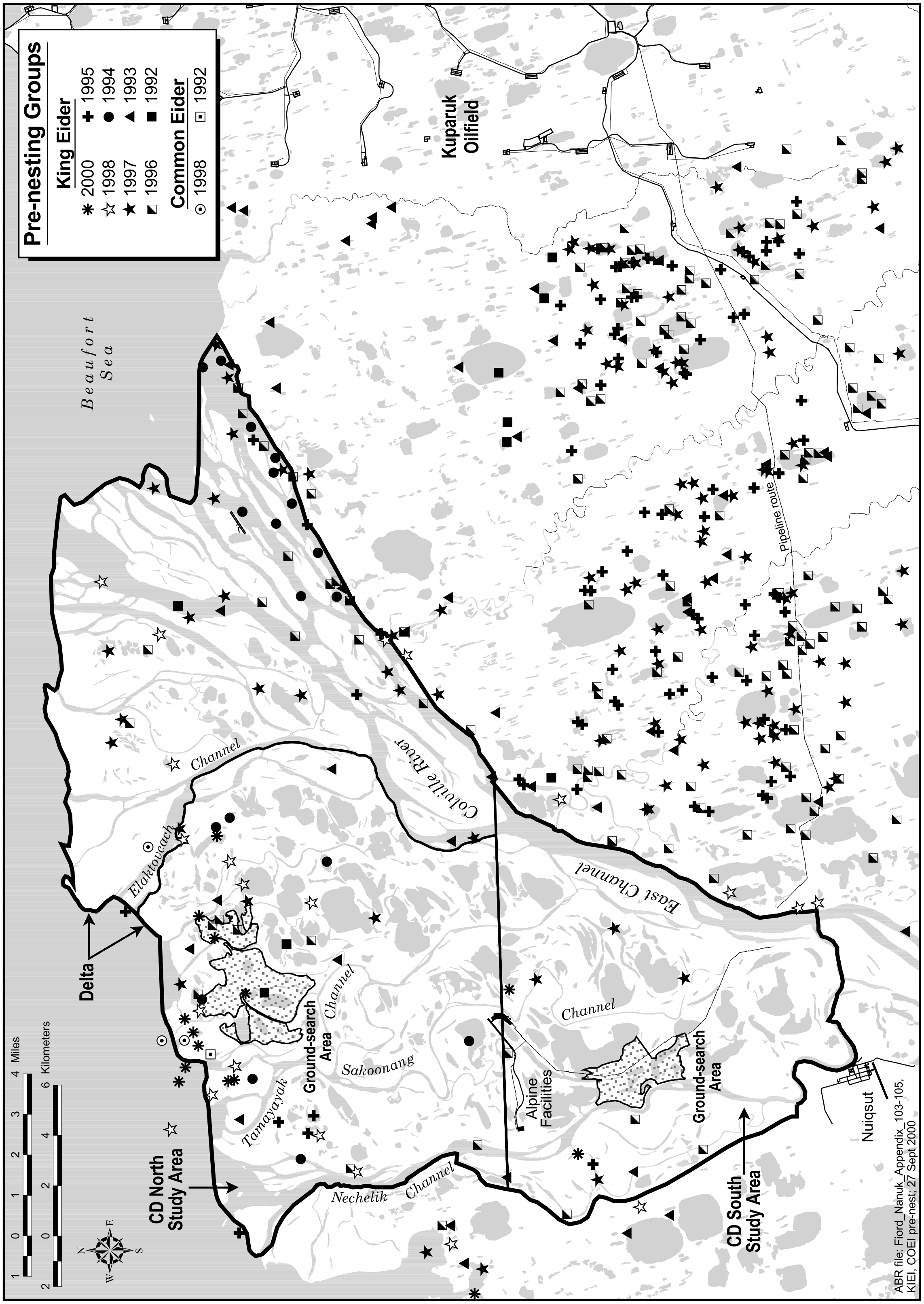
Habitat	Description
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strangmoor cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. The uninterrupted movement of water and dissolved nutrients in nonpatterned ground results in more robust growth of sedges than in polygonized habitats. *Carex aquatilis* and *Eriophorum angustifolium* usually dominate, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata, S. arctica,* and *S. planifolia*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying fine-grained silt.
Wet Sedge–Willow Meadow	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.
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.



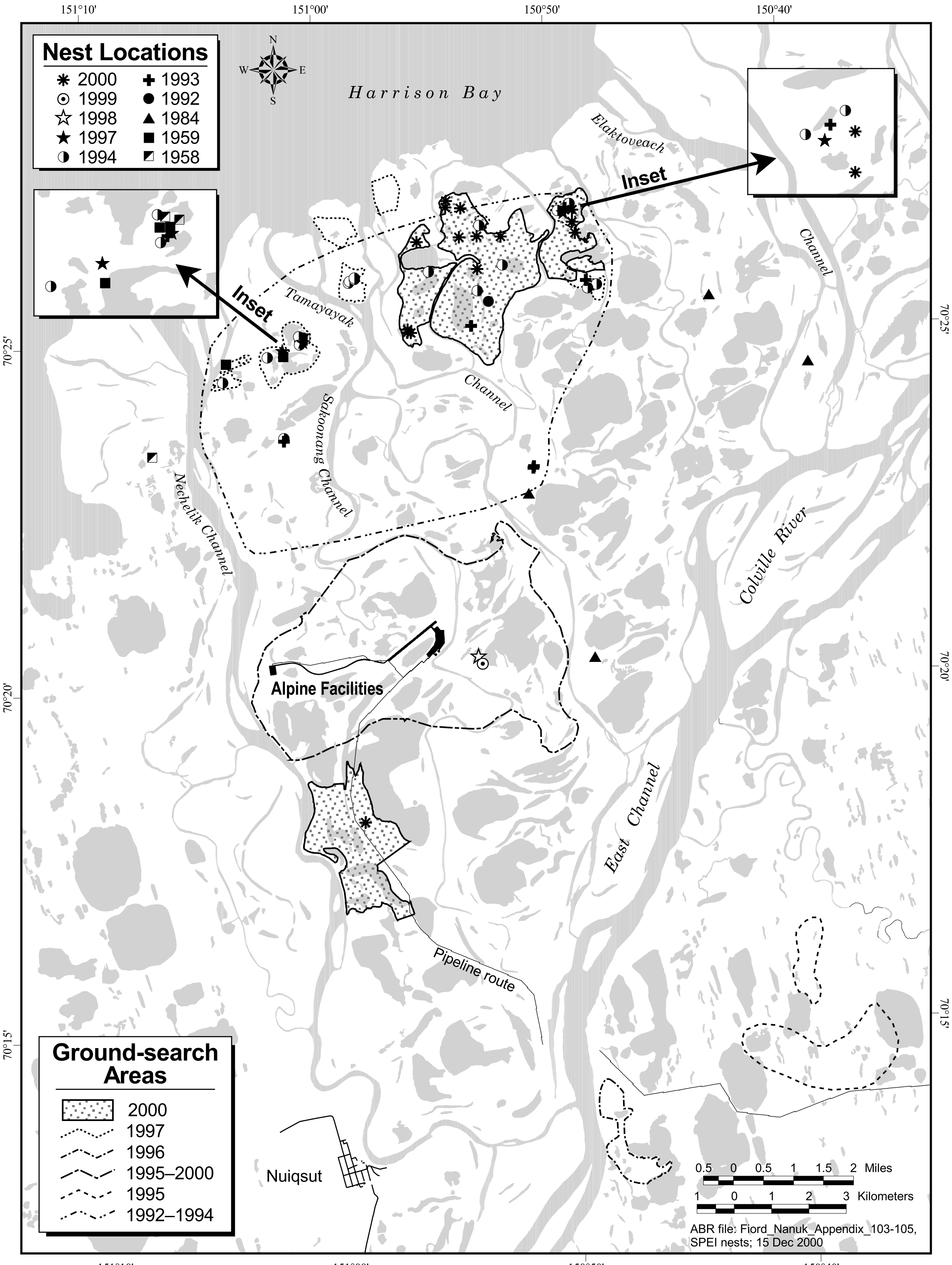
Appendix B2. Wildlife habitats on the Colville River Delta, Alaska.



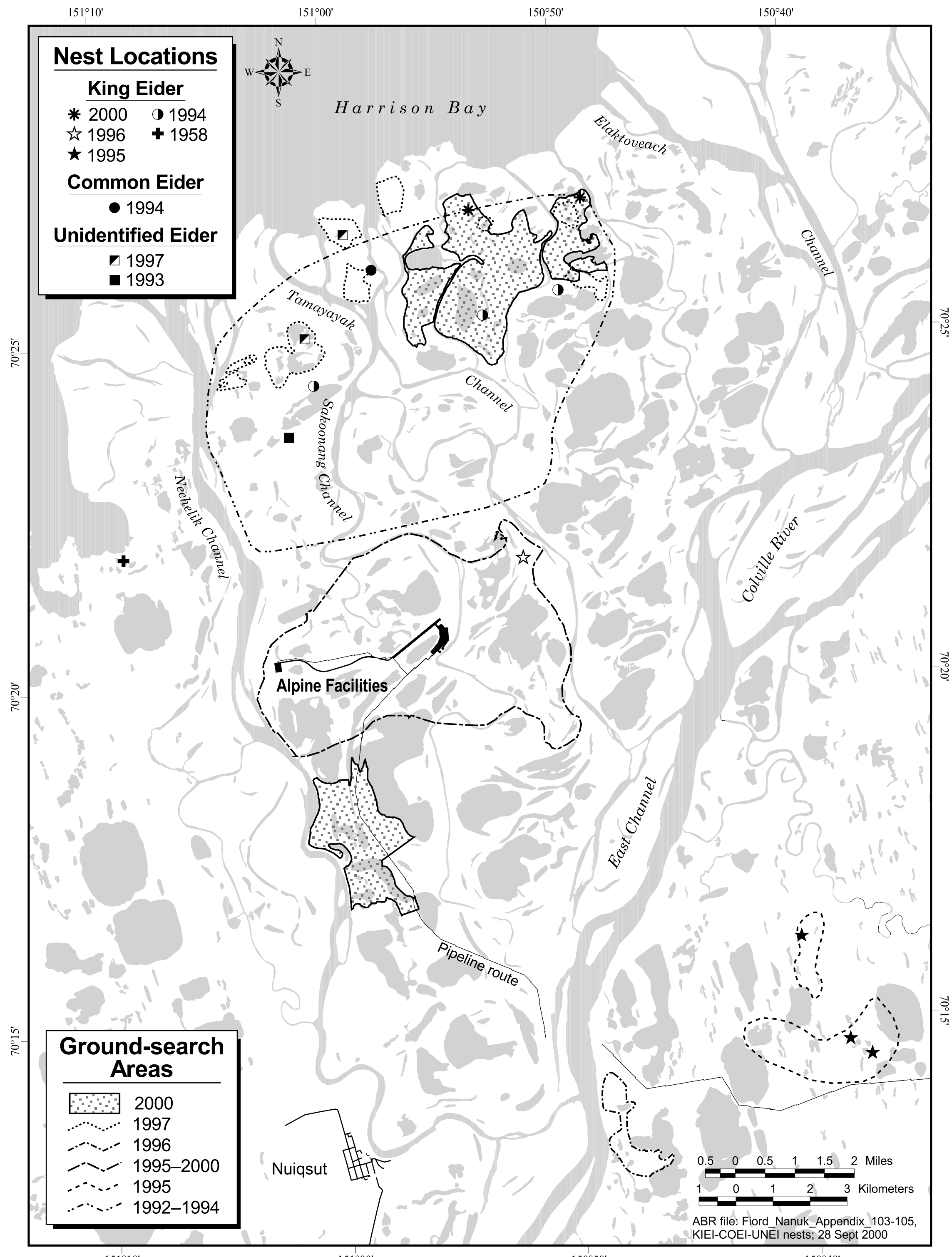
Appendix C1. Distribution of Spectacled Eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).



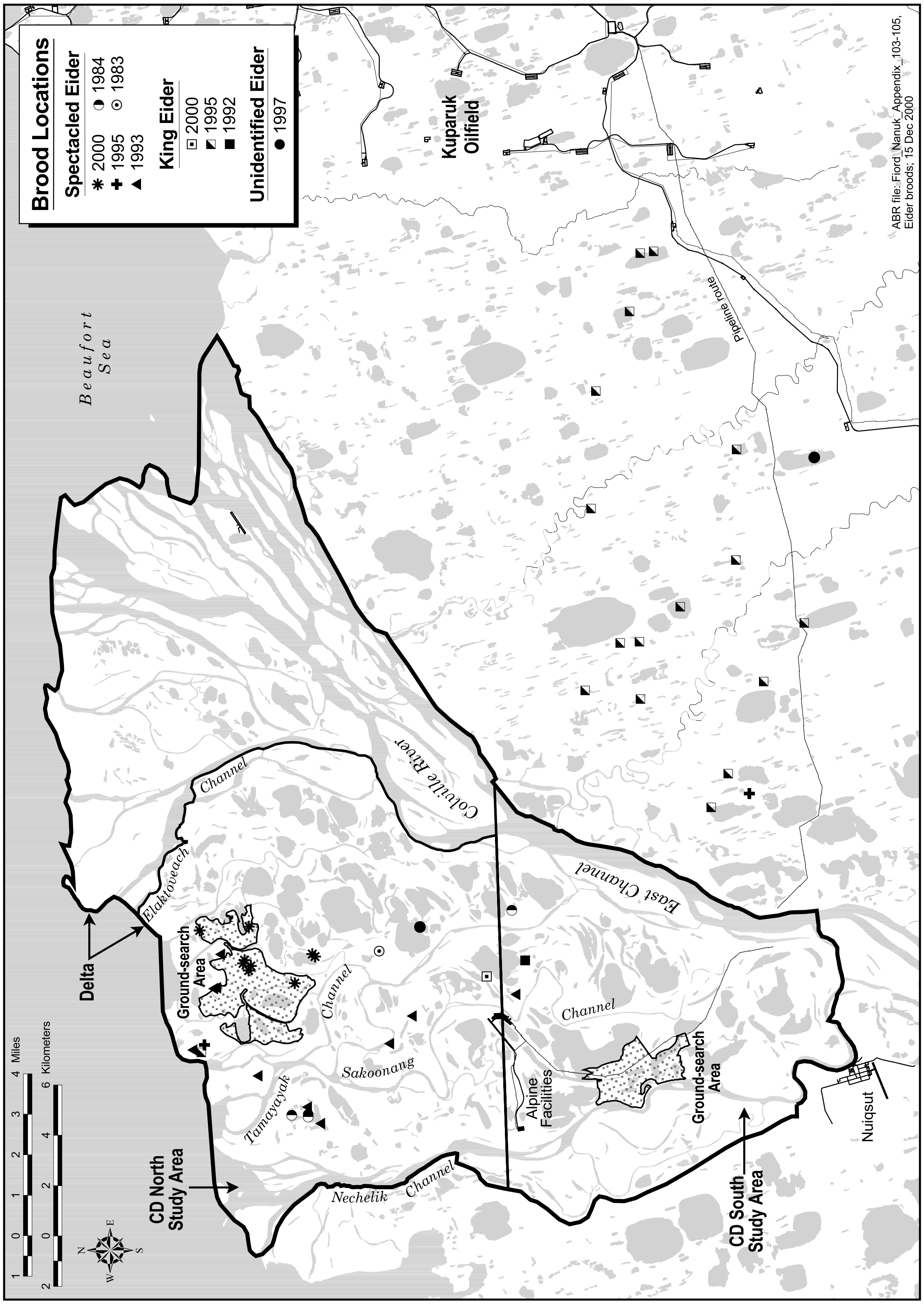
Appendix C2. Distribution of King and Common eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).



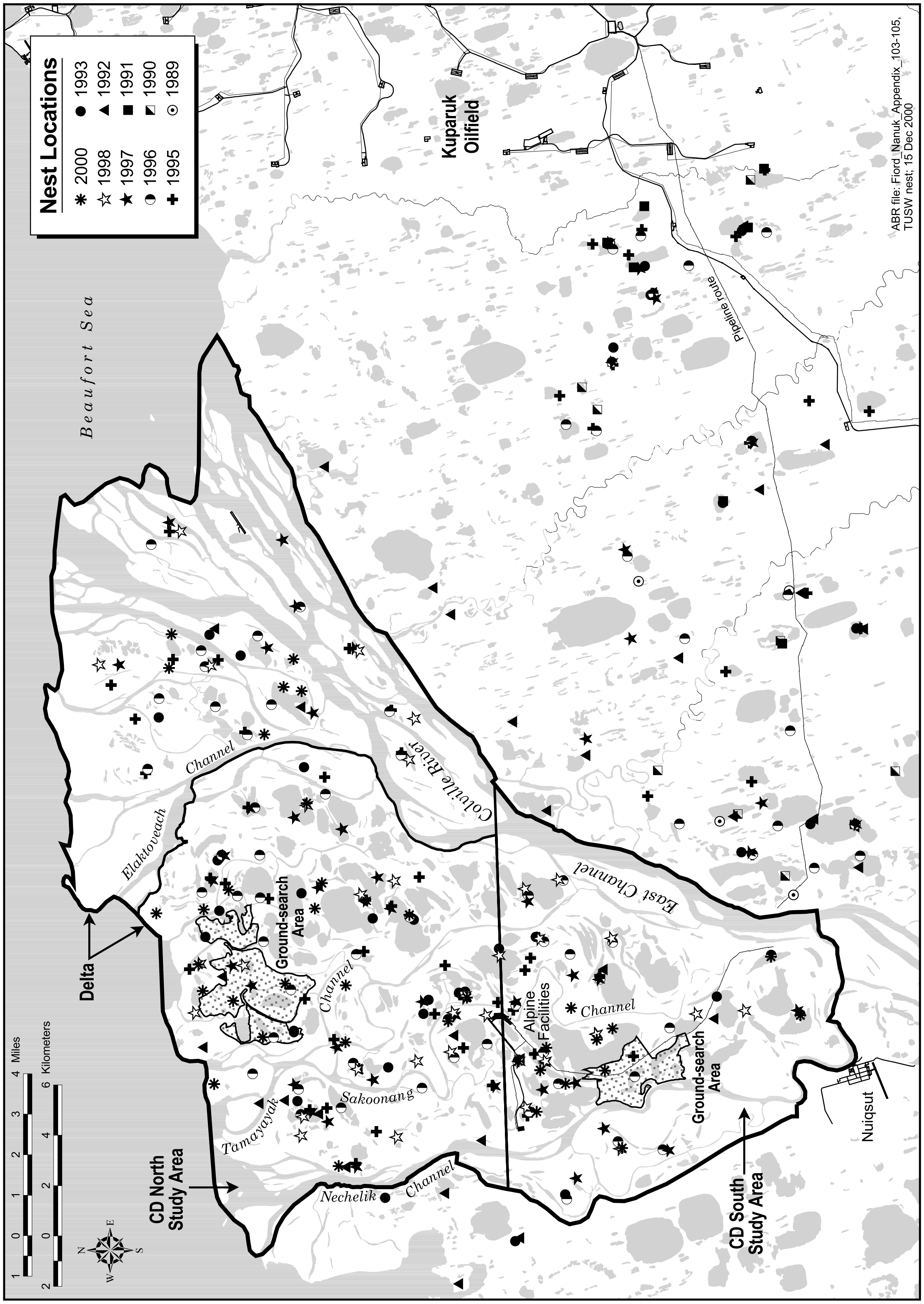
Appendix C3. Distribution of Spectacled Eider nests during ground searches on the Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–2000 (pre-2000 data from T. Myres 1958, 1959, unpubl. data; M. North 1984, unpubl. data; Smith et al. 1993, 1994; and Johnson et al. 1999a).



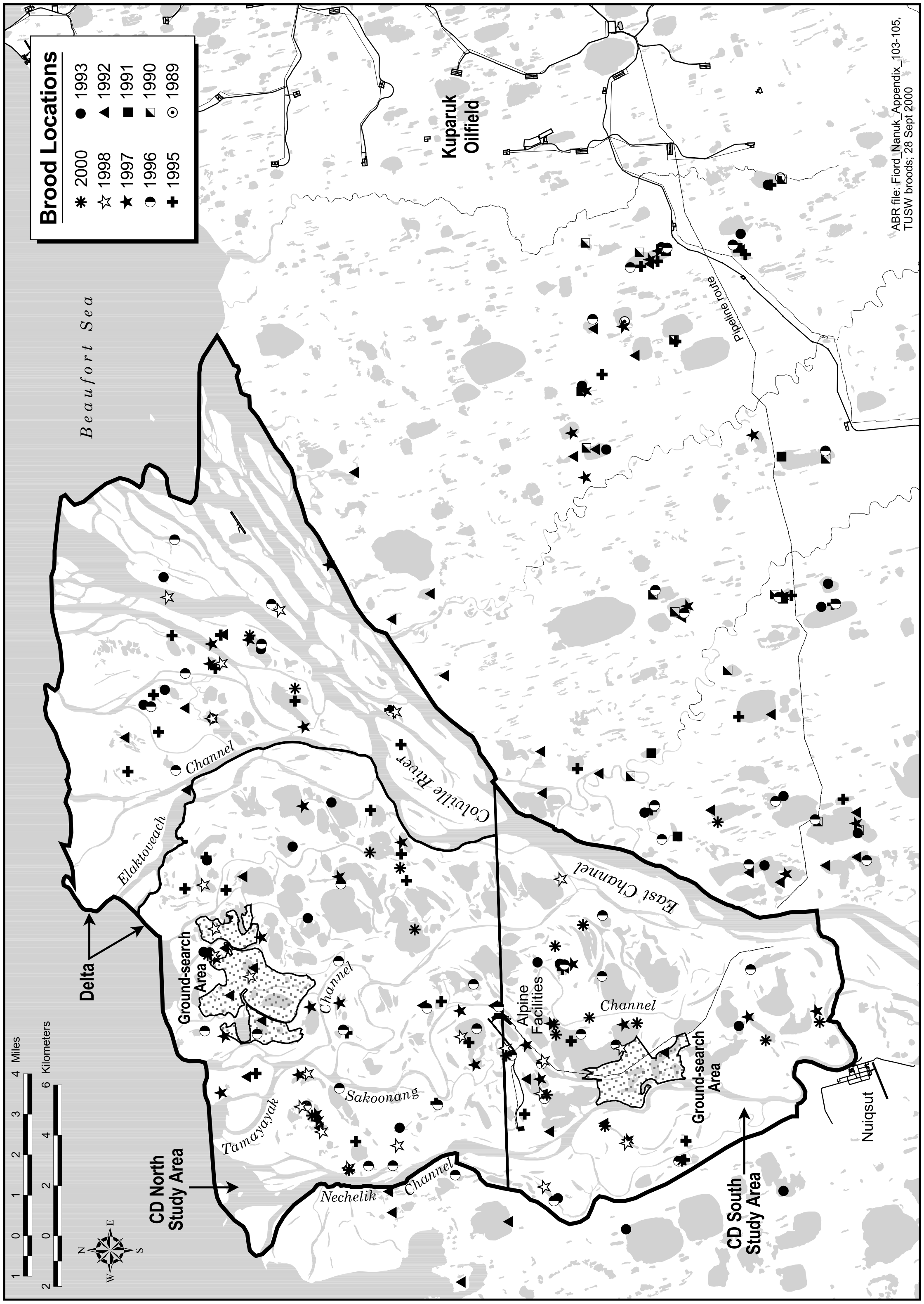
Appendix C4. Distribution of King, Common, and unidentified eider nests during ground searches on the Colville River Delta, Alaska, 1958, and 1992–2000 (pre-2000 data from T. Myres 1958, unpubl. data; Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



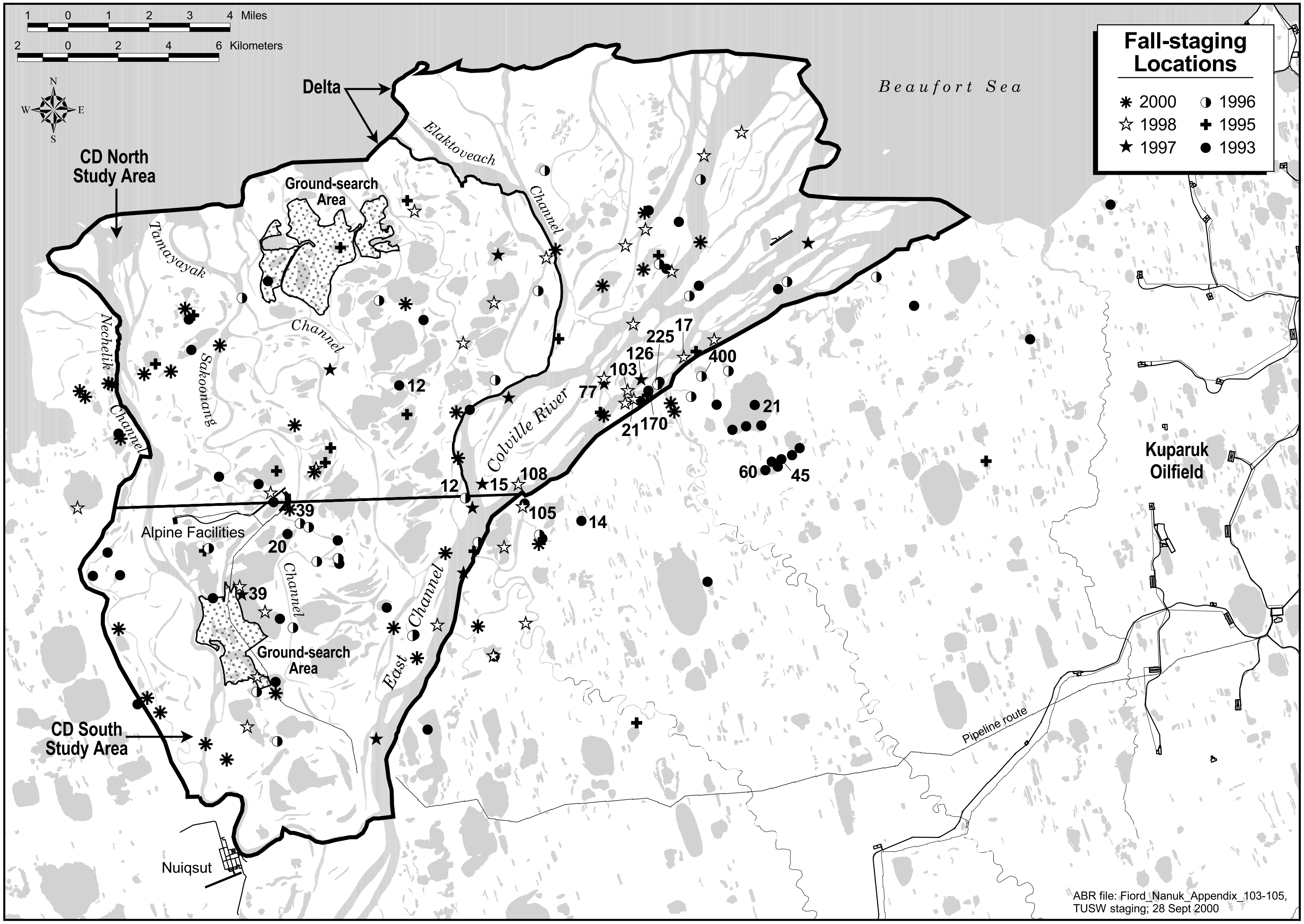
Appendix C5. Distribution of Spectacled, King, and unidentified eider broods during aerial and ground surveys of the CD North and CD South study areas, Colville River Delta, Alaska, 1983, 1984, 1992, 1993, 1995, 1997, and 2000 (pre-2000 data from M. North 1983, 1984, unpubl. data; Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



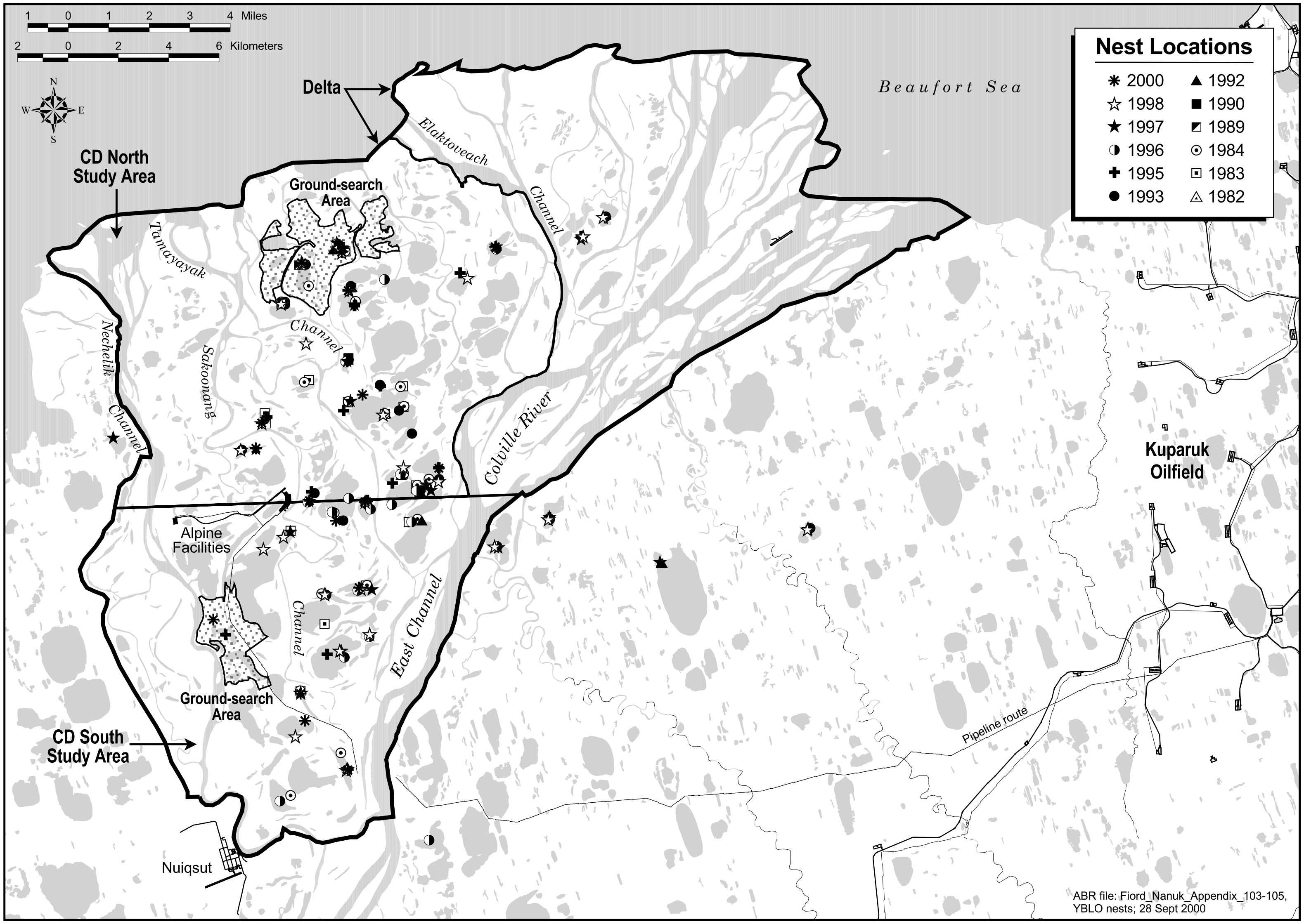
Appendix C6. Distribution of Tundra Swan nests during aerial and ground surveys on the Colville River Delta, Alaska, 1989–1993, 1995–1998, and 2000 (pre-2000 data from Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Smith et al. 1993, 1994; and Johnson et al. 1999a).



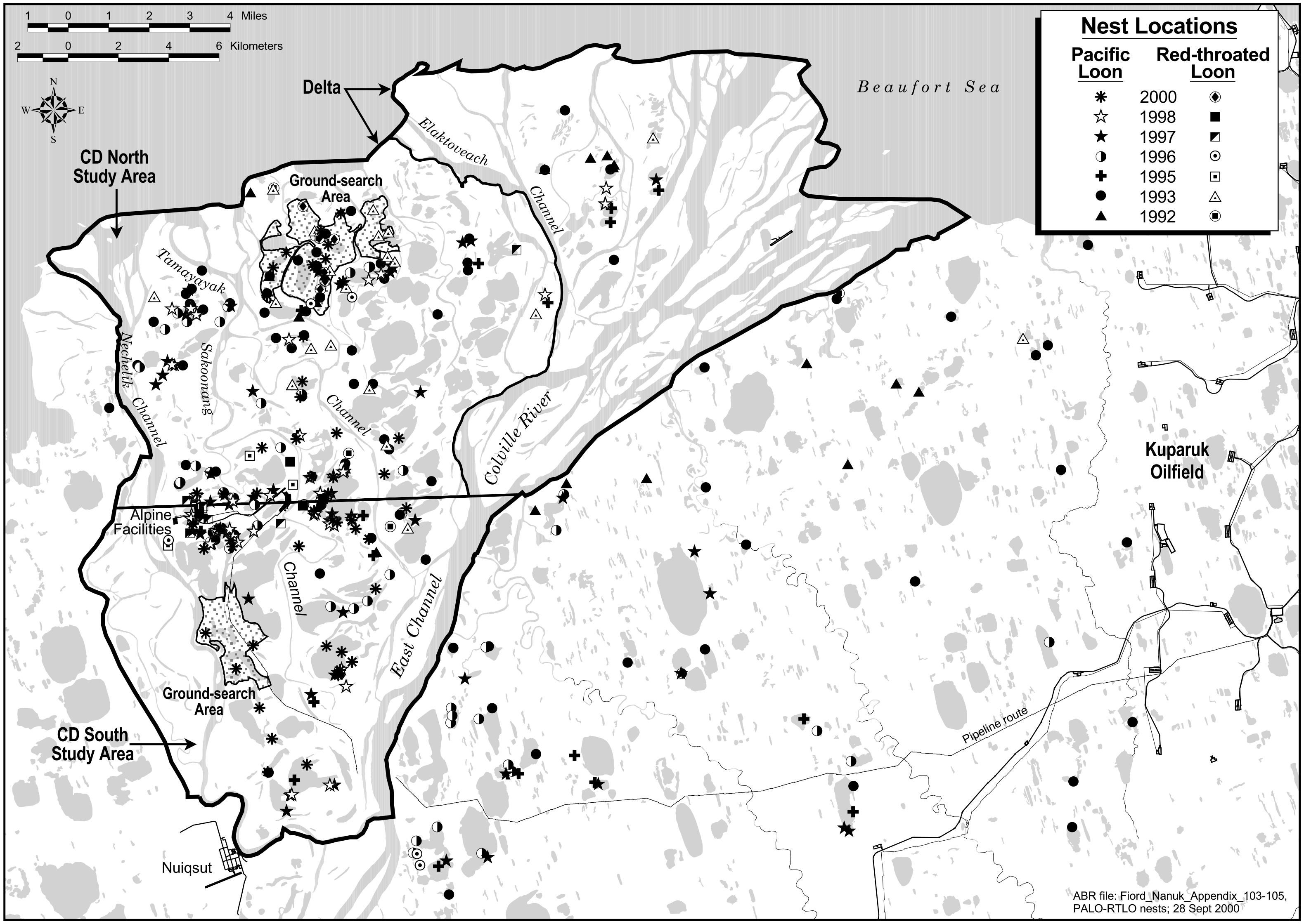
Appendix C7. Distribution of Tundra Swan broods during aerial and ground surveys on the Colville River Delta, Alaska, 1989–1993, 1995–1998, and 2000 (pre-2000 data from Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Smith et al. 1993, 1994; and Johnson et al. 1999a).



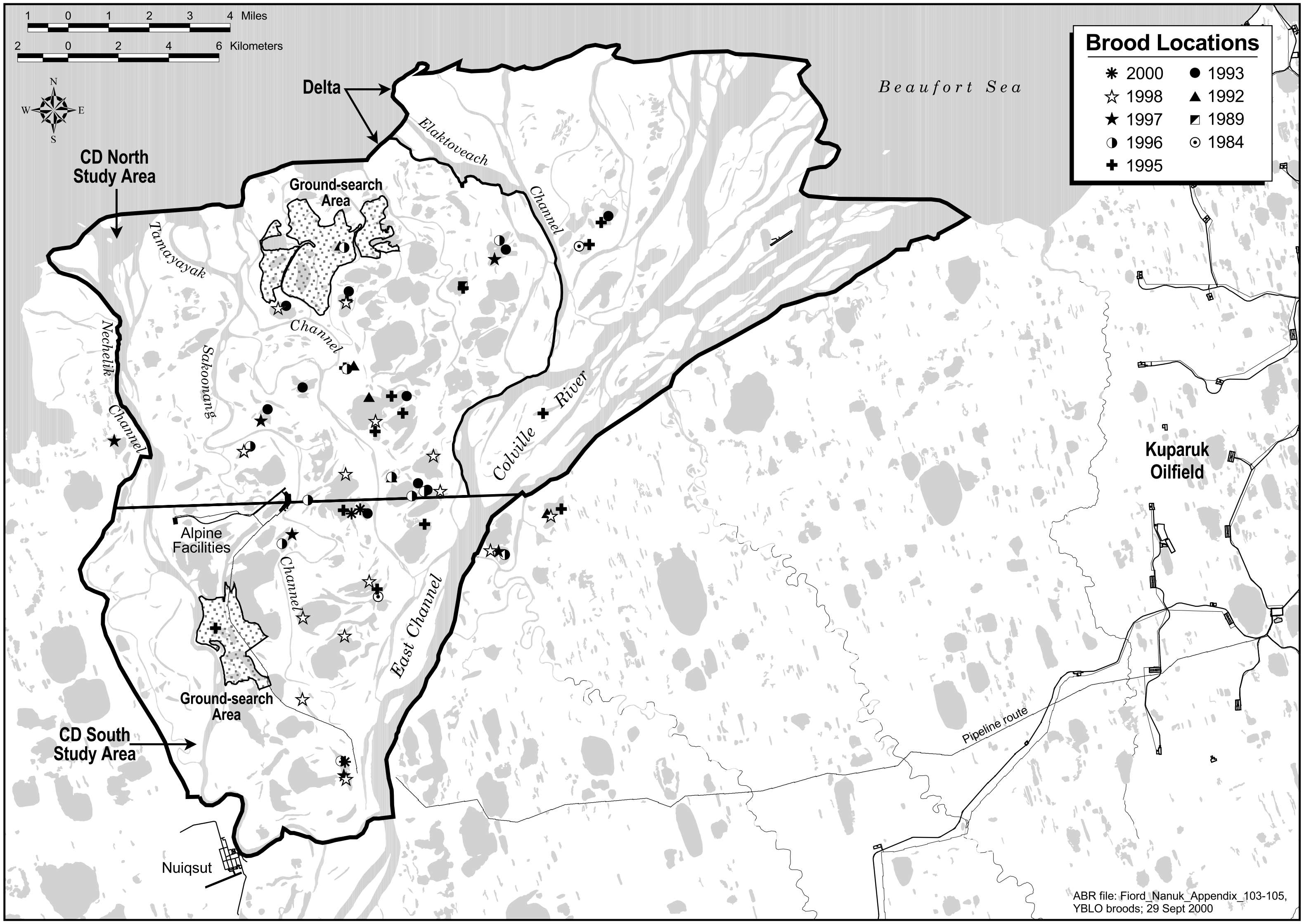
Appendix C8. Distribution of Tundra Swan fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1993, 1995–1998, and 2000 (pre-2000 data from Smith et al. 1994 and Johnson et al. 1999a). Numbers indicate size of groups >10.



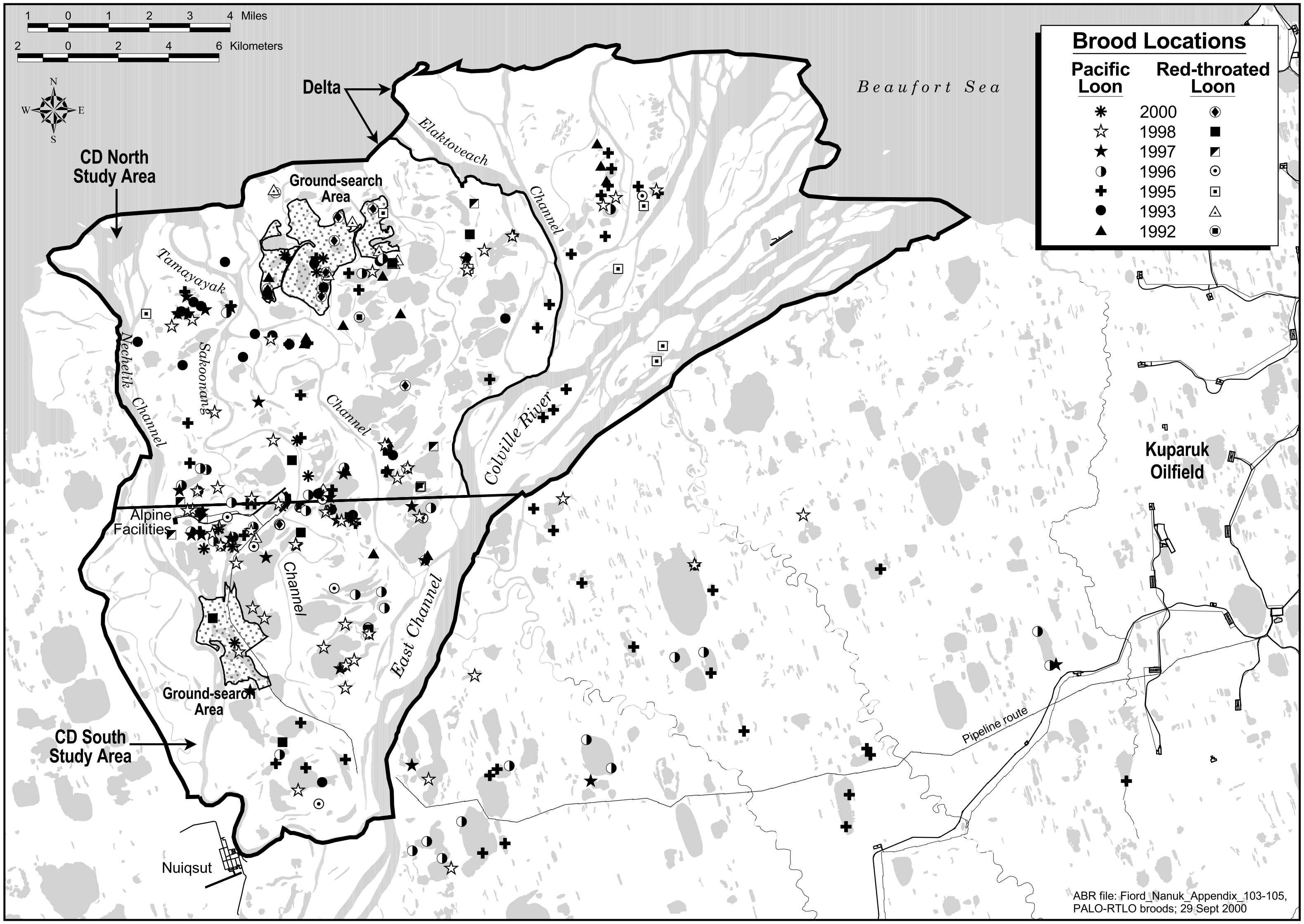
Appendix C9. Distribution of Yellow-billed Loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1982–1984, 1989, 1990, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from M. North 1982–1984, 1989, 1990, unpubl. data; Smith et al. 1993, 1994; S. Earnst 1995–1997, unpubl. data; and Johnson et al. 1999a).



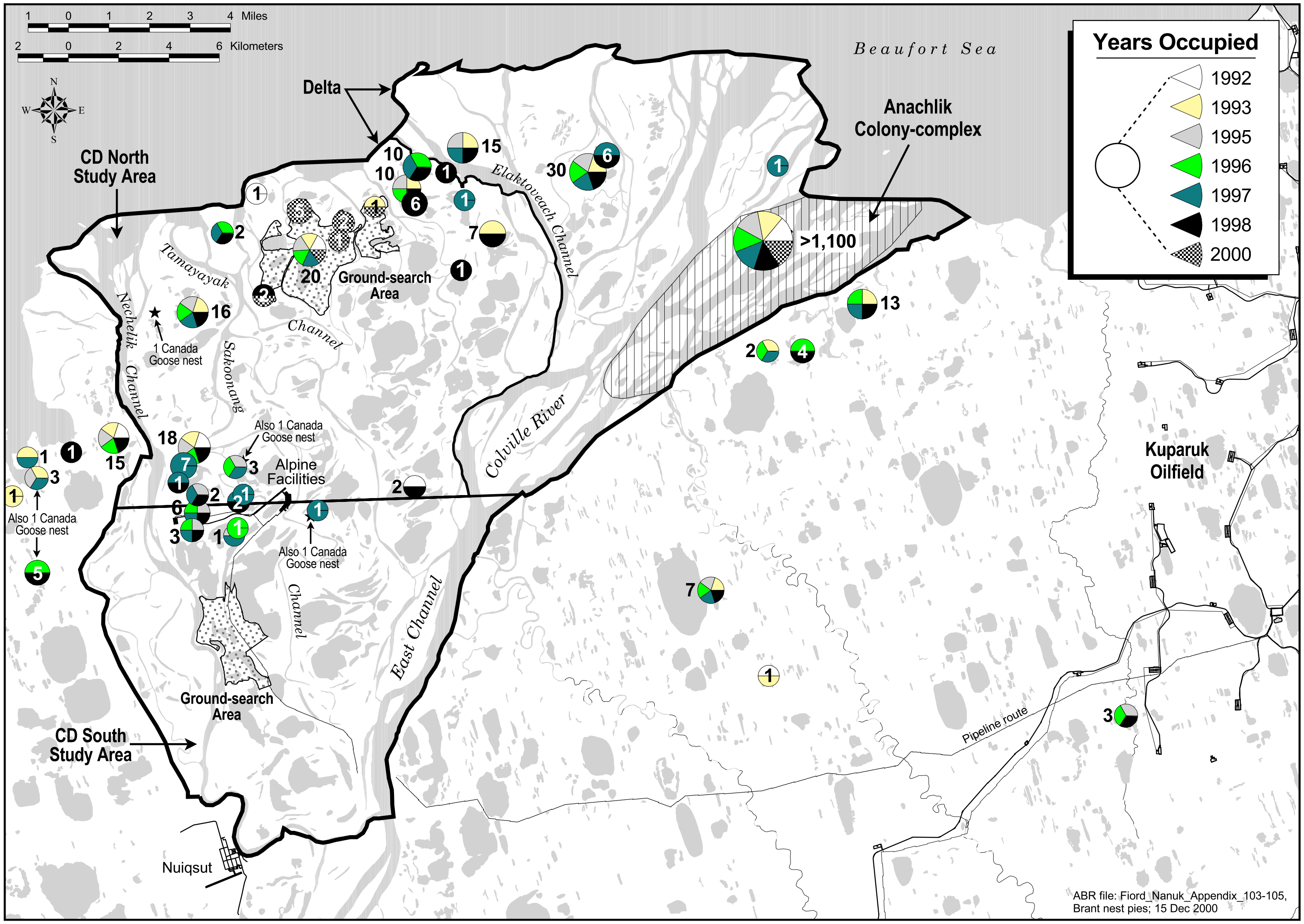
Appendix C10. Distribution of Pacific and Red-throated loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Smith et al. 1993, 1994 and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



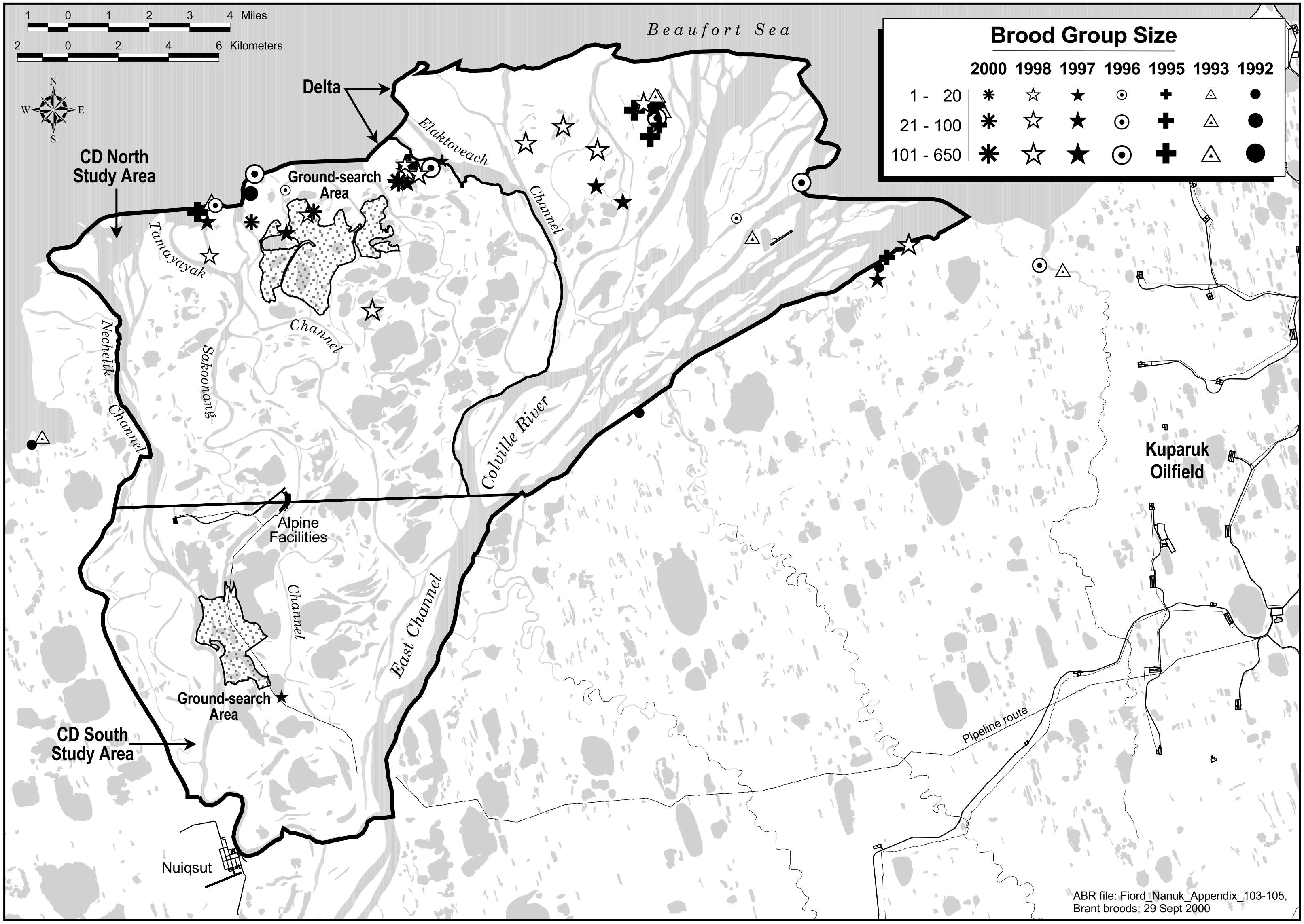
Appendix C11. Distribution of Yellow-billed Loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1984, 1989, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from M. North 1984, 1989, unpubl. data; Smith et al. 1993, 1994; S. Earnst 1996, unpubl. data; and Johnson et al. 1999a).



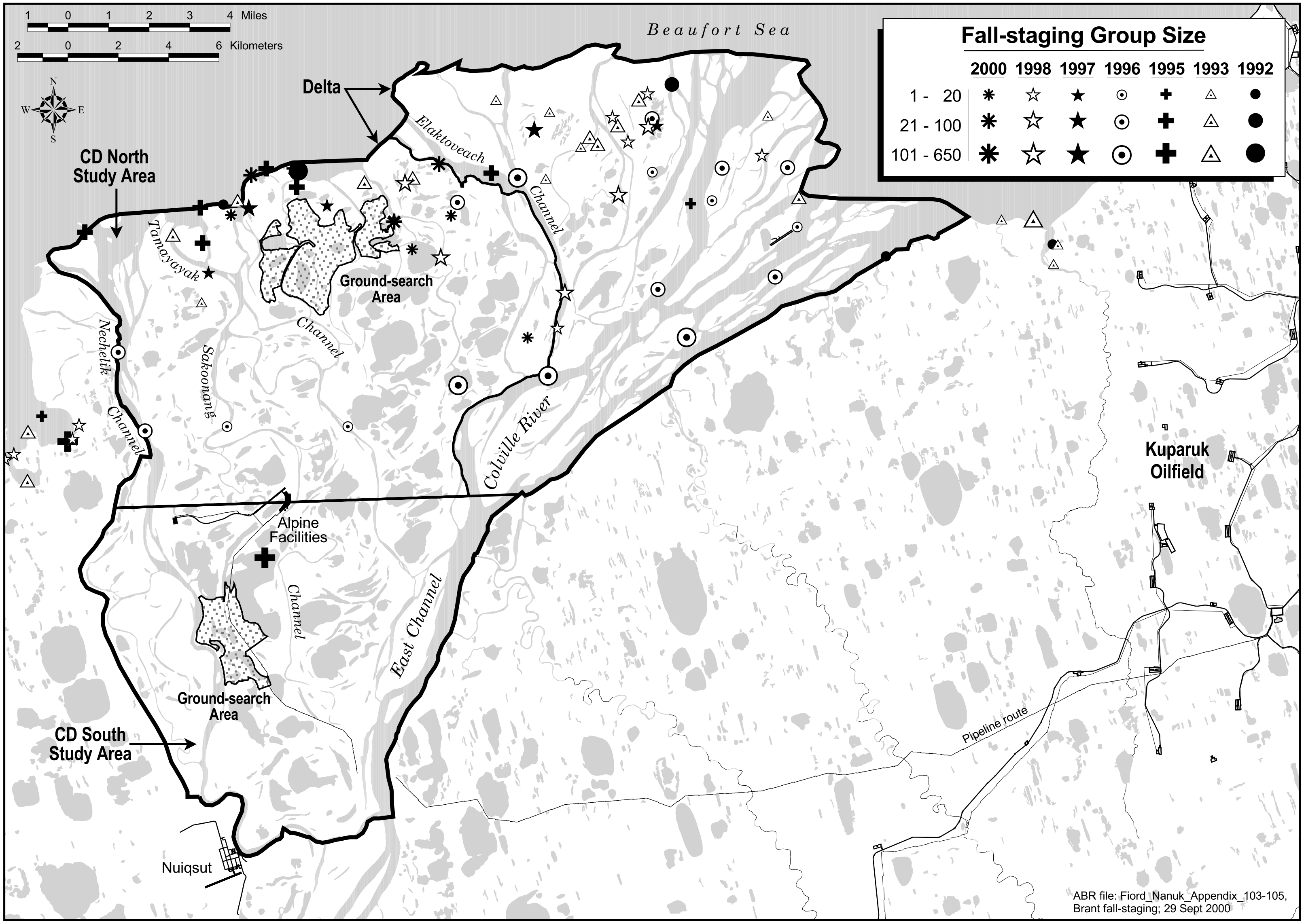
Appendix C12. Distribution of Pacific and Red-throated loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Smith et al. 1993, 1994 and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



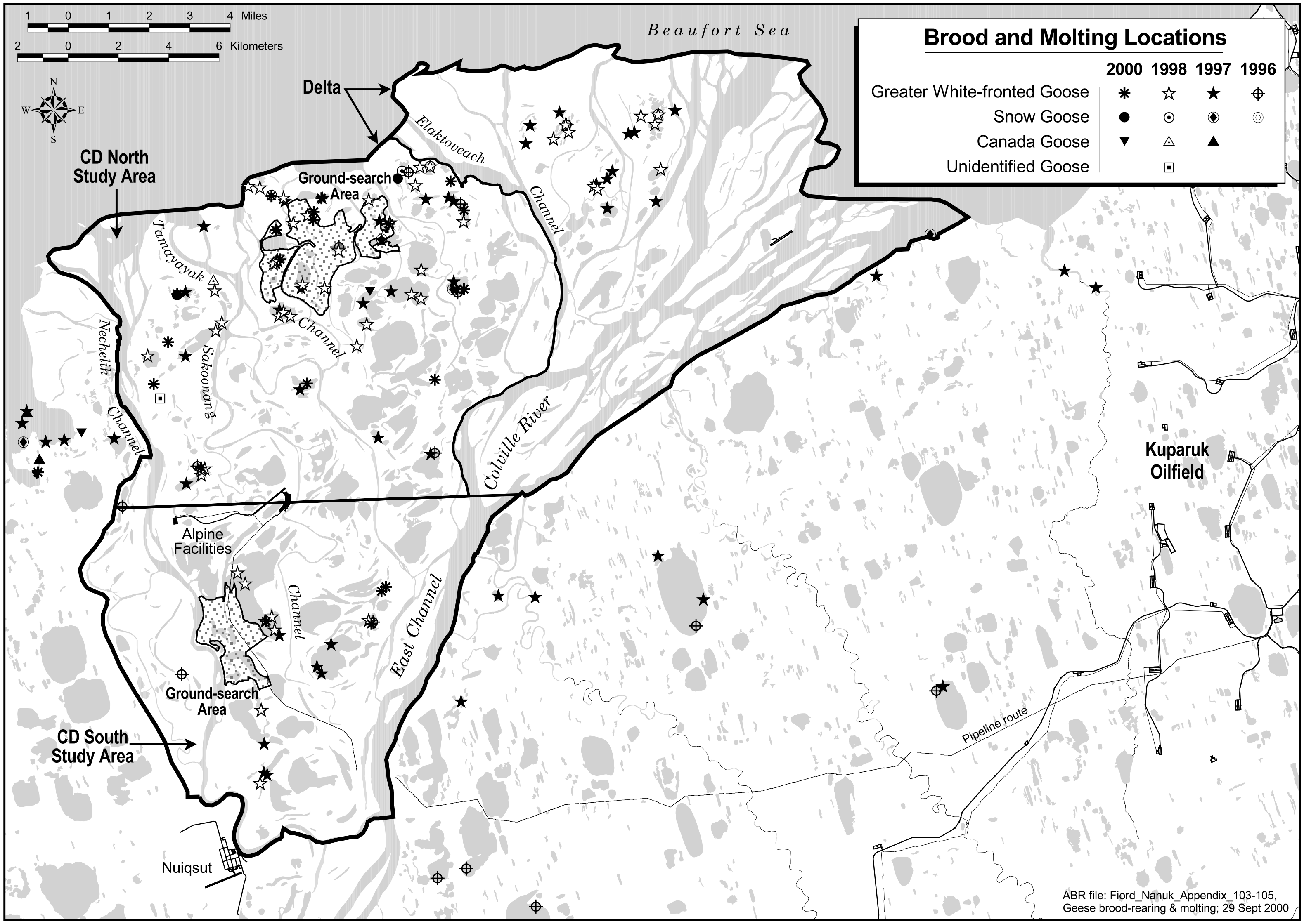
Appendix C13. Distribution and size of Brant colonies and locations of four Canada Goose nests during aerial and ground surveys on the Colville River Delta, Alaska, 1992, 1993, and 1995–1998 (data from Smith et al. 1993, 1994 and Johnson et al. 1999a). The number near each circle represents the maximal number of nests counted during the five years of study. Surveys were not conducted during 2000.



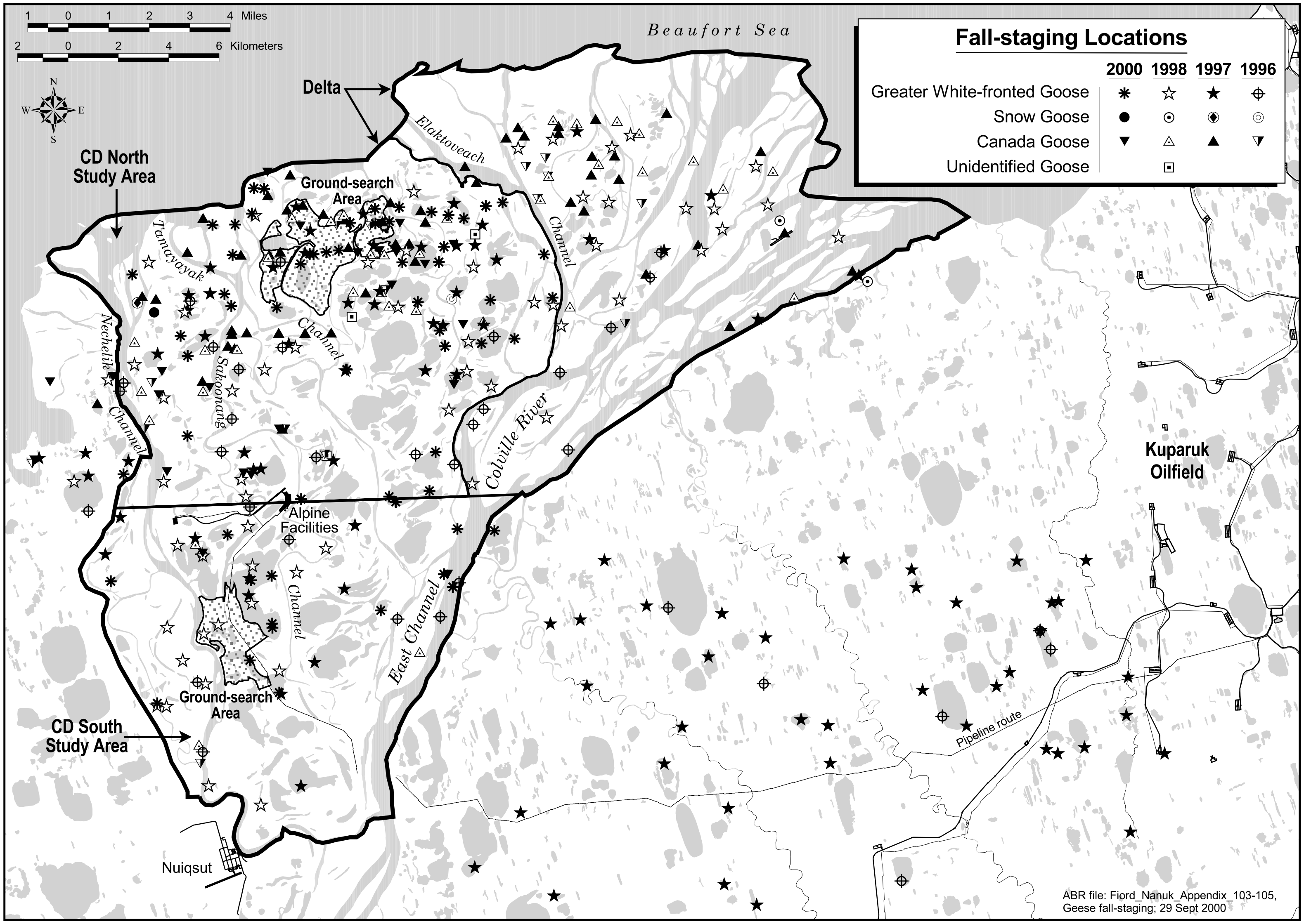
Appendix C14. Distribution and size of Brant brood-rearing groups during aerial surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Smith et al. 1993, 1994 and Johnson et al. 1999a).



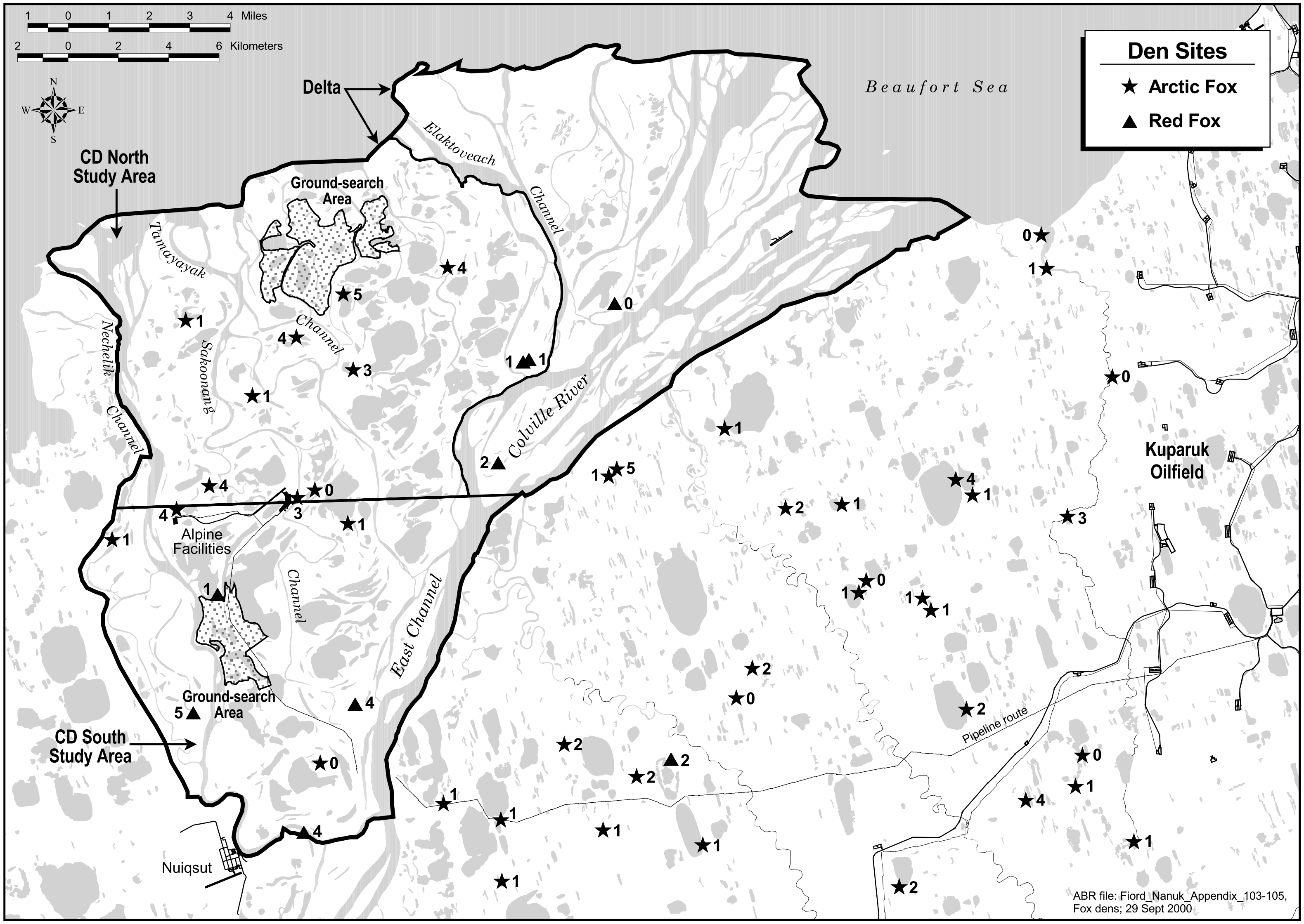
Appendix C15. Distribution and size of Brant fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Smith et al. 1993, 1994 and Johnson et al. 1999a).



Appendix C16. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese during aerial surveys on the Colville River Delta, Alaska, 1996–1998, and 2000 (pre-2000 data from Johnson et al. 1999a). Survey coverage was 25% in 1996 and 50% in subsequent years.



Appendix C17. Distribution of fall-staging groups of Greater White-fronted, Snow, and Canada geese during aerial surveys on the Colville River Delta, Alaska, 1996–1998, and 2000 (pre-2000 data from Johnson et al. 1999a). Survey coverage was 25% in 1996 and 50% in subsequent years.



Appendix C18. Distribution of arctic and red fox dens and number of years each den is known to have been occupied by breeding foxes on the Colville River Delta, Alaska, 1992, 1993, and 1995–2000 (pre-2000 data from Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed and not all dens were known or monitored in every year.

Appendix D1. Habitat use by Spectacled Eiders and King Eiders during pre-nesting in the CD South study area, Colville River Delta, Alaska, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a)

SPECIES Habitat	Total Groups	Total Adults	Use (%)
SPECTACLED EIDER			
Tapped Lake w/ Low-water Connection	1	2	25
Tapped Lake w/ High-water Connection	1	2	25
River or Stream	1	2	25
Aquatic Sedge w/ Deep Polygons	1	2	25
Total	4	8	100
KING EIDER			
Tapped Lake w/ Low-water Connection	1	2	8.3
Tapped Lake w/ High-water Connection	2	6	16.7
River or Stream	7	19	58.3
Wet Sedge–Willow Meadow	1	1	8.3
Riverine or Upland Shrub	1	2	8.3
Total	12	30	100

Appendix D2. Habitat selection (pooled among years) by Spectacled Eiders and King Eiders during pre-nesting on the Colville River Delta, Alaska, 1993–1998 and 2000 (pre-2000 data from Johnson et al. 1999a).

SPECIES Habitat	No. Adults	No. Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
SPECTACLED EIDERS					
Open Nearshore Water (marine)	0	0	0	1.5	ns
Brackish Water	43	18	12.7	1.3	prefer
Tapped Lake w/Low-water Connection	24	10	7.0	4.4	ns
Tapped Lake w/High-water Connection	8	5	3.5	4.1	ns
Salt Marsh	23	11	7.8	3.2	prefer
Tidal Flat	0	0	0	6.8	avoid
Salt-killed Tundra	24	13	9.2	5.0	ns
Deep Open Water w/o Islands	7	5	3.5	4.0	ns
Deep Open Water w/Islands or Polygonized Margins	7	5	3.5	1.6	ns
Shallow Open Water w/o Islands	4	2	1.4	0.4	ns
Shallow Open Water w/Islands or Polygonized Margins	1	1	0.7	0.1	ns
River or Stream	10	5	3.5	14.0	avoid
Aquatic Sedge Marsh	0	0	0	0	ns
Aquatic Sedge w/Deep Polygons	66	36	25.4	2.6	prefer
Aquatic Grass Marsh	2	2	1.4	0.3	ns
Young Basin Wetland Complex	0	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	ns
Nonpatterned Wet Meadow	30	14	9.9	8.1	ns
Wet Sedge–Willow Meadow	33	14	9.9	19.7	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.6	ns
Moist Tussock Tundra	0	0	0	0.5	ns
Riverine or Upland Shrub	0	0	0	5.1	avoid
Barrens (riverine, eolian, lacustrine)	2	1	0.7	14.9	avoid
Artificial (water, fill, peat road)	0	0	0	<0.1	ns
Total	284	142	100	100	
KING EIDERS					
Open Nearshore Water (marine)	10	2	2.8	1.5	ns
Brackish Water	6	4	5.6	1.3	prefer
Tapped Lake w/Low-water Connection	9	4	5.6	4.4	ns
Tapped Lake w/High-water Connection	8	3	4.2	4.1	ns
Salt Marsh	2	1	1.4	3.2	ns
Tidal Flat	2	1	1.4	6.8	avoid
Salt-killed Tundra	10	6	8.3	5.0	ns
Deep Open Water w/o Islands	0	0	0	4.0	ns
Deep Open Water w/Islands or Polygonized Margins	2	1	1.4	1.6	ns
Shallow Open Water w/o Islands	0	0	0	0.4	ns
Shallow Open Water w/Islands or Polygonized Margins	0	0	0	0.1	ns
River or Stream	127	38	52.8	14.0	prefer
Aquatic Sedge Marsh	0	0	0-	0	ns
Aquatic Sedge w/Deep Polygons	6	3	4.2	2.6	ns
Aquatic Grass Marsh	0	0	0	0.3	ns
Young Basin Wetland Complex	0	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	ns
Nonpatterned Wet Meadow	1	1	1.4	8.1	avoid
Wet Sedge–Willow Meadow	10	6	8.3	19.7	avoid
Moist Sedge–Shrub Meadow	0	0	0.0	2.6	ns
Moist Tussock Tundra	0	0	0.0	0.5	ns
Riverine or Upland Shrub	2	1	1.4	5.1	avoid
Barrens (riverine, eolian, lacustrine)	1	1	1.4	14.9	avoid
Artificial (water, fill, peat road)	0	0	0	<0.1	ns
Total	196	72	100	100	

[a] 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.

Appendix D3. Habitat use by Spectacled Eiders during nesting on the Colville River Delta, Alaska, 1992–1994, 1997–1999 and 2000 (pre-2000 data from Johnson et al. 1999a). Nests were found during ground searches of selected portions of the study area. No nests were found in 1995 or 1996.

Habitat	No. of Nests[a]	Use (%)
HABITAT USED		
Brackish Water	6	13.3
Tapped Lake w/ High-water Connection	1	2.2
Salt Marsh	1	2.2
Salt-killed Tundra	12	26.7
Deep Open Water w/ Islands or Polygonized Margins	3	6.7
Shallow Open Water w/out Islands	1	2.2
Aquatic Sedge w/ Deep Polygons	9	20.0
Nonpatterned Wet Meadow	7	15.6
Wet Sedge–Willow Meadow	5	11.1
Total	45	100
NEAREST WATERBODY HABITAT[b]		
Brackish Water	21	46.7
Tapped Lake w/ Low-water Connection	1	2.2
Tapped Lake w/ High-water Connection	5	11.1
Deep Open Water w/out Islands	3	6.7
Deep Open Water w/ Islands or Polygonized Margins	12	26.7
Shallow Open Water w/out Islands	1	2.2
Shallow Open Water w/ Islands or Polygonized Margins	2	4.4
Total	45	100

[a] Total includes seven unoccupied nests for which we used contour feathers to identify the eider species.

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

Appendix D4. Habitat use by Spectacled Eiders and King Eiders during brood-rearing on the Colville River Delta, Alaska, 1992, 1993, 1995, and 2000 (pre-2000 data from Johnson et al. 1999a). Broods were located during both aerial and ground surveys.

SPECIES Habitat Type	Total Brood-rearing Groups	Total Young	Use (%)
SPECTACLED EIDER			
Brackish Water	3	11	15.0
Tapped Lake w/ Low-water Connection	1	3	5.0
Salt-killed Tundra	4	22	20.0
Deep Open Water w/o Islands or Polygonized Margins	3	8	15.0
Deep Open Water w/ Islands or Polygonized Margins	4	12	20.0
Aquatic Sedge w/ Deep Polygons	1	4	5.0
Aquatic Grass Marsh	1	4	5.0
Wet Sedge–Willow Meadow	3	14	15.0
Total	20	78	100
KING EIDER			
Aquatic Sedge w/ Deep Polygons	1	7	50.0
Wet Sedge–Willow Meadow	1	5	50.0
Total	2	12	100

Appendix D5. Numbers and densities (no/km²) of Tundra Swan nests and broods during aerial surveys of the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

	Nests		Broods		Mean Brood	Estimated Nesting
Year	No.	No./km^2	No.	No./km^2	Size	Success[a] (%)
2000	32	0.06	21	0.04	2.0	66
1998	31	0.06	22	0.04	2.4	71
1997	32	0.06	24	0.04	2.5	75
1996	45	0.08	32	0.06	3.4	71
1995	38	0.07	25	0.05	3.7	66
1993	20	0.04	14	0.03	2.6	70
1992	14	0.03	16	0.03	2.4	114

[a] Percent nesting success = nests/broods x 100.

Appendix D6. Numbers and densities (no/km²) of Tundra Swan adults and young during fall-staging surveys of the Colville River Delta, Alaska, 1992–1993, 1995–1996, and 2000 (pre-2000 data from Johnson et al. 1999a).

	Adults		Young		
Year	Total	Density	Total	Density	Number of Groups
2000	66	0.12	23	0.04	34
1998	411	0.75	20	0.04	26
1997	194	0.35	92	0.17	11
1996	314	0.57	41	0.07	21
1995	28	0.05	36	0.07	15
1993	260	0.47	35	0.06	28
1992	0	–	0	–	0

Appendix D7. Habitat selection (pooled among years) by Tundra Swans during nesting and brood-rearing on the Colville River delta, Alaska, 1992, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo[a] Results
NESTING				
Open Nearshore Water (marine)	0	0	1.8	avoid
Brackish Water	0	0	1.2	ns
Tapped Lake w/ Low-water Connection	2	0.9	3.9	avoid
Tapped Lake w/ High-water Connection	3	1.4	3.8	avoid
Salt Marsh	12	5.7	3.0	ns
Tidal Flat	4	1.9	10.2	avoid
Salt-killed Tundra	23	10.8	4.7	prefer
Deep Open Water w/out Islands	3	1.4	3.8	avoid
Deep Open Water w/ Islands or Polygonized Margins	8	3.8	1.4	prefer
Shallow Open Water w/out Islands	0	0	0.4	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	14.9	avoid
Aquatic Sedge Marsh	1	0.5	<0.1	ns
Aquatic Sedge w/ Deep Polygons	16	7.5	2.4	prefer
Aquatic Grass Marsh	2	0.9	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	23	10.8	7.5	ns
Wet Sedge–Willow Meadow	83	39.2	18.6	prefer
Moist Sedge–Shrub Meadow	17	8.0	2.4	prefer
Moist Tussock Tundra	3	1.4	0.5	ns
Riverine or Upland Shrub	5	2.4	5.0	avoid
Barrens (riverine, eolian, lacustrine)	7	3.3	14.3	avoid
Artificial (water, fill, peat road)	0	0	<0.1	ns
Total	212	100	100	
BROOD-REARING				
Open Nearshore Water (marine)	0	0	1.8	ns
Brackish Water	10	6.5	1.2	prefer
Tapped Lake w/ Low-water Connection	22	14.4	3.9	prefer
Tapped Lake w/ High-water Connection	10	6.5	3.8	ns
Salt Marsh	11	7.2	3.0	prefer
Tidal Flat	1	0.7	10.2	avoid
Salt-killed Tundra	11	7.2	4.7	ns
Deep Open Water w/out Islands	13	8.5	3.8	prefer
Deep Open Water w/ Islands or Polygonized Margins	9	5.9	1.4	prefer
Shallow Open Water w/out Islands	1	0.7	0.4	ns
Shallow Open Water w/ Islands or Polygonized Margins	1	0.7	0.1	ns
River or Stream	6	3.9	14.9	avoid
Aquatic Sedge Marsh	0	0	<0.1	ns
Aquatic Sedge w/ Deep Polygons	6	3.9	2.4	ns
Aquatic Grass Marsh	2	1.3	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	9	5.9	7.5	ns
Wet Sedge–Willow Meadow	29	19.0	18.6	ns
Moist Sedge–Shrub Meadow	2	1.3	2.4	ns
Moist Tussock Tundra	0	0	0.5	ns
Riverine or Upland Shrub	3	2.0	5.0	avoid
Barrens (riverine, eolian, lacustrine)	7	4.6	14.3	avoid
Artificial (water, fill, peat road)	0	0	<0.1	ns
Total	153	100	100	

[a] 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.

Appendix D8. Habitat selection (pooled among years) by Yellow-billed Loons during nesting and brood-rearing on the Colville River Delta, Alaska, 1993, 1995–1998, and 2000 (pre-2000 data from Johnson et al. 1999a).

SEASON Habitat	No. Nests or Broods	Use (%)	Availability (%)	Monte Carlo[a] Results
NESTING				
Open Nearshore Water (marine)	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake w/Low-water Connection	0	0	5.3	avoid
Tapped Lake w/High-water Connection	10	11.8	5.4	prefer
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	ns
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water w/o Islands	6	7.1	5.5	ns
Deep Open Water w/Islands or Polygonized Margins	17	20.0	1.8	prefer
Shallow Open Water w/o Islands	0	0	0.4	ns
Shallow Open Water w/Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	1	1.2	<0.1	prefer
Aquatic Sedge w/Deep Polygons	5	5.9	2.9	ns
Aquatic Grass Marsh	1	1.2	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	11	12.9	8.7	ns
Wet Sedge–Willow Meadow	34	40.0	24.7	prefer
Moist Sedge–Shrub Meadow	0	0	3.5	ns
Moist Tussock Tundra	0	0	0.7	ns
Riverine or Upland Shrub	0	0	6.5	avoid
Barrens (riverine, eolian, lacustrine)	0	0	12.2	avoid
Artificial (water, fill, peat road)	0	0	<0.1	ns
Total	85	100	100	
BROOD-REARING				
Open Nearshore Water (marine)	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake w/Low-water Connection	0	0	5.3	ns
Tapped Lake w/High-water Connection	8	23.5	5.4	prefer
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	ns
Salt-killed Tundra	0	0	4.2	ns
Deep Open Water w/o Islands	21	61.8	5.5	prefer
Deep Open Water w/Islands or Polygonized Margins	5	14.7	1.8	prefer
Shallow Open Water w/o Islands	0	0	0.4	ns
Shallow Open Water w/Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	ns
Aquatic Sedge Marsh	0	0	<0.1	ns
Aquatic Sedge w/Deep Polygons	0	0	2.9	ns
Aquatic Grass Marsh	0	0	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	0	0	8.7	ns
Wet Sedge–Willow Meadow	0	0	24.7	avoid
Moist Sedge–Shrub Meadow	0	0	3.5	ns
Moist Tussock Tundra	0	0	0.7	ns
Riverine or Upland Shrub	0	0	6.5	ns
Barrens (riverine, eolian, lacustrine)	0	0	12.2	avoid
Artificial (water, fill, peat road)	0	0	<0.1	ns
Total	34	100	100	

[a] 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.

Appendix D9. Habitat selection by foxes, as indicated by den site locations on the Colville River Delta, Alaska, 2000 (pre-2000 data from Johnson et al. 1999a). The sample analyzed includes all active and inactive dens of arctic foxes and red foxes confirmed during 1992–2000, because both species may use the same dens in different years.

Habitat	Area (km^2)	No. Dens	Use (%)	Availability[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	-	-	0	-
Salt Marsh	16.55	0	0	4.4	ns
Tidal Flat	56.01	0	0	14.8	ns
Salt-killed Tundra	25.64	0	0	6.8	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	13.22	0	0	3.5	ns
Aquatic Grass Marsh	0	-	-	0	-
Young Basin Wetland Complex	<0.01	0	0	<0.1	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.54	1	4.8	11.0	ns
Wet Sedge–Willow Meadow	102.63	3	14.3	27.2	ns
Moist Sedge–Shrub Meadow	13.20	1	4.8	3.5	ns
Moist Tussock Tundra	2.55	0	0	0.7	ns
Riverine or Upland Shrub	27.58	15	71.4	7.3	prefer
Barrens (riverine, eolian, lacustrine)	78.67	1	4.8	20.8	avoid
Artificial (water, fill, peat road)	0.39	0	0	0.1	ns
Total	377.99	21	100	100	

[a] Aquatic habitats were assigned zero availability for fox dens.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$: ns = not significant; prefer = use significantly greater than availability; avoid = use significantly less than availability.