WILDLIFE STUDIES IN THE CD SOUTH STUDY AREA, 2001

SECOND ANNUAL REPORT

Prepared for

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EXECUTIVE SUMMARY

In spring 2000, ARCO Alaska, Inc. (now ConocoPhillips Alaska, Inc.) contracted with ABR, Inc., to conduct multi-year wildlife studies in 2 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 2001 field season, the results from 2 years of study of the wildlife resources in the CD South study area are presented. 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 River 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 were selected as focal species: Yellow-billed Loon, Tundra Swan, Brant, Spectacled Eider, caribou, and arctic fox (Smith et al. 1993). After 1992, 3 additional species were targeted for more focused attention: King Eider, Greater White-fronted Goose, and Bar-tailed Godwit. Other species were monitored opportunistically, including Red-throated and Pacific loons, gulls, red fox, muskox, and brown bear. 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) evaluate the use of the specific area proposed for oilfield development by nesting and brood-rearing waterbirds, 3) locate fox dens, estimate litter sizes, and describe their habitat associations, and 4) monitor the distribution of other large mammals in the study area. Information on caribou is reported separately (Lawhead and Prichard 2002).

The Colville River Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. The Colville River 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 2001 breeding season was similar to 2000, but both were unusual among recent years, because weather and river conditions delayed the onset of nesting for birds on much of the Colville River Delta. Spring temperatures were colder and snowmelt was later in both 2001 and 2000 relative to previous years since 1992 (when many of these surveys were initiated on the delta). Late snowmelt was coupled with late and rapid river breakup in early June, resulting in extensive flooding of low-lying and coastal areas, but not as extensive as in 2000. The late season had direct impacts on large 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 2001.

Both aerial and ground surveys of wildlife were conducted. Between the CD North (Johnson et al. 2002b) and CD South study areas, aerial surveys in 2001 covered most of the delta. Ground surveys of nesting birds were conducted on a smaller scale, focusing on a study plot that encompassed the proposed project facilities. Wildlife observations were plotted on a wildlife habitat map, previously developed for the Colville River Delta, 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 2001, reported in Johnson et al. 2002b) and over all previous years of wildlife observations in the delta.

LARGE WATERBIRD GROUND-SEARCHES

A ground-based nest search was conducted to determine the composition and abundance of nesting large waterbirds in the proposed development area, with particular attention to eiders and geese. Another ground-based brood search was conducted after hatch, during which nests of waterbirds were revisited to determine nest fate and to estimate nesting success. Nests of 16 species of birds were located during ground searches in the CD South study plot in 2001. Twenty species have been recorded nesting in the ground-search area since searches were initiated in 2000. The most common nesting birds were Greater White-fronted Geese, Willow Ptarmigan, and Northern Pintails (surveys excluded nests of shorebirds and passerines). Noteworthy nesting species in 2001 included a Northern Harrier (nests are rare on the Arctic Coastal Plain) and 3 Short-eared Owls.

Single broods or brood-rearing groups of 4 species were observed during ground searches in the CD South study plot in 2001. Of 23 brood-rearing groups observed, 15 were Greater White-fronted Geese. Several broods of Red-breasted Merganser were observed, although no nests were located during the nest search.

One Spectacled Eider nest was located in the CD South ground-search area in 2001, similar to 2000. The nests in both years failed. No other eider nests were found in the ground-search areas in either year. Spectacled Eider broods were not observed in the CD South study area in 2001 or 2000.

EIDER SURVEYS

Aerial surveys for eiders were conducted during the pre-nesting period. Methods were similar to previous years (1992–1998 and 2000). No Spectacled Eiders and only 2 King Eiders were observed. In 2000, 2 Spectacled Eiders and 6 King Eiders were counted. 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 River Delta were closely associated with coastal areas in all years.

In 10 years of nest searching in various locations on the entire delta, 55 nests of Spectacled Eiders have been found in 9 habitats. The coastal portion of the delta, where Spectacled Eiders concentrate during pre-nesting, also is where eiders nest most commonly. The farthest distance from the coast that a Spectacled Eider nest has been observed on the Colville River Delta is 13 km. Over all years of data on the delta, the mean distance of Spectacled Eider nests from the coast was 3.5 km ($n = 55$). Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 2.9 m from permanent water.

No broods of Spectacled or King eiders were observed during either 2001 or 2000 in the CD South study area. Since our surveys began on the delta in 1992, one Spectacled Eider brood has been sighted in the CD South study area. On the entire delta, only 24 groups of brood-rearing Spectacled Eiders have been seen since 1992. Broods appear to be attracted to coastal lakes; one third of broods were associated with Deep Open Water with Islands or Polygonized Margins, and 29% of the broods were associated with Brackish Water. Mean distance to the coast for broods was 3.2 km ($n = 24$).

TUNDRA SWAN SURVEYS

Aerial surveys for Tundra Swans were conducted during nesting and brood-rearing. During the nesting survey in 2001, 98 swans were observed in the CD South study area, which was the lowest number recorded since 1995. About 18% of swans observed appeared to be nesting. In the CD South study area, 10 swan nests were found in 2001 (including one nest found by ground observers). 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. Over 8 years of surveys across the entire Colville River Delta, Tundra Swans used a wide range of habitats for nesting, with nests ($n = 239$) located in

18 of 24 available habitats. Nearly 53% of nests were located in Wet Sedge–Willow Meadow, a preferred habitat.

During brood-rearing in 2001, 70 Tundra Swans (54 adults and 16 young) were observed in the CD South study area; this count was the lowest since 1995. In 2001, 30% of adults were accompanied by broods, a larger percentage than in any previous year. Eight broods were observed in 2001, with a mean brood size of 2.0 young/brood. Although apparent nesting success was high in 2000 (89%), 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 2001 due to prolonged snow cover in nesting habitats followed by widespread flooding of the delta. Twenty Tundra Swan broods observed in the CD South study area during aerial surveys in 2001 and 2000 were found in 10 habitats.

LOON SURVEYS

Aerial surveys for Yellow-billed Loons were conducted during nesting and brood-rearing. Similar surveys were conducted on the Colville River Delta in 1993, 1995–1998, and 2000. (Surveys conducted during 1992 excluded most of the CD South study area.) In 2001, we counted 26 Yellow-billed Loons and 9 nests in the CD South study area during the nesting aerial survey. The number of loons seen in 2001 was greater than the number recorded during each of 6 previous years. The count of 9 nests in 2001 was within the range of values (2–10 nests) observed in previous years of surveys, however. All 9 nests found in 2001 were on lakes where Yellow-billed Loons have nested in previous years.

During 7 years (1993, 1995–1998, 2000–2001) of aerial surveys on the Colville River Delta, 104 Yellow-billed Loon nests were found in 8 of 24 available habitats. Nests found in the CD South study area occurred most commonly near the following aquatic habitats: Deep Open Water without Islands (50% of all nests), Deep Open Water with Islands or Polygonized Margins (25%), Tapped Lake with High-water Connection (19%), and Aquatic Sedge Marsh (6%). All nests were close (<5 m) to water.

Seventeen adult Yellow-billed Loons and 2 broods were counted during the brood-rearing survey in the CD South study area in 2001. Most adult loons seen on the brood-rearing survey in 2001 were found on lakes where nesting occurred either in 2001 or in a previous year. During aerial surveys in 1995–1998, 2000–2001, 38 Yellow-billed Loon broods were found in 3 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 by loons 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.

GOOSE SURVEYS

Surveys for geese were conducted during brood-rearing and fall staging. Similar surveys have been conducted in the Colville River Delta since 1996. Only Greater White-fronted Geese were observed in the CD South study area during brood-rearing in 2001: 274 geese in 6 groups. In previous brood-rearing surveys of the delta, Brant and Canada Geese were observed in the CD South study area only in 1997. In 5 years of surveys of the CD South study area, the number of Greater White-fronted Geese has ranged from 33 to 528. Thirty-six goslings were observed in 2001; in previous years the number of goslings has ranged from 24 to 266. In all years, densities of Greater White-fronted Geese (0.8–7.2 birds/km^2) observed in the CD South area during brood-rearing were low compared to those in the CD North area (6.4–13.1 birds/km^2) and on the delta (4.2–12.8 birds/km^2) as a whole. During brood-rearing aerial surveys in 2000 and 2001, Greater White-fronted Geese were observed using 6 of 20 habitats in the CD South study area. Brood-rearing geese occurred mainly near the center of the study area, typically in or near water

Two species of geese were recorded in the CD South study area during fall-staging surveys in 2001: Greater White-fronted Geese and Brant. During fall staging in 2001, 137 Greater White-fronted Geese were observed in the CD South study area in 5 groups that averaged 27 birds. Twenty Brant were observed in one group. Brant typically use salt marshes and other coastal habitats during fall staging. As in the brood-rearing period, staging Greater White-fronted Geese were found primarily in lake habitats or in other habitats adjacent to lakes or river channels.

GULL SURVEYS

Information on the distribution and abundance of Glaucous Gulls was collected during aerial surveys for nesting Tundra Swans and Yellow-billed Loons in 2001. Fourteen Glaucous Gull nests were located during these surveys and an additional 3 nests were found during ground surveys in the CD South study area and during aerial surveys of lakes in the Alpine project area. Thirteen of the 17 nests were part of a Glaucous Gull colony located ~6 km east of the CD South ground-search area. Counts at this colony have ranged from 10 to 18 nests during 3 years of surveys (1998, 2000, 2001). The density of Glaucous Gull nests in the CD South study area in 2001 was 0.1 nests/km². Because Glaucous Gulls were being counted on aerial surveys designed to survey other species, some nests probably were missed.

FOX DEN SURVEYS

Aerial surveys have been used since 1992 to assess the distribution and status of arctic and red fox dens on the Colville River Delta. We checked den status at known dens on an initial visit in late June and then returned to active dens in mid-July to count pups. The 9 fox dens in the CD South study area in 2001 included active and inactive sites of both species; 5 were arctic fox sites and 4 were red fox sites. In marked contrast to other areas on the outer coastal plain, red fox dens are as common as 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 km²) was 1 den/17 km². The densities of arctic and red fox dens were similar at 1 den/31 km² and 1 den/39 km², respectively.

The 4 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 4 red fox dens (50–100%) were active each year since 1995. Since 1993, no more than one den has ever been occupied by arctic foxes in the CD South study area. In 2001, pups were confirmed at one den of each species in the CD South study area; the arctic fox den had 4 pups and the red fox den had at least 3 pups.

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. In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville River 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. Across the entire delta, 70% of dens were located in the Riverine or Upland Shrub type, the only denning habitat that was preferred.

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INTRODUCTION

In spring 2000, ARCO Alaska, Inc., (now ConocoPhillips Alaska, Inc.) contracted with ABR, Inc., to conduct wildlife studies in 2 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. This annual report on the 2001 field season presents the results from the second year of study of the wildlife resources in the CD South study area. The CD South Development Project proposed by ConocoPhillips Alaska, Inc. (CPA) 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 CPA's proposed CD North Development Project, which lies 10.1 km to the north and east of the Alpine Development, are reported elsewhere (Johnson et al. 2000a and Johnson et al. 2002b).

Wildlife studies have been conducted by the oil industry in the Colville River Delta region since 1992 when ARCO Alaska, Inc. (now CPA) initiated studies to examine the biological, physical, and cultural resources of the delta (biological reports include Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b). By 1995, attention was focused on the central delta as the area with highest potential for oil development. The Alpine Development Project received its federal permits on 13 February 1998, and construction began that spring. The Alpine Oilfield is the first oilfield to be developed on the Colville River Delta and the first west of the Kuparuk Oilfield. Oil flowed for the first time through the Alpine pipeline in November 2000, and, with the establishment of the Alpine facilities and pipeline, oil development in other locations on the delta became more feasible.

The primary goal of ecological investigations on the Colville River 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 concerns of regulatory agencies. Accordingly, the Yellow-billed Loon, Tundra Swan, Brant, Spectacled Eider, caribou, and arctic fox were selected for study (Smith et al. 1993; see Appendix A for scientific names of birds and mammals). After 1992, 3 additional species were targeted for more focused attention: King Eider, Greater White-fronted Goose, and Bar-tailed Godwit. Other species were monitored opportunistically, including Red-throated and Pacific loons, gulls, red fox, muskox, and brown bear. The 2001 program included ground searches for nests of large waterbirds and aerial surveys of pre-nesting Spectacled Eiders; nesting and brood-rearing Tundra Swans, Yellow-billed Loons, and Glaucous Gulls; brood-rearing and fall-staging geese; and arctic fox dens. Information on caribou in the western segment of the Central Arctic Herd is reported separately (Lawhead and Prichard 2002).

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 were 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, 2000b, 2001). The reader is referred to these reports for a complete outline of mapping methods and techniques.

The overall goal of the study in 2001 was to continue to build the multi-year baseline on the use of the CD South study area by selected birds and mammals during June through fall staging (August–September). Specific objectives for the CD South wildlife studies were to:

1. monitor the distribution, abundance, and habitat use of selected waterbird species during pre-nesting, nesting, brood-rearing, and fall staging;
2. evaluate the use of the specific area proposed for oilfield development by nesting and brood-rearing waterbirds,
3. locate fox dens, estimate litter sizes, and describe their habitat associations, and
4. monitor the distribution of other large mammals in the study area.

STUDY AREA

The CD South Study Area comprises the region of the Colville River Delta south of the Alpine Development facilities, west of the East Channel of the Colville River, and north of the village of Nuiqsut (Figure 1). Within the CD South Study Area, the CD South Ground-search Area lies between the Sakoonang and Nigliq (Nechelik) channels, north to the boundary of the Alpine Ground-search Area (see Johnson et al. 2002a) and south to approximately midway between the Alpine facilities and Nuiqsut (Figure 1).

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. Two permanent human settlements occur on the Colville River Delta—the Iñupiaq village of Nuiqsut and the Helmericks family homesite. Both rely heavily on these fish and wildlife resources.

The Colville River drains a watershed of ~53,000 km^2, or ~29% of the Arctic Coastal Plain of Alaska (Walker 1976). The high-volume flow and heavy sediment load of the Colville River have created a large (551 km^2), dynamic delta system, which includes a diversity of lakes, wetlands, and terrestrial habitats. The Colville River has 2 main distributaries in the delta, the Nigliq Channel and the East Channel. These 2 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). The East Channel is deep and flows under the ice during winter, whereas the Sakoonang, Tamayagiaq, Nigliq, 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 land that is 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 River Delta. The most abundant waterbodies on the delta are polygon ponds, which generally are shallow (i.e., ≤2 m deep), and freeze to the bottom during winter and thawing by June. Deep ponds and lakes (>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 that result from thermokarst of ice wedges and by the migration of river channels (Walker 1978). Channel connections allow water

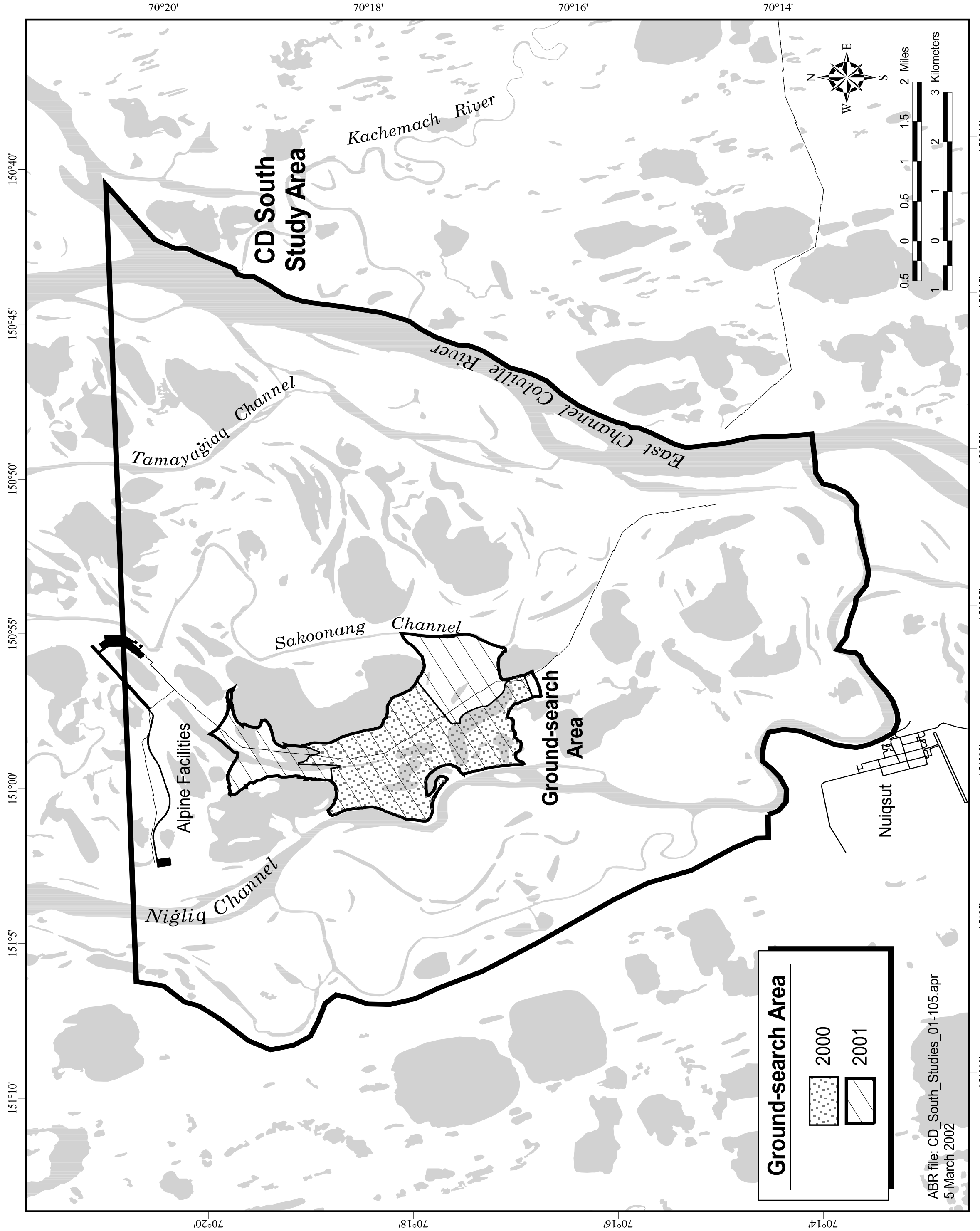

Figure 1. Survey area boundaries for wildlife studies in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

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). Winter lasts ~8 months and is 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). Summer temperatures are cool, 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 River Delta supports a wide array of wildlife, providing breeding habitat for passerines, shorebirds, gulls, and predatory birds such as jaegers and owls. The 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). 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 extensive salt marshes and mudflats on the delta are used by geese and shorebirds for feeding and staging (Andres 1994). 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. Brown bears occur regularly, 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 used 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 denning habitats of foxes and nesting habitats of the Greater White-fronted Goose. 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 differed between seasons, because survey areas often differed (as described below).

Except for nesting Greater White-fronted Geese, 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

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

Johnson et al. 2002) in 2001. Because of relatively small annual sample sizes in any particular study area, combining the 2001 data sets with previous data over the larger region yields a more robust analysis of habitat selection. For nesting Greater White-fronted Geese, sample sizes were large and the area searched for nests varied considerably among years; therefore, habitat selection was tested separately for each ground-search area and year. Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat selection and this distribution was used 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 0.05 (2-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.

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 South and CD North (Johnson et al. 2000a, 2002) study areas, covered most of the delta. Ground surveys of nesting birds were conducted on a smaller scale, focusing on a study plot that encompassed proposed footprints of CD South facilities. Aerial surveys 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. Ground surveys focused on large waterbirds, including all of the species targeted by aerial surveys plus all other waterfowl, gulls, jaegers, terns, and large shorebirds, and also including other large birds such as ptarmigan and raptors. Mammalian studies focused on arctic foxes, but information on other species, such as red foxes, brown bears, moose, and muskoxen, also was collected opportunistically.

LARGE WATERBIRD GROUND SEARCHES

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, as such, the ground-search areas differed between years 2000 and 2001 with changes in project footprints (Figure 1). Nest searches (except loons, see below) were conducted between 15 and 25 June 2000 and 14 and 28 June 2001. 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. Each team member thoroughly searched all dry ground between themselves and adjacent observers for nests of large birds, including loons, grebes, geese, swans, ducks, ptarmigan, cranes, large shorebirds (Whimbrel, Bar-tailed Godwit, and Common Snipe), jaegers, gulls, terns, and raptors. (Nests of small shorebirds and songbirds were not noted during this survey.) All bird nests of these species were mapped on aerial photos and nest locations that were difficult to map also were located with a GPS (Global Positioning System) unit. Observers attempted to not 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 (including contour feathers, if present) was collected and the length and width of one or 2 eggs were recorded. When possible, unidentified nests later were assigned to a species based on this information. Habitat information was recorded at each waterbird nest, including the distance to nearest standing water, 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 2000 and 17–18 July 2001 for waterfowl and 27 August 2000 and

21–22 August 2001 for loons). During the July nest check, waterbodies also were searched for nests of loons, which initiate their nests later than other waterbirds. 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 later was associated with that nest site. Evidence of predation, such as odor of fox urine or crushed egg remnants, 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 m on their long axis (approximately the minimal waterbody size to support nesting Red-throated Loons). The number of adults and young of each brood were recorded and their locations plotted on aerial photos of the study area.

EIDER SURVEYS

Pre-nesting aerial surveys for eiders were conducted on 16 June 2000 and 12–14 June 2001 (Table 2). Methods were similar to previous years (1994–1998 and 2000), although the survey areas differed among years. The aerial survey employed 2 observers (in addition to the pilot) in a Cessna 185 fixed-wing aircraft. 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. Eiders were counted 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 on the Colville River Delta since 1992. The habitat present at each eider location (singles, pairs, or flocks) was determined by plotting locations on the digital habitat map (Figure 2, Appendix B1). In 1992, the aerial survey covered 3 plots (46.6 km² each) on the delta (not the entire delta, as in subsequent years) and was flown at 50% coverage (0.8 km between transects) (Smith et al. 1993). Results of that survey were included in maps of eider distribution, but not in annual calculations of density or habitat use, because the resulting density and selection estimates were not comparable to the more recent surveys. The aerial survey in 1993 also was conducted at 50% coverage, but the entire delta was surveyed so results were included in calculations of density and habitat use with corrections for the lower survey intensity (e.g., doubled the counts of eiders for survey totals).

From the pre-nesting survey, the observed number of birds, the observed number of pairs, the indicated number of birds, the indicated number of pairs, and densities (number/km²) were calculated for the CD South study area (Figure 1). Total indicated birds was calculated following the procedures of the USFWS survey protocol (in which the number of lone males is doubled, and flocks are accounted for depending on composition, USFWS 1987a), and indicated density of birds was based on the total area covered during the survey.

Habitat selection was evaluated from all aerial survey locations across the entire delta in 1993–2001 (including both the CD South and CD North areas in 2000 and 2001). 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 and 23–26 June 2001) and brood-rearing (17–19 August 2001 and 16–18 August 2001) (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

Table 2. Descriptions of wildlife surveys conducted in the CD South study area, Colville River Delta, Alaska, 2001.

AREA SURVEYED Survey Type	Season	Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
CD SOUTH GROUND-SEARCH AREA (9.7 km²)							
Large Waterbird Ground Searches[b]	Nesting	15–-30 June	-	-	-	-	
	Brood-rearing[c]	17–18 July.	-	-	-	-	Includes loon nest search
	Brood-rearing	21 August					Primarily for loons
CD SOUTH STUDY AREA (156 km²)							
Eider Survey	Pre-nesting	12–14 June	C185	0.4	0.4	30–35	
Tundra Swan Surveys	Nesting	23–26 June	C185	1.6	1.6	150	
	Brood-rearing	16–18 August	C185	1.6	1.6	150	
Yellow-billed Loon Surveys[d]	Nesting	25–26, 30 June	206L & 206B	n/a	n/a	30–40	Includes survey for gull nests
	Brood-rearing	20, 23 August	206L	n/a	n/a	30–70	Includes survey for gull broods
Goose Surveys	Brood-rearing	26 July	C206	0.8	1.6	90	
	Fall staging	19 August	C185	0.4	1.6	90	
Fox Den Surveys	Denning	28 June	206B	-	-	-	Status check at known den sites
	Denning	11–15 July	-	-	-	-	Pup observations at active den sites

[a] Dash indicates ground search, no aircraft used. C185 = Cessna 185 fixed-wing airplane; C206 =Cessna 206 fixed-wing airplane; 206B = Bell "Jet Ranger" helicopter; 206L = Bell "Long Ranger" helicopter.
[b] Nest searches included loons and grebes, waterfowl, gulls, terns, jaegers, ptarmigan, and large shorebirds (Whimbrel and Bar-tailed Godwit).
[c] This survey also included nest searches for loons, which initiate their nests later than most other waterbirds.
[d] Glaucous Gull nests and broods also were surveyed during both nesting and brood-rearing surveys for Yellow-billed Loons. Pacific and Red-throated loons were recorded incidentally.

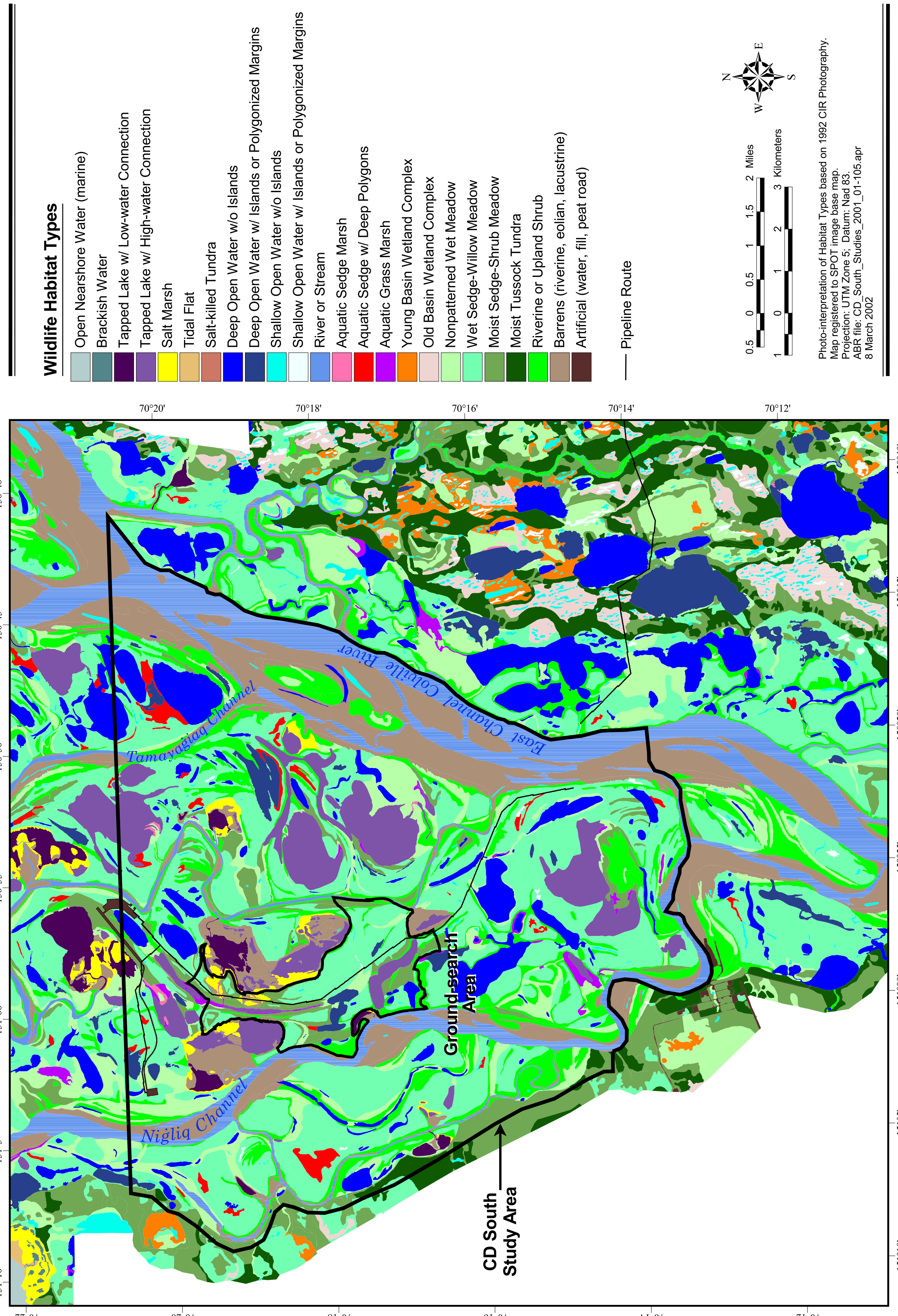

Figure 2. Habitat map of the CD South study area, Colville River Delta, Alaska.

area (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993, 1994; Smith et al. 1994; Anderson et al. 1995, 1996, 1997, 1998, 1999, 2000, 2001; Johnson et al. 1996, 1997, 1998, 1999a, 2000b), with the exception of 1992 (Smith et al. 1993) when transect configurations differed (but yielded comparable results). The CD South study area was surveyed in 2001 in conjunction with similar surveys in the Kuparuk Oilfield (Anderson et al. 2002) and in the CD North study area (Johnson et al. 2002).

Surveys for nesting and brood-rearing Tundra Swans were flown in a Cessna 185 aircraft along east-west, 1.6-km wide transects. Navigation of transects was aided with a GPS receiver. 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 2 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, allowing observers to 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. During 2001, nesting Glaucous Gulls were recorded similarly during the swans surveys, except that no photographs were taken.

Fall-staging Tundra Swan surveys were not flown in 2001. In past years, staging surveys for Tundra Swans were flown in a Cessna 185 aircraft in mid-September. In addition to the transects described above, non-transect paths were flown 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 surveys, all location data were entered into a GIS database and plotted on the wildlife habitat map of the delta (Figure 2, Appendix B1). 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, the number of swans, nests, and broods, and densities were calculated 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, 2000, and 2001. 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 in the CD South study area were conducted during nesting (27 and 30 June 2000 and 25–26 and 30 June 2001) and brood-rearing (25 and 27 August 2000 and 20 and 23 August 2001). Similar surveys were conducted on the Colville River Delta in 1993, 1995–1998, and 2000 (Smith et al. 1994; Johnson et al. 1996, 1997, 1998, 1999a, 2000a). Surveys also were conducted in 1992 in 3 plots (46.6 km² each) on the delta (Smith et al. 1993), but only 15.4 km² of one plot were located in the CD South study area. Results of 1992 surveys are included in maps of loon distribution, but not in annual calculations of density or habitat use, because the plots are not representative samples of the delta or CD South study areas. In 2000 and 2001, 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 lake size for nesting Yellow-billed Loons [Sjolander and Agren 1976, North and Ryan 1989]) and adjacent smaller lakes. 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). In 1996–1998 and in 2000–2001, a second nesting survey was conducted with a helicopter to visit lakes where Yellow-billed Loons were observed but no nests were found. Observations of Pacific and Red-throated loons, their nests and broods, and observations of nesting and brood-rearing Glaucous Gulls were recorded incidentally. Loon locations were recorded on 1:63,360-scale USGS maps.

From the survey data, the total number of adults, nests, broods, and young were calculated by season for all species of loons in the CD South study area. Density (number/km²) was calculated only for Yellow-billed Loons because the coverage for Pacific and Red-throated loons was inadequate for estimating density. Habitat use was calculated for Yellow-billed Loon nests and broods found in 2000 and 2001. 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 combined nest location data from 1993, 1995–1998, and 2000–2001, and for brood locations in 1995–1998 and 2000–2001.

GOOSE SURVEYS

Surveys for geese were conducted during brood-rearing (31 July 2000 and 26 July 2001) and fall staging (20 August 2000 and 19 August 2001) (Table 2). The surveys were developed originally to count Greater White-fronted Geese (although we also counted Brant, and Canada, and Snow geese) and have been conducted on 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%). Species, numbers, and locations were recorded on 1:63,360-scale USGS maps.

For Greater White-fronted Geese (the only abundant goose in the CD South area), habitat use was assessed from nest locations in the ground-search area (field methods are described above) and from aerial-survey locations during brood-rearing and fall staging. Habitat selection indices were calculated only for the nesting period (sample sizes were too small to test other periods). Selection analyses were conducted separately for 2000 and 2001 because the ground-search areas differed between years.

GULL SURVEYS

Glaucous Gull nests and broods were recorded during the nesting and brood-rearing aerial surveys for Tundra Swans and Yellow-billed Loons on the Colville River Delta (see Tundra Swan and Loons survey methods, above). All Glaucous Gull nests and broods observed on those surveys were recorded on 1:63,360-scale USGS maps. Gull nests and broods also were recorded during aerial surveys of lakes in the Alpine project area (Johnson et al. 2001). These lake surveys were conducted by a single observer in a helicopter, and observations were marked on a large-scale schematic map of the study area. Glaucous Gull nests also were recorded during ground surveys for breeding-waterbirds in the ground-search area at CD South.

FOX SURVEYS

Aerial and ground-based surveys were used to evaluate the distribution and status of arctic and red fox dens on the Colville River Delta in 2000–2001, continuing the annual monitoring effort begun in 1992 for baseline wildlife studies across the entire delta and adjacent coastal plain. The status of known dens was assessed briefly on helicopter-supported ground visits during 30 June–1 July 2000 and 28–30 June 2001, and observations of active dens were made to count pups during 11–13 July 2000 and 11–15 July 2001. Most survey effort was focused on checking dens found in previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a, 2000b, 2001), although we also searched opportunistically for dens in suitable habitats while transiting between known dens and conducting surveys for other species. Soil disturbance from digging by adults and pups and soil fertilization by fox feces and prey 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. The nature and extent of fox sign was used 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). Dens were classified into 4 categories (following Burgess et al. 1993), the first 3 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 are known to move pups from natal dens to secondary dens, repeated observations are needed to classify den status with confidence. Therefore, we made a concerted effort to confirm den occupancy and to count pups. Based on the initial assessment of den activity, observations during mid- 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 2.5–4 hours. Observations usually were conducted in the morning and evening, 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 1992–2001 on the Colville River Delta survey areas (updating the analyses presented by Johnson et al. 1999a). The total area of all terrestrial habitats was 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 actually visited, confirmed as dens, and mapped on aerial photographs or with a GPS receiver 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 (Figure 2; Table 3). 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 with 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,

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

	CD South Study Area		Colville Delta	
Habitat	Area (km²)	Availability (%)	Area (km²)	Availability (%)
Open Nearshore Water (marine)	0	0.0	10.02	1.8
Brackish Water	0	0.0	6.53	1.2
Tapped Lake with Low-water Connection	1.61	1.0	21.62	3.9
Tapped Lake with High-water Connection	13.56	8.7	20.77	3.8
Salt Marsh	1.59	1.0	16.55	3.0
Tidal Flat	0	0.0	56.01	10.2
Salt-killed Tundra	0	0.0	25.64	4.7
Deep Open Water without Islands	10.02	6.4	20.77	3.8
Deep Open Water with Islands or Polygonized Margins	2.43	1.6	7.76	1.4
Shallow Open Water without Islands	0.39	0.3	2.02	0.4
Shallow Open Water with 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 with 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

Brackish Water, Salt Marsh, and Salt-killed Tundra than either the more northerly CD North area (Johnson et al. 2002) or the entire delta as a whole.

The ground-search area at CD South (Figure 2) included 14 wildlife habitat types (Table 4). Wet Sedge–Willow Meadow 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 with 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.

CONDITIONS IN THE STUDY AREA IN 2001

The breeding season in 2001 was similar to 2000, and both years were unusual among recent years, because weather and flooding river conditions delayed the onset of nesting for large waterbirds on much of the Colville River Delta. May 2001 was characterized by below average temperatures on the Colville River Delta, with mean daily temperatures above freezing only on 31 May, and it was the coldest May recorded at Colville Village (the Helmericks homesite)

Table 4. Availability of wildlife habitat types in the CD South ground-search area, Colville River Delta, Alaska, 2000–2001.

Habitat	2000 Area (km²)	2000 Availability (%)	2001 Area (km²)	2001 Availability (%)
Tapped Lake with Low-water Connection	<0.01	0.0	<0.01	0.0
Tapped Lake with High-water Connection	0.54	9.3	0.64	6.6
Salt Marsh	<0.01	<0.1	0.24	2.5
Deep Open Water without Islands	0.22	3.8	0.22	2.3
Deep Open Water with Islands or Polygonized Margins	0.39	6.7	0.44	4.5
Shallow Open Water without Islands	0.01	0.2	0.02	0.2
Shallow Open Water with Islands or Polygonized Margins	0.01	0.1	0.01	0.1
Aquatic Sedge with Deep Polygons	0.02	0.3	0.02	0.2
Aquatic Grass Marsh	0.02	0.4	0.11	1.1
Nonpatterned Wet Meadow	0.28	4.8	0.39	4.0
Wet Sedge–Willow Meadow	2.20	37.6	3.99	41.2
Moist Sedge–shrub Meadow	1.27	21.8	2.18	22.5
Riverine or Upland Shrub	0.85	14.6	1.15	11.9
Barrens	0.03	0.5	0.29	3.0
TOTAL	5.85	100	9.70	100

between 1997 and 2001. During winter 2000–2001, cumulative snow deposition was high in the region—total snow deposition in Prudhoe Bay was one of the highest on record, with much of the snow falling in May (National Resources Conservation Service, unpubl. data). Snow was recorded at Colville Village on all but 7 days in May 2001 (NOAA: http// lwf. ncdc. noaa. gov/ oa/ ncdc. html). However, snowmelt was rapid in June 2001—in the Kuparuk Oilfield (~25 km east of the Colville River Delta), snow cover on the tundra decreased from nearly 100% on 1 June to 30–40% on 9 June. On the delta, ice remained on small, shallow lakes until at least mid-June 2001, and on large, deep lakes into early July. Late snowmelt was coupled with late and rapid river breakup in early June 2001, resulting in extensive flooding of low-lying and coastal areas, but not as extensive as in 2000.

Comparison of recent temperature records from the Colville River Delta with long-term temperature records from the adjacent Kuparuk Oilfield indicate that annual trends are similar but temperatures tend to be cooler on the delta (more coastally influenced) (Figure 3). In Kuparuk, May 2001 was among the coldest on record. Based on the long-term records from the Kuparuk Oilfield, May temperatures were colder and snowmelt was later in 2001 relative to all previous years since 1992 (when ARCO initiated wildlife investigations on the delta), even more so than in 1997 and 1999, 2 years that were marked by cool temperatures and late snowmelt. In total, only 54 thaw-degree days accumulated between 15 May (approximate arrival date of birds) and 15 June (usual end of nest initiation for most geese and swans), with almost all of the accumulation in June (Figure 3; thaw-degree days are calculated as the cumulative number of degrees per day above freezing [0° C] during a particular period). In comparison, 120 thaw-degree days accumulated during the same period in 1998, a year of early snowmelt.

Cold temperatures and late snowmelt can delay the onset of nesting and increase energy expenditure by nesting birds, often exerting strong impacts on breeding success. Observations

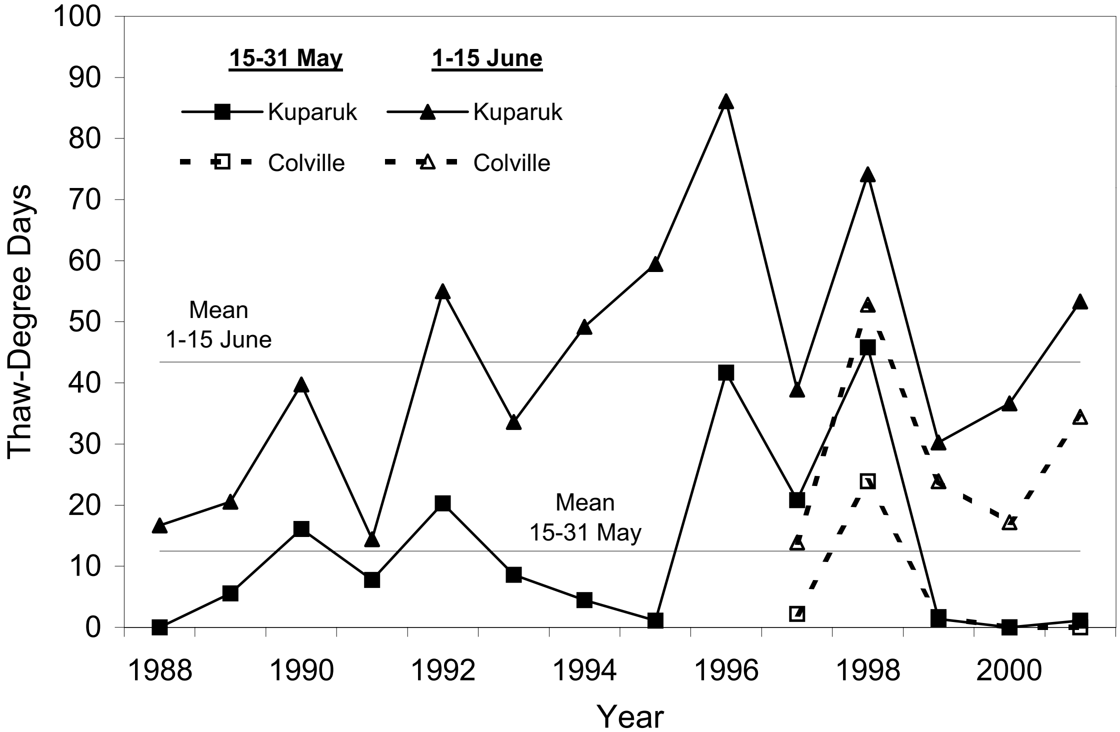

Figure 3. Cumulative number of thaw-degree days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield (1988–2001) and Colville River Delta (1997–2001), Alaska. Mean values computed from Kuparuk data (*n* = 14 years).

confirmed late nest initiation of large birds in 2001, including Tundra Swans, Greater White-fronted Geese, and all 3 species of loons. Young Tundra Swans were unusually small during the brood-rearing survey on 16–18 August. Observations by researchers in Prudhoe Bay in mid-September also indicated that many young swans and loons were still incapable of migrating. These observations suggest that some young of large waterbirds may not have survived to migrate from the breeding area in 2001.

WILDLIFE SURVEYS AND HABITAT ANALYSES

GROUND SEARCHES FOR LARGE WATERBIRDS

In 2001, 83 nests of 16 species of birds were located in the ground-search area at CD South (Figure 4, Table 5). Twenty species have been recorded nesting in the ground-search area since surveys were initiated in 2000. The most common nesting birds were Greater White-fronted Geese, Willow Ptarmigan, and Northern Pintails (this survey excludes nests of small shorebirds and songbirds). All other species had fewer than 5 nests. Noteworthy nesting species in 2001 included a Northern Harrier (1 nest; it rarely nests on the Arctic Coastal Plain) and Short-eared Owl (3 nests). Short-eared Owls nest irruptively, being uncommon or absent during most years but periodically abundant when lemmings and voles also are abundant.

Estimates of nesting success were calculated for waterfowl and other species that generally leave adequate sign at the nest site for determination of success (this excludes ptarmigan, shorebirds, and most gulls, jaegers, and terns). In general, nesting success in the ground-search area at CD South was low in both years. Nesting success of Greater White-fronted Geese was similar between years: 55% in 2000 and 56% in

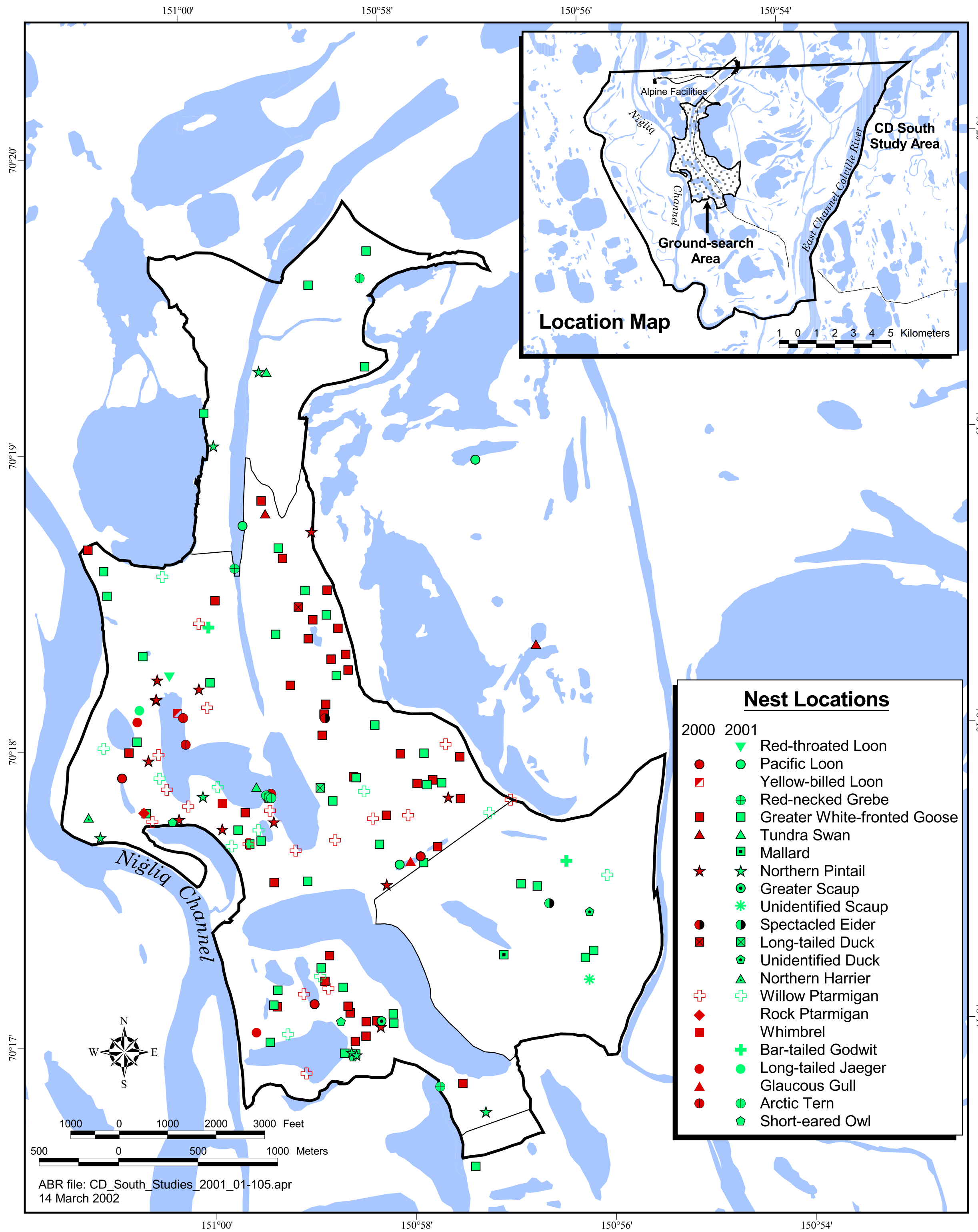

Figure 4. Distribution of waterfowl, loon, and other waterbird nests in the CD South ground-search area, Colville River Delta, Alaska, 2000 and 2001.

Table 5. Number of nests and nest success of birds in the CD South ground-search area, Colville River Delta, Alaska, 2000–2001.

	Number of Nests					Nesting Success[a] (%)	
	2000	2001					
Species	Total	Total	Failed	Successful	Unknown Fate	2000	2001
Red-throated Loon	1[b]	1	1	0	0	100[b]	0
Pacific Loon	3	2	2	0	0	≥33	0
Yellow-billed Loon	1[c]	0	0	0	0	0	-
Red-necked Grebe	0	2	0	0	2	-	unk
Greater White-fronted Goose	36	40	17	22	1	55	56
Tundra Swan	1	2	0	2	0	0	100
Mallard	0	1	0	1	0	-	100
Northern Pintail	12	7[d]	5	2	0	29	8
Greater Scaup	0	1	1	0	0	-	0
Unidentified Scaup	0	1[e]	1	0	0	-	0
Spectacled Eider	1	1	1	0	0	0	0
Long-tailed Duck	1	2	2	0	0	0	0
Unidentified duck	0	1	1	0	0	-	0
Northern Harrier	0	1	1	0	0	-	0
Willow Ptarmigan	17	11	1	0	10	unk	unk
Rock Ptarmigan	1	0	0	0	0	unk	-
Whimbrel	1	0	0	0	0	unk	-
Bar-tailed Godwit	0	2	0	0	2	-	unk
Long-tailed Jaeger	2	1	0	0	1	unk	unk
Glaucous Gull	1	0	0	0	0	0	-
Arctic Tern	4	4	0	0	4	unk	unk
Short-eared Owl	0	3	2	1	0	-	33
TOTAL	82	83	35	29	20		

[a] Post-hatch nest checks were appropriate for estimating nest success only for waterfowl species and owls (which have a long nestling period). Estimates are provided for loons and gulls, when possible, based on observations of sign of failure at nests (i.e., predator sign) or observation of broods on nesting lakes.
[b] Includes nests presumed from the presence of broods during the nest fate check.
[c] Yellow-billed Loon nest seen on aerial survey.
[d] Includes two probable Northern Pintail nests identified from down and feather characteristics.
[e] Includes one probable Scaup spp. nest identified from down and feather characteristics.

2001 (Table 5). For Northern Pintails, nesting success decreased from 29% in 2000 to 8% in 2001. In both years, all nests of other duck species failed. All 3 loon nests in the ground-search area failed in 2001. The one Red-throated Loon nest and 1 of 3 Pacific Loon nests were known to be successful in 2000 (fates were unknown for the Yellow-billed Loon and 2 Pacific Loon nests in 2000). Only 1 of the 3 Short-eared Owl nests in 2001 was successful.

Nest density for all species was 8.6 nests/km² in the ground-search area in 2001 (Table 6). The density of waterbird nests was 7.0 nests/km². This density compares to 14.2 nests/km² (all species) and 10.9 waterbird nests/km² in a smaller ground-search area in 2000 (Burgess et al. 2000). The nesting density was lower in 2001 than it was in 2000, even within the area that was searched in both years, where 81 nests were found in 2000 and 72 nests were found in 2001. The reduction in nest density is attributable primarily to fewer nesting Northern Pintails and ptarmigan in 2001 (Table 5).

The density of nests in the ground-search area at CD South is similar to, or slightly higher than, the 6-year mean nest density in the ground-search area at Alpine (7.7 nests/km², SD = 1.9 nests/km²), and considerably lower than that reported in 2000 and 2001 for the ground-search area at CD North (20.1 and 16.7 nests/km², respectively) (Table 6). CD South supports higher densities of Greater White-fronted Goose, Northern Pintail, and ptarmigan nests and lower densities of Long-tailed Duck nests than Alpine (Table 6; Johnson et al. 2000b, 2002a). Higher densities were reported for most species in the CD North area than in either CD South or Alpine; exceptions were Northern Pintail and ptarmigan, which were higher in both Alpine and CD South. The density of waterbird nests in CD North was 1.8 to 2.1 times that recorded in the ground-search area at CD South.

Sixteen broods or brood groups of 8 species were observed in the ground-search area at CD South during 2000, and 23 broods or brood groups of 4 species were observed in 2001 (Table 7, Figure 5). Most broods in both years (8 and 15, respectively) belonged to Greater White-fronted Geese. Although no Red-throated Loon nests were found in 2000, one brood was observed in the ground-search area (Table 7), suggesting that a nest was missed during the nest search that year. No loon broods were observed in the ground-search area at CD South in 2001. Three broods of Tundra Swans were observed in the ground-search area in 2001 (none in 2000) although only 2 nests occurred, undoubtedly reflecting the relatively high mobility of swan broods. Larger numbers of duck broods were observed in 2000 than in 2001, suggesting higher nesting success for ducks in 2000. Interestingly, broods of Red-breasted Mergansers were observed in the ground-search area at CD South in both years of the study, although no nests were found in either year. Gerhardt et al. (1988) also reported broods of Red-breasted Mergansers on the delta without detecting nests. The most likely explanation at CD South is that mergansers (like swans and other waterfowl) have highly mobile broods and that they nested outside the search area and brought their broods to the large lakes in CD South.

Since 2000, all 3 species of loons have been found nesting in the ground-search area at CD South (Table 5). One Red-throated Loon nest was found in 2001 and brood observations suggested that at least one nest was located in the area in 2000. Pacific Loons were the most abundant loon in the area, with 3 nests in 2000 and 2 nests in 2001. One Yellow-billed Loon nest was found (during aerial surveys) in 2000. Nesting success of loons was estimated from brood observations and evidence of predation at nests. Based on this evidence, nesting success of loons appeared to be lower in 2001 than in 2000, because no broods were located in the ground-search area in 2001. Habitat information was collected for one Red-throated Loon nest (in 2001) and one brood (in 2000)—both were located in Aquatic Sedge with Deep Polygons (Table 8). Pacific Loon nests occurred in 4 habitats: Shallow Open Water with Islands, Aquatic Grass Marsh, Wet Sedge–Willow Meadow, and Moist Sedge–Shrub Meadow. The single Yellow-billed Loon nest was located in Aquatic Sedge with Deep Polygons. The distribution of loon nests and broods across the CD South study area, as well as habitat selection on the delta is discussed in greater detail under *Loon Surveys*, below.

Four species of geese are known to nest on the Colville River Delta (Canada Goose, Brant, Greater White-fronted Goose, and Snow Goose), but only the Greater White-fronted Goose has been

Table 6. Densities (nests/km²) of nests in the CD South and CD North ground-search areas, 2000–2001, and mean nest density in the Alpine project area, 1996–2001, Colville River Delta, Alaska (Alpine data from Johnson et al. 2001, 2002a; CD North data from Johnson et al. 2000a, 2002b).

	CD South		CD North		Alpine 6-year
Species	2000	2001	2000	2001	Mean
Red-throated Loon	0.17[a]	0.10	0.82[a]	0.50[a]	0.14
Pacific Loon	0.52	0.21	0.74	0.61	0.29
Yellow-billed Loon	0.17[b]	0	0.16	0.22[b]	0.05
Red-necked Grebe	0	0.21	0	0	0.12
Greater White-fronted Goose	6.15	4.12	9.84	9.89[c]	3.42[c]
Canada Goose	0	0	0	0	0.07
Brant	0	0	2.46	1.34	0.23[c]
Tundra Swan	0.17	0.21	0.25	0.17	0.39
Mallard	0	0.10	0	0	0
Northern Shoveler	0	0	0	0	0.07[c]
Northern Pintail	2.06[c]	0.72	0.25[c]	0.11[c]	0.49[c]
Green-winged Teal	0	0	0	0	0.09[c]
Greater Scaup	0	0.10	0	0	0.13
Lesser Scaup	0	0	0	0	0.01
Unidentified Scaup	0	0.10	0	0	0.14[c]
Spectacled Eider	0.17	0.10	1.15[c]	0.39[c]	0.04
King Eider	0	0	0.16	0	0.01
Long-tailed Duck	0.17	0.21	1.48[c]	1.17[c]	0.39[c]
Unidentified duck	0	0.10	0.08	0.06	0.08
Northern Harrier	0	0.10	0	0	0
Willow Ptarmigan	2.92	1.13	0.66	0.45	0.72
Rock Ptarmigan	0.17	0	0	0	0.03
Unidentified ptarmigan	0	0	0	0.06	0.07
Sandhill Crane	0	0	0	0	0.01
Whimbrel	0.17	0	0	0	0
Bar-tailed Godwit	0	0.21	0	0	0.08
Common Snipe	0	0	0	0	0.02
Parasitic Jaeger	0	0	0.08	0.11	0.12
Long-tailed Jaeger	0.34	0.10	0	0	0.06
Glaucous Gull	0.17	0	0.82	0.17	0.06
Sabine's Gull	0	0	0.41	0.50	0.02
Arctic Tern	0.69	0.41	0.77	0.95	0.44
Short-eared Owl	0	0.31	0	0	0.01
Area searched (km²)	5.85	9.70	12.20	17.90	11.4–17.2
Waterbird[d] nest density	10.77	7.01	19.43	16.20	6.99
Total nest density	13.85	8.55	20.08	16.70	7.67
Total number of nests	82	83	245	299	69–177
Number of species	14	16	15	14	16–19

[a] Includes nests presumed from the presence of broods during the nest fate check
[b] Includes Yellow-billed Loon nest or nests seen on aerial surveys.
[c] Includes nests identified from feather and down samples.
[d] Waterbirds include: loons, grebes, swans, ducks, cranes, jaegers, gulls, terns, and large shorebirds.

Table 7. Broods or brood groups located in the CD South ground-search area, Colville River Delta, Alaska, 2000–2001.

	2000			2001		
Species	Adults	Young	Broods or Brood Groups	Adults	Young	Broods or Brood Groups
Red-throated Loon	2	1	1	0	0	0
Pacific Loon	1	1	1	0	0	0
Greater White-fronted Goose	22	32	8	28	51	15
Tundra Swan	0	0	0	6	7	3
Northern Pintail	1	7	1	0	0	0
Green-winged Teal	1	6	1	0	0	0
Greater Scaup	2	11	2	0	0	0
Red-breasted Merganser	1	5	1	4	16	4
Willow Ptarmigan	0	0	0	2	4	1
Long-tailed Jaeger	2	1	1	0	0	0
TOTAL	32	64	16	40	78	23

found nesting or rearing broods in the ground-search area at CD South (Table 5). Greater White-fronted Geese were the most abundant breeding bird in the ground-search area in both years with nest densities of 6.2 and 4.1 nests/km² in 2000 and 2001, respectively (Table 6). The density of Greater White-fronted Goose nests appears somewhat higher in the CD South ground-search area than in the adjacent Alpine ground-search area, where the 6-year mean was 3.4 nests/km² (range 2.0–5.0 nests/km²) (Johnson et al., 2002a). These densities are in the upper limits of ranges reported for the lower Colville River Delta in the early 1980s (0–6.6 nests/km²; Rothe et al. 1983), and in the upper limit of ranges reported for other known nesting areas of Greater White-fronted Geese: the Yukon-Kuskokwin Delta in western Alaska (2.7–6.3 nests/km²) and Kent Peninsula in the Northwest Territories (2.6–5.2 nests/km²) (Ely and Dzubin 1994). However, the highest nest densities of the Greater White-fronted Goose were reported recently in the CD North ground-search area in both 2000 and 2001 (9.8 and 9.9 nests/km², respectively; Johnson et al. 2002). Although annual nesting success in the ground-search area at CD South was relatively low (29% and 8% in 2000 and 2001, respectively; Table 5), Greater White-fronted Goose broods were more abundant than any other species (Table 7). The ratio of young per adult was similar between years (1.5 young/adult in 2000 and 1.8 young/adult in 2001; Table 7). Nests were located in 4 habitats: Wet Sedge–Willow Meadow (52 nests), Moist Sedge–Shrub Meadow (22 nests), Nonpatterned Wet Meadow (1 nest), and Riverine or Upland Shrub (1 nest) (Table 8). Broods were widespread, occurring in 8 of 14 available habitats (Table 9). The 2 habitats most used for brood-rearing by Greater White-fronted Geese were Aquatic Grass March (36% of all groups) and Tapped Lake with High-water Connection (21%). Analysis of habitat selection and further discussion of the abundance and distribution of Greater White-fronted Geese during brood-rearing and fall staging can be found under *Goose Surveys*, below.

Tundra Swans nest widely across the Colville River Delta and 3 nests have been found in the ground-search area at CD South, 1 in 2000 and 2 in 2001 (Table 5). The 2000 nest failed and both nests in 2001 were successful. Three broods were observed in the ground-search area in 2001, undoubtedly reflecting the movement of at least one brood into the area after hatching. The density of swan nests was similar among the 3 ground-search areas on the delta: 0.17–0.21 nests/km² in CD South, 0.17–0.25 nests/km² in CD North, and a 6-year mean of 0.39 nests/km² in the Alpine area (Table 6). Swan nests occurred in 2

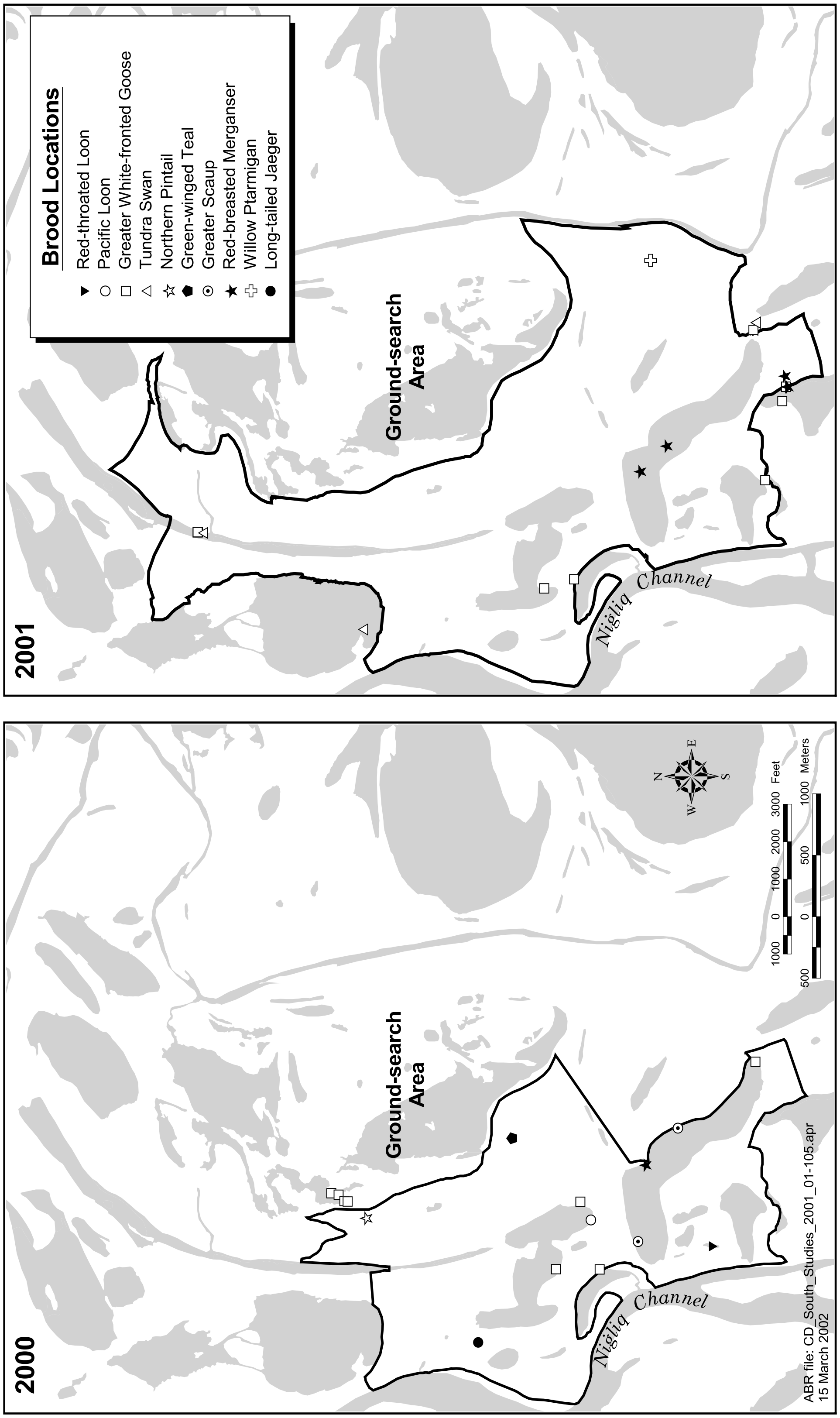

Figure 5. Distribution of broods in the CD South ground-search area, Colville River Delta, Alaska, 2000 and 2001.

Table 8. Number of nests in each habitat type in the CD South ground-search area, Colville River Delta, 2000–2001.

Species	Tapped Lake with High Water Connection	Salt Marsh	Deep Open Water with Islands	Shallow Open Water with Islands	Aquatic Sedge with Deep Polygons	Aquatic Grass Marsh	Nonpatterned Wet Meadow	Wet Sedge-Willow Meadow	Moist Sedge–Shrub Meadow	Riverine or Upland Shrub	Total
Red-throated Loon					1						1
Pacific Loon				1		1		2	1		5
Yellow-billed Loon					1						1
Red-Necked Grebe	1					1					2
Greater White-fronted Goose							1	52	22	1	76
Tundra Swan			1						2		3
Mallard								1			1
Northern Pintail							1	5	11	2	19
Greater Scaup									1		1
Unidentified Scaup								1			1
Spectacled Eider								2			2
Long-tailed Duck								3			3
Unidentified Duck								1			1
Northern Harrier										1	1
Willow Ptarmigan							1	15	5	7	28
Rock Ptarmigan									1		1
Whimbrel								1			1
Bar-tailed Godwit								2			2
Long-tailed Jaeger								1	2		3
Glaucous Gull				1							1
Arctic Tern		1	2					5			8
Short-eared Owl									2	1	3
TOTAL	1	1	3	2	2	2	3	91	47	12	164

Table 9. Number of broods or brood groups in each habitat type in the CD South ground-search area, Colville River Delta, 2000–2001.

Species	Tapped Lake with High-water Connection	Salt Marsh	Deep Open Water with Islands	Shallow Open Water without Islands	Aquatic Grass Marsh	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		11	2	1		2	2	23
Tundra Swan	1				1					1	3
Northern Pintail								1			1
Green-winged Teal							1				1
Greater Scaup	2										2
Red-breasted Merganser	3				2						5
Willow Ptarmigan							1				1
Long-tailed Jaeger								1			1
TOTAL	8	2	2	1	14	2	3	2	2	3	39

habitats in the ground-search area at CD South: Deep Open Water with Islands and Moist Sedge–Shrub Meadow (Table 8). Broods were observed in 3 habitats (Tapped Lake with High-water Connection, Aquatic Grass Marsh, and Barrens; Table 9), but brood locations may have been affected by disturbance from observers on foot. Analysis of habitat selection and further information on abundance and distribution of Tundra Swans in provided under *Swan Surveys*, below.

At least 5 duck species nested in the ground-search area at CD South in 2000 and 2001 (2 nests could not be identified to species): Northern Pintail (19 nests), Long-tailed Duck (3 nests), Spectacled Eider (2 nests), Mallard (1 nest), and Greater Scaup (1 nest) (Table 5). Broods of 2 additional duck species also were observed in 2000–2001: Green-winged Teal (1 brood) and Red-breasted Merganser (5 broods) (Table 7).

The Northern Pintail was the only abundant nesting duck species in CD South and it was more abundant in 2000 than in 2001. Pintails appear to nest at higher densities in the CD South ground-search area than in either the Alpine or CD North areas (Table 6). Northern Pintails nested in the same 4 habitats used by nesting Greater White-fronted Geese in the ground-search area at CD South (Table 8).

Long-tailed Duck nests were found in both years in the ground-search area at CD South, although nest density was low (≤0.2 nests/km²). The density of Long-tailed Duck nests appears to increase from south to north on the Colville River Delta, ranging from the low density at CD South to moderate densities at Alpine (6-year mean = 0.4 nests/km²) to the highest densities at CD North (1.5 and 1.2 nests/km² in 2000 and 2001, respectively). All 3 Long-tailed Duck nests in the ground-search area at CD South were located in Wet Sedge–Willow Meadow (no broods were observed). In the early 1980s, the USFWS recorded the Long-tailed Duck as the second-most-abundant large bird on the Colville River 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).

A single Spectacled Eider nest was located in the ground-search area at CD South in both 2000 and 2001. Both nests failed and no Spectacled Eider broods were observed in the CD South area. The eider nest in 2001 was 1.8 km southeast of the nest found in 2000. The 2000 and 2001 nests were located 9.6 and 11.4 km inland from the Beaufort Sea coast, respectively, and both were in Wet Sedge–Willow Meadow. Nesting Spectacled Eiders are uncommon this far inland on the delta and nest densities are much higher in the more coastal CD North area (Table 6). Eider distribution and habitat selection are discussed in greater detail under *Eider Surveys*, below.

The Mallard nest found in 2001 was the first recorded evidence of breeding by this species on the Colville River Delta. Mallards are not abundant either on the delta (Rothe et al. 1983) or on the Arctic Coastal Plain (Mallek et al. 2002). Typically, only a few thousand Mallards are recorded on annual breeding-pair aerial surveys of the Arctic Coastal Plain (Mallek et al. 2002).

One Greater Scaup nest was located in the ground-search area at CD South in 2001 (none in 2000). An unidentified scaup nest also was located in the area in 2001. Both nests failed. Nesting scaup are uncommon on the delta but have been recorded in the Alpine area, where the 6-year mean density was 0.28 nests/km² (both species combined, Table 6).

Green-winged Teal and Red-breasted Mergansers were recorded in the ground-search area at CD South only during brood-rearing, no nests were found in either 2000 or 2001. Green-winged Teal regularly nest in the adjacent Alpine ground-search area (mean density = 0.09 nests/km², *n* = 6 years), but no nests of Red-breasted Mergansers have been found in that area either.

The Willow Ptarmigan was the second-most-abundant nesting species in the ground-search area at CD South. The density of Willow Ptarmigan nests appears to increase from north to south across the 3 ground-search areas on the delta: ranging from 0.5–0.7 nests/km² in CD North to 0.72 nests/km² in the Alpine area (6-year mean) to 1.1–2.9 nests/km² in CD South (Table 6). Willow Ptarmigan nested in the same 4 habitats used by Greater White-fronted Geese and Northern Pintails: Nonpatterned Wet Meadow, Wet Sedge–Willow Meadow, Moist Sedge–Shrub Meadow, and Riverine or Upland Shrub (Table 8).

Two large shorebird species were found during nest searches in the ground-search areas at CD South. One Whimbrel nest was found in 2000 and 2 Bar-tailed Godwit nests were found in 2001 (Table 5). Both species nest at relatively low densities across the delta, but no Whimbrel nests have been found in the other 2 ground-search areas on the delta. The mean nest density of Bar-tailed Godwits in the Alpine ground-search area was 0.1 nests/km² (n = 6 years), which is similar to that observed in CD South (0 and 0.2 nests/km², in 2000 and 2001, respectively; Table 6). Bar-tailed Godwits have not been found nesting in the ground-search area at CD North. All 3 nests of the 2 shorebird species in the ground-search area at CD South were located in Wet Sedge–Willow Meadow (Table 8).

Three species in the family Laridae have been observed nesting in the ground-search area at CD South: Long-tailed Jaeger, Glaucous Gull, and Arctic Tern (Table 5). Parasitic and Pomarine jaegers and Sabine's Gulls also have been observed, but no nests have been found. The density of Long-tailed Jaegers in the ground-search area at CD South was 0.1–0.3 nests/km², which is somewhat higher than in the Alpine area (mean = 0.06 nests/km², n = 6 years; Table 6). No Long-tailed Jaeger nests have been found in the ground-search area at CD North. Only one Glaucous Gull nest has been found in the ground-search area at CD South (in 2000). Arctic Terns are the most common larid species among the 3 ground-search areas in the delta and nest densities appear similar among areas, ranging from 0.41–0.95 nests/km².

EIDER SURVEYS

Background

Between 1957 and 1992, Spectacled Eiders 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). Since 1993, the western Alaska population appears to be stable or declining only slightly (Peterson et al. 2000). 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). On the Arctic Coastal Plain, Spectacled Eider numbers may have declined slightly (~2%) since 1993, but the trend is not significant (Larned et al. 2001). 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 (NPRA), but uncommon east of there at Storkersen Point. Spectacled Eiders arrive on the Colville River Delta in early June, and the earliest nests have been recorded between 8 and 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 River 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 (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 River Delta, King Eiders are common visitors but uncommon or rare nesters (Simpson et al. 1982, North et al. 1984, Johnson 1995). King Eiders arrive on the Colville River Delta slightly later than Spectacled Eiders, frequently occurring in flocks on open channels and waterbodies in early June, after Spectacled Eiders have dispersed to nesting habitats (Johnson 1995). King Eiders appear to 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 coast they favor barrier islands as nesting sites (Johnson and Herter 1989). Except for the barrier islands, Common Eiders are rare on the Colville River Delta (Simpson et al. 1982, Renken et al. 1983, North et al. 1984, Johnson et al. 1998). None have been observed in the CD South area.

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 east of Point Barrow (Johnson and Herter 1989). Five Steller's Eiders were seen briefly on the outer delta in June 1995 (J. Bart, Boise State University, pers. comm.), and one pair was observed on the outer delta in June 2001 (Johnson et al. 2002). Single pairs also were sighted in the Kuparuk Oilfield in June 2000 and 2001 (S. Schlentner and D. Lum, ABR, Inc., pers. comm.).

Distribution and Abundance

Pre-nesting

The pre-nesting distribution of both Spectacled and King eiders on the delta in 2001 was similar to that recorded on surveys flown between 1992 and 2000 (Figure 6, Appendix C1 and C2). Spectacled and King eiders on the Colville River Delta were closely associated with coastal areas in all years. Across the entire delta, the mean distance of Spectacled Eiders from the coast was 4.0 km (n = 219 sightings). The maximal distance of Spectacled Eiders from the coast was 14.3 km. Derksen et al. (1981) reported that Spectacled Eiders in the NPRA 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 River Delta had a similar affinity for the coast: the maximal distance a group was found from the coast between 1993 and 2001 was 14.2 km, and the mean distance was 5.2 km (n = 126 sightings).

Two eiders (both King Eiders) were observed in the CD South study area during pre-nesting surveys in 2001 (Table 10). In 8 years of surveys, the number of eiders observed in the CD South area has ranged from 0 to 11. Although neither species is abundant, King Eiders tend to outnumber Spectacled Eiders (in 7 of 8 years). The maximum number of Spectacled Eiders observed in the CD South study area in any year was 2 (in 1995, 1997, 1998, and 2000).

Over 8 years (1993–1998, and 2000–2001; 1992 was not included because the sample of plots that year was not representative of the delta), the indicated density of pre-nesting Spectacled Eiders in the CD South study area has been ≤0.01 birds/km² (Table 10). The indicated density of King Eiders during pre-nesting has varied from 0 to 0.08 birds/km², averaging 0.03 birds/km². In nearby areas, the densities of Spectacled and King eiders during pre-nesting are higher than they are in the CD South study area. In the adjacent CD North study area, indicated densities of Spectacled Eiders in 1993–2001 ranged from 0.14 to 0.28 birds/km² and densities of King Eiders ranged from 0.01 to 0.08 birds/km² (mean = 0.05 birds/km²; Johnson et al. 2002). East of the delta in the Kuparuk Oilfield, indicated densities of Spectacled and King eiders 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. 2002). Across the entire Arctic Coastal Plain from 1993 to 2001, indicated densities of Spectacled Eiders were 0.17–0.31 birds/km² and indicated densities of King Eiders were 0.32–0.55 birds/km² (Larned et al. 2001).

Habitat Use

Pre-nesting

In 8 years of surveys during pre-nesting, Spectacled Eiders were observed in 4 habitat types in the CD South study area: Tapped Lake with Low-water Connection, Tapped Lake with High-water Connection, River or Stream, and Aquatic Sedge with Deep Polygons (1 group of 2 adults in each type) (Appendix D1). King Eiders were observed in 5 habitats: River or Stream (54% of 13 groups), Tapped Lake with High-water Connection (15%), Wet Sedge–Willow Meadow (15%), Tapped Lake with Low-water Connection (8%), and Riverine or Upland Shrub (8%).

During 8 years of surveys across the entire delta, 6 of 24 habitats were preferred by pre-nesting Spectacled Eiders: Brackish Water, Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons (Appendix D2). None of these habitats comprise more than 2% of the CD South study area and Brackish Water and Salt-killed Tundra do not occur there (Table 3). Pre-nesting Spectacled Eiders avoided 6 habitats: Tidal Flat, River or Stream, Wet Sedge–Willow

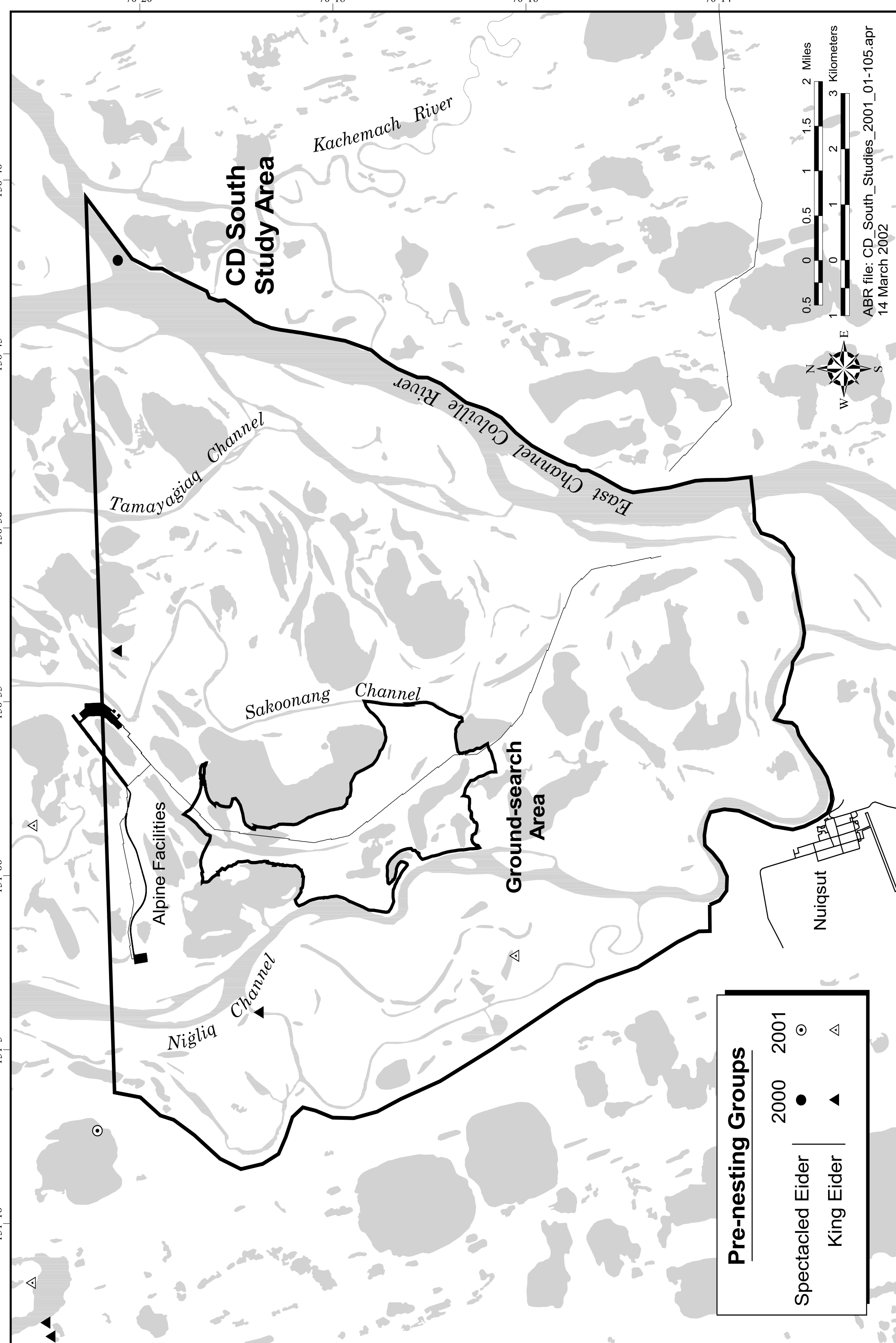

Figure 6. Distribution of Spectacled and King eider groups during pre-nesting aerial surveys in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

Table 10. Observed number (flying and non-flying birds), indicated number, and indicated density (birds/km²) of eiders during pre-nesting aerial surveys in the CD South study area (155.9 km²), Colville River Delta, Alaska, 1993–1998, and 2000–2001 (pre–2000 data from Johnson et al. 1999a)

	Spectacled Eider			King Eider			Unidentified Eider			Total		
Year	Observed Number	Indicated Number[a]	Indicated Density	Observed Number	Indicated Number	Indicated Density	Observed Number	Indicated Number	Indicated Density	Observed Number	Indicated Number	Indicated Density
1993[b]	0	0	0	3	2	0.03	1	0	0	4	2	0.03
1994[c]	0	0	0	0	0	0	0	0	0	0	0	0
1995	2	2	0.01	4	4	0.03	0	0	0	6	6	0.04
1996	0	0	0	8	12	0.08	0	0	0	8	12	0.08
1997	2	2	0.01	9	10	0.06	0	0	0	11	12	0.08
1998	2	2	0.01	0	0	0	0	0	0	2	2	0.01
2000	2	2	0.01	6	6	0.04	0	0	0	8	8	0.05
2001	0	0	0	2	2	0.01	0	0	0	2	2	0.01

[a] Indicated number = (number of non-flying males not in groups × 2) + number of non-flying birds in groups (see USFWS 1987a).
[b] Coverage of survey area in 1993 was 50%.
[c] In 1994, 31 km² west of the Nigliq (Nechilik) Channel were not surveyed.

Meadow, Moist Sedge–Shrub Meadow, Riverine or Upland Shrub, and Barrens. The remaining habitats were used in proportion to their availability. Elsewhere, studies have emphasized the importance of emergent vegetation for eiders using waterbodies. West of the Colville River Delta in the NPRA, 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 River Delta; however, Aquatic Sedge with Deep Polygons (a preferred habitat on the delta), Aquatic Sedge Marsh, and Aquatic Grass Marsh probably are 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 (Table 3).

During 8 years of surveys across the entire delta, 2 habitats were preferred by King Eiders: Brackish Water and River and Stream (Appendix D1). Four habitats were avoided: Nonpatterned Wet Meadow, Wet Sedge–Willow Meadow, Riverine or Upland Shrub, and Barrens. 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, suggests that King Eiders on the delta had not yet dispersed into breeding areas by the time of the pre-nesting surveys (Johnson et al. 1999a). The low number of nests found during later nest searches indicates that the Colville River Delta is used by King Eiders mainly as a stopover during movements to nesting habitats elsewhere. 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

Only 2 Spectacled Eider nests have been found in the ground-search areas at CD South, one each in 2000 and 2001. Both nests were located on polygon rims in Wet Sedge–Willow Meadow habitat about 0.5 m from permanent water.

During 10 years (1992–2001) of nest searching in various locations on the entire delta, 55 nests of Spectacled Eiders have been found in 9 habitats (Appendix D3). The coastal portion of the delta, where Spectacled Eiders concentrate during pre-nesting, also is where eiders nest most commonly (Appendix C3). The farthest distance from the coast that a Spectacled Eider nest has been observed on the Colville River Delta is 13 km. The mean distances from the coast of all eider nests on the delta for which we have records are 3.5 km (n = 55) for Spectacled Eider, 3.9 km (n = 7) for King Eider, 1.4 km (n = 1) for Common Eider, and 2.3 km (n = 4) for unidentified eider. At least 5 nests were located in each of the following habitats (Appendix D3): Salt-killed Tundra (14 nests), Aquatic Sedge with Deep Polygons (12), Wet Sedge–Willow Meadow (8), Nonpatterned Wet Meadow (7), Brackish Water (6), and Deep Open Water with Islands or Polygonized Margins (5).

Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 2.8 m from permanent water (range = 0.1–80 m, n = 55; Johnson et al. 2002; and this study). Because nests are associated with waterbodies, we also evaluated nearest waterbody type for each nests (11 aquatic habitat types total). Most (71%) nests were associated with one of 2 waterbody types: Brackish Water or Deep Open Water with Islands or Polygonized Margins (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 9 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. 2002). 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 NPRA, 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 River Delta: the 3 habitat types that comprise waterbodies with emergents (Aquatic Sedge with Deep Polygons, Aquatic Grass Marsh, and Aquatic Sedge Marsh) together cover only 2.8% of the delta. Therefore, Spectacled Eider nesting habitat on the delta differs somewhat from adjacent tundra areas that have more abundant *Carex* and *Arctophila* waterbodies.

Brood-rearing

No Spectacled or King eider broods were observed during either 2000 or 2001 in the CD South study area. In both years, the nesting attempts of the Spectacled Eiders in the ground-search area were unsuccessful. Since our surveys began on the delta in 1992, we have seen only one Spectacled Eider brood in the CD South study area, and it was using Wet Sedge–Willow Meadow. Little effort has been expended specifically to locate eider broods on the Colville River Delta, but 29 groups of brood-rearing Spectacled Eiders have been recorded since 1983 (Appendix D4). Because eider broods can mix, or creche, the total number of actual broods is unknown; however, the average group size was only 3.7 young, suggesting that most of the groups comprised only 1 or 2 broods. Brood-rearing Spectacled Eiders were located in 9 habitats: Deep Open Water with Islands or Polygonized Margins (24% of groups), Salt-killed Tundra (17%), Wet Sedge–Willow Meadow (14%), Brackish Water (10%), Deep Open Water without Islands (10%), Tapped Lake with Low-water Connection (10%), Aquatic Sedge with Deep Polygons (7%), Tapped Lake with High-water Connection (3%), and Aquatic Grass Marsh (3%). Broods appear to be attracted to coastal lakes; most broods (62%) were seen on water, and the mean distance to waterbodies was 22 m and mean distance to the coast was 3.7 km ($n = 29$). Almost a third of all broods were associated with Deep Open Water with Islands or Polygonized Margins and 24% of all broods were associated with Brackish Water. In the NPRA, 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* wetlands (Bergman et al. 1977).

Only 2 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 20 m from Brackish Water. The other King Eider brood was found in 1992 in Wet Sedge–Willow Meadow, approximately 70 m from Deep Open Water without Islands.

TUNDRA SWAN SURVEYS

Background

Tundra Swans arrive on the Colville River Delta in mid–late May (Simpson et al. 1982, Hawkins 1983) and they 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 1980, 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 aerial surveys, 98 swans and 9 nests were observed in the CD South study area in 2001 (Table 11, Figure 7). One additional nest was found during ground-search activities in 2001. About 18% of the swans observed appeared to be nesting (i.e., they were associated with an observed nests). During 8 years of nesting surveys, between 4% and 18% of swans in the CD South area appeared to be nesting each year. The total number of swans observed during nesting surveys in 2001 was the lowest since 1995, when 87 swans were counted (Table 11). In 1992, 1993, and 1995, fewer than 90 swans were observed during nesting surveys, while in 1997, 1998, and 2000, more than 170 swans were observed.

The number of Tundra Swan nests found in the CD South study area has ranged from 3 to 17 (Table 11). The peak number 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 across the entire delta since 1997 and numbers in the CD South study area parallel those on the Colville River Delta as a whole (Table 11, Appendix D5, Appendix C6). Annually since 1992, 15–38% of swan nests on the delta have been located within the CD South study area.

A previous investigation on the Colville River Delta reported swan nest densities similar to those in CD South: Simpson et al. (1982) found 48 nests (~0.11 nests/km²) on the northern 80% of the delta in 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/km² on the eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km² in the Kuparuk Oilfield and adjacent areas (Anderson et al. 2001).

Brood-rearing

During brood-rearing in 2001, 54 adult and 16 young Tundra Swans were observed in the CD South study area (Figure 7, Table 12). Eight broods were observed (mean brood size = 2.0 young/brood) and 30% of adults were accompanied by broods (Table 12). The apparent nesting success was 89% (8 broods observed/9 known nests), but this estimate may be inflated by movements of broods into the study area (apparent nest success for the entire delta was 81%; Appendix D5). Nonetheless, nesting success appeared to be high in the CD South study area in 2001 by comparison with previous years.

Estimates of apparent nesting success have ranged from 64% to >100% in the CD South study area (Table 11), although values of more than 100% in 1992, 1993, and 2000, indicate that either all nests were not located during aerial surveys or broods from outside the study area moved into the area after hatching and inflated the estimates. Although apparent nesting success was high in 2001, the mean brood size (2.0 young/brood) was the lowest that has been observed in the CD South area since we began conducting aerial surveys. Low brood sizes may be attributable to the late initiation of nesting in 2001 due to prolonged snow cover in nesting habitats followed by widespread flooding of the delta. In general, in the CD South study area in 2001, Tundra Swans were present in numbers similar to those observed in recent years but, despite what appears to be relatively high nesting success, production of young swans was poor due to the small average brood size.

Since 1992, the total number of swans observed in the CD South study area during the brood-rearing survey each year has ranged from 65 (1992) to 98 (1996) (Table 12). The 70 swans counted in 2001 represent the lowest count since 1995. The annual number of young swans observed in CD South has ranged from 10 (1993) to 35 (1996), and the number observed in 2001 (16) was slightly below the 8-year mean of 18.5 young. The proportion of adults with broods was higher in 2001 than in any previous year.

Table 11. Number and density (no./km²) 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 2000–2001 (pre-2000 data from Johnson et al. 1999a).

	Birds			Nests		
Year	Total	Density	Percent Nesting	Total	Density	Apparent Success[a] (%)
1992	72	0.46	4	3	0.02	166
1993	51	0.33	10	3	0.02	133
1995	87	0.56	15	7	0.04	71
1996	174	1.12	15	17	0.11	65
1997	232	1.49	8	11	0.07	64
1998	256	1.64	7	11	0.07	64
2000	179	1.15	10	10	0.06	120
2001	98	0.63	18	9	0.06	89

Across the entire delta and during all 8 years of aerial surveys, the number of broods has varied from 14 (1993) to 32 (1996) (Appendix D5, Appendix C7). Nest and brood densities in 2001 were similar to recent seasons, but mean brood size for the whole delta (1.7 young/brood; $n = 22$) was less than that in the CD South study area (2.0 young/brood; $n = 8$), and the lowest value observed since 1992.

During 8 years of monitoring between 1992 and 2001, 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 adjacent areas of the Arctic Coastal Plain. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995–2001) recorded mean brood sizes of 2.0–2.8 young/brood and densities of 0.02–0.04 broods/km² (Anderson et al. 2002). In the Kuparuk Oilfield, nesting success of swans was 88% and mean brood size was 2.1 young ($n = 70$) in 2001. These statistics represent one of the highest estimates for nesting success and one of the lowest estimates for mean brood size on record in Kuparuk since 1988 (Anderson et al. 2002).

Two earlier studies on the Colville River 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 River Delta in 1981. In 1982, nesting success was 71% ($n = 48$ nests), and mean brood size was 2.5 young/brood (Simpson et al. 1982). In a 3-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

A fall-staging survey for swans was not conducted in 2001. In previous years, fall-staging surveys have covered the Colville River Delta and staging areas adjacent to the delta on both the east and west sides. In general, large numbers of swans have not been found on the CD South study area during fall staging (Table 13).

During previous fall-staging surveys, Tundra Swans have been widely distributed on the delta but most swans occur in several large flocks that occupy river channels on the outer delta (Appendix C8). Our observations confirm earlier records indicating that the largest aggregations of fall-staging Tundra Swans on the Arctic Coastal Plain occur in wetlands immediately to the east of the delta, between the Miluveach River and Kalubik Creek (Seaman et al. 1981). In 1996, 355 swans were counted on the delta and 415 were counted 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

Table 12. Numbers and density (no./km²) 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 2000–2001 (pre-2000 data from Johnson et al. 1999a).

Year	Adults	Young	Total	Density[a]	Percent with Broods[b]	Percent Young	Mean Brood Size	Broods Total	Broods Density
1992	53	12	65	0.42	15	18	2.4	5	0.03
1993	57	10	67	0.43	10	15	2.5	4	0.03
1995	53	17	70	0.45	14	24	3.4	5	0.03
1996	63	35	98	0.63	21	36	3.2	11	0.07
1997	56	17	73	0.47	18	23	2.4	7	0.04
1998	78	16	94	0.60	15	17	2.3	7	0.04
2000	60	25	85	0.55	28	29	2.1	12	0.08
2001	54	16	70	0.45	30	23	2.0	8	0.05

[a] Density is calculated based on total birds (adults plus young).
[b] Calculated as number of adults with broods divided by the number of adults without broods.

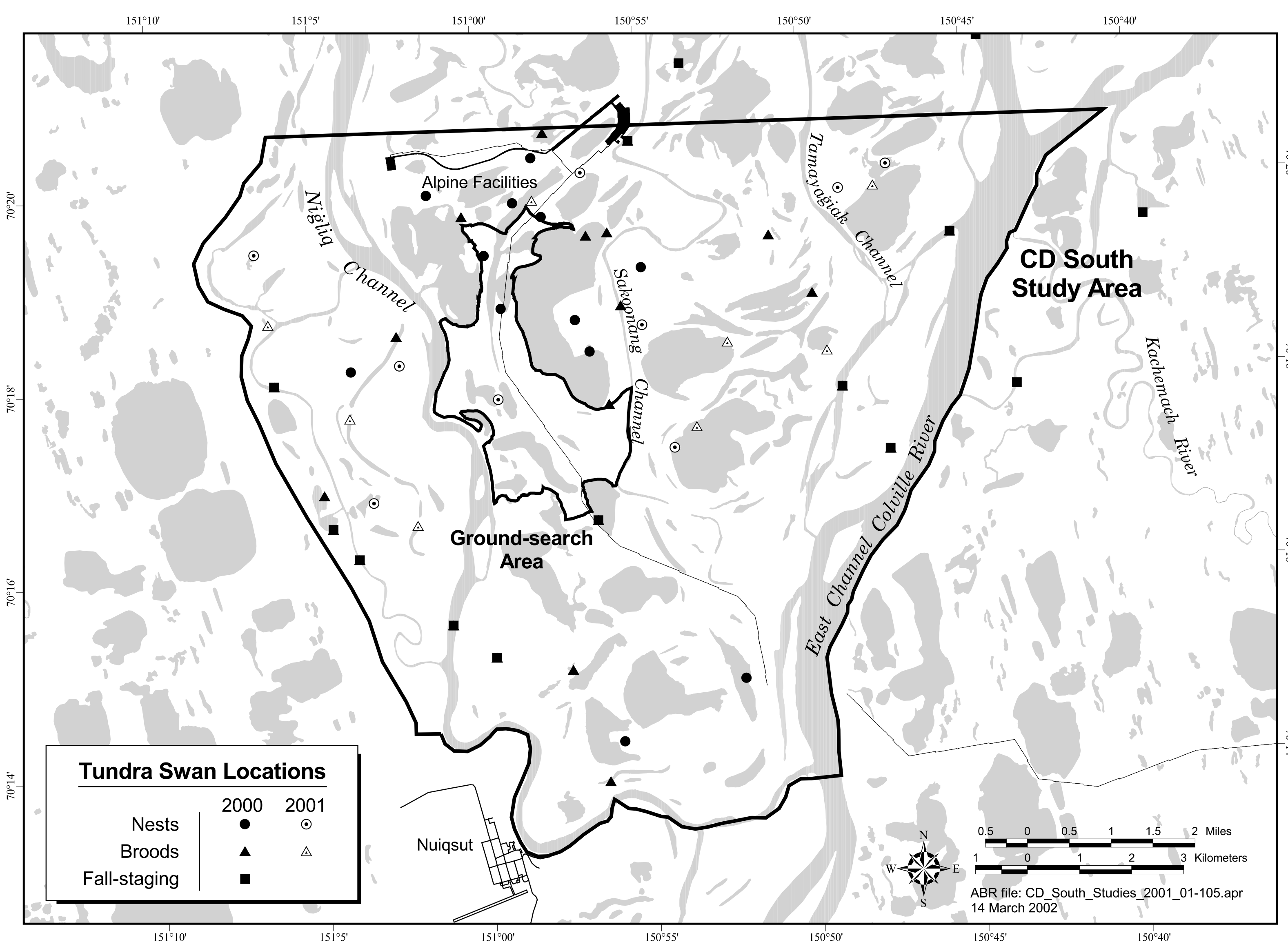

Figure 7. Distribution of Tundra Swan nests, broods, and fall-staging groups in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

Table 13. 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). (No staging survey in 2001.)

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

the Miluveach River; rather, swans were found primarily in the East Channel of the Colville River Delta (e.g., near the mouth of the Miluveach River). The fall-staging survey area was expanded in 1998, flying over the wetlands at the mouths of the Tingmeachsiovik River and Fish Creek, west of the mouth of the Nigliq Channel. We counted 231 swans there in 1998, most within a single group. This area was not surveyed 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 left the delta earlier. In years when nesting is delayed by prolonged snow conditions, and freezing temperatures occur prior to our staging surveys, such as in 1995 and 2000, only family groups remained on the delta. Early freeze-up combined with delayed nesting may be a source of mortality for young swans in those years (Monda 1991; R. King, USFWS, pers. comm.).

Habitat Use

Nesting

During aerial surveys of the CD South study area in 2000 and 2001, a total of 19 swan nests were observed in 7 habitats (Table 14). Wet Sedge–Willow Meadow was the most frequently used nesting habitat, with 52.6% of all nests; other habitats had no more than 3 nests each. Wet Sedge–Willow Meadow is the single most available habitat in the CD South study area (and in the delta as a whole).

Nesting habitat preferences were assessed using nest locations from across the entire Colville River Delta (Appendix D7, Appendix C6). Tundra Swans on the delta used a wide range of habitats for nesting. During 8 years of surveys on the delta, 239 swan nests were located in 18 of 24 habitats. Five habitat types were preferred: Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, Wet Sedge–Willow Meadow, and Moist Sedge–Shrub Meadow. Nonpatterned Wet Meadow was a heavily used habitat (11% of nests), but not preferred. Other non-preferred habitats had no more than 6% of all 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 7 habitats were recognized in that study and because the habitats differed in availability from those on the Colville River Delta, the habitat use reported by Monda et al. (1994) was not directly comparable with our findings. Monda

Table 14. Habitat use by nesting and brood-rearing Tundra Swans in the CD South study area, Colville River Delta, Alaska, 2000–2001.

	Nests		Broods	
Habitat Type	No.	Use (%)	No.	Use (%)
Tapped Lake with Low-water Connection	0	0	3	15.0
Tapped Lake with High-water Connection	1	5.2	2	10.0
Salt Marsh	1	5.2	2	10.0
Deep Open Water without Islands	1	5.2	5	25.0
Deep Open Water with Islands or Polygonized Margins	2	10.5	1	5.0
River or Stream	0	0	1	5.0
Non-patterned Wet Meadow	1	5.2	0	0
Wet Sedge–Willow Meadow	10	52.6	3	15.0
Moist Sedge–Shrub Meadow	3	15.8	1	5.0
Riverine or Upland Shrub	0	0	1	5.0
Barrens	0	0	1	5.0
TOTAL	19	100	20	100

et al. (1994) found that nesting habitat preferences differed between their 2 study sites, which reflected differences in habitat availability. On the Kongakut River delta, 42% of 36 nests were in areas classified as saline graminoid-shrub (probably equivalent to Salt Marsh). On the Canning River delta, 52% of 54 nests were in graminoid-marsh (probably equivalent to Aquatic Grass Marsh and Aquatic Sedge Marsh), 26% were in graminoid-shrub-water sedge (probably equivalent to Wet Sedge–Willow Meadow).

Brood-rearing

During aerial surveys of the CD South study area in 2000 and 2001, a total of 20 swan broods were observed in 10 habitats (Table 14). Five habitats had more than one brood observation: Deep Open Water without Island (25% of broods), Tapped Lake with Low-water Connection (15%), Wet Sedge–Willow Meadow (15%), Tapped Lake with High-water Connection (10%), and Salt Marsh (10%).

Across the entire delta, Tundra Swans with broods used a wide range of habitats, occurring in 18 of 24 habitats (Appendix D7, Appendix C7). Six habitats were preferred: Brackish Water, Tapped Lake with Low-water Connection, Tapped Lake with High-water Connection, Salt Marsh, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins. Four habitats were avoided: Tidal Flats, Rivers and Streams, Riverine or Upland Shrub, and Barrens. Avoided habitats were alike in the absence of foraging and escape habitats. Most (35%) broods were located in salt-affected habitats (Brackish Water, Salt Marsh, Tidal Flat, Salt-killed Tundra, and Tapped Lake with Low-water Connection). This apparent preference for coastal habitats by brood-rearing swans represents a seasonal change in distribution and habitat preference: only 20% of all nests were located in salt-affected habitats. 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 young 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 River 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 River 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 River Delta also is an important nesting area for Yellow-billed Loons (North and Ryan 1988a). 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 1988a). Nest initiation begins during 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 2001, 26 Yellow-billed Loons and 9 nests were located in the CD South study area during the nesting aerial survey (Figure 8). The number of loons recorded in 2001 was greater than during any of the previous 6 years (Table 15). The density of Yellow-billed Loons in the CD South study area ranged from 0.10 to 0.2 birds/km² during our 7 years of study in this area (1993, 1995–1998, and 2000–2001; plot surveys in 1992 were not included because they were not a representative sample of loon habitat). Similar densities have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska: Square Lake in the NPRA (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 2001 was similar to that recorded on aerial surveys in 1993, 1995–1998, and 2000 (Smith et al. 1994; Johnson et al. 1999a), and during ground-based surveys in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

After 1995, nesting surveys included a second visit to lakes where Yellow-billed Loon pairs were observed but no nests were located. During these second visits in 1996–1998, an additional 1–3 nests were found in the CD South study area that either were missed or were initiated after the first survey. In 2000 and 2001, no additional nests were found during revisit surveys or during foot surveys in the ground-search area. The count of 9 nests in 2001 was within the range of counts (2–10 nests) for the previous 6 years of surveys (Table 15). During intensive ground surveys of the delta in 1983 and 1984, North (1986) found 6 and 8 nests, respectively, in the CD South study area. All 9 nests found in 2001 were on lakes where nesting Yellow-billed Loons have been recorded in previous years (Figure 8, Appendix C9). No Yellow-billed Loon nests were found within the ground-search area in 2001. Nesting occurred within the ground-search area in 1995 and 2000. Nest densities for the CD South study area have ranged from 0.01 to 0.06 nests/km².

Eighteen nests of Pacific Loons were located opportunistically during Yellow-billed Loon surveys in the CD South study area in 2001; no nests of Red-throated Loons were seen during the aerial survey (Table 15). 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, densities are not calculated for these 2 species. Although our counts are not

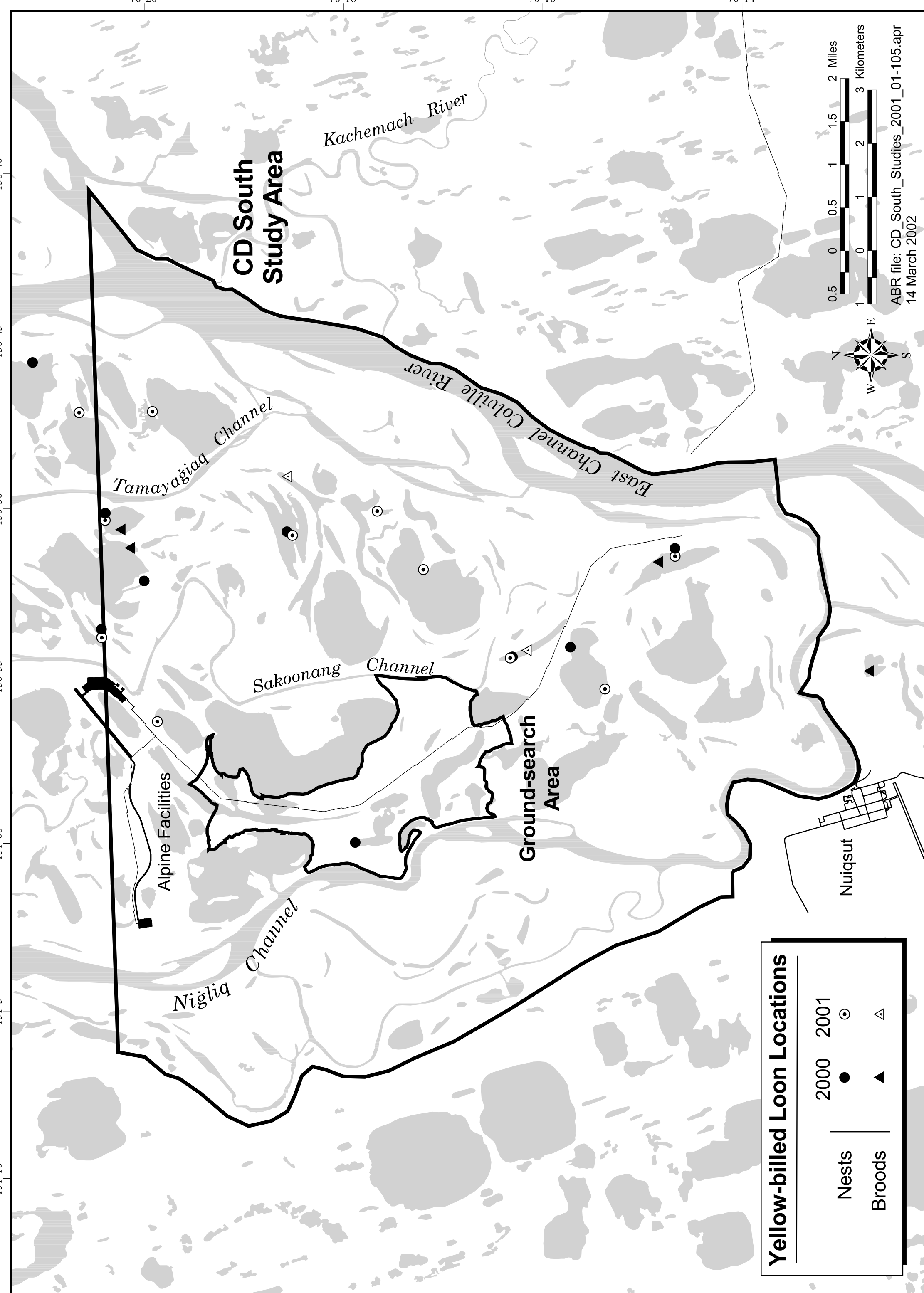

Figure 8. Distribution of Yellow-billed Loon nests and broods in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

Table 15. 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 2000–2001 (pre-2000 data from Johnson et al. 1999a).

	Yellow-billed Loons					Pacific Loons (number)			Red-throated Loons (number)		
	Number			Density (no/km²)							
Year	Adults	Nests/ Broods[b]	Young	Adults	Nests/ Broods[b]	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
NESTING											
1993	15	2	-	0.10	0.01	63	10	-	10	0	-
1995	15	3	-	0.10	0.02	29	4	-	7	0	-
1996	23	7/ 10	-	0.15	0.04/ 0.06	37	7	-	0	0	-
1997	18	3/ 3	-	0.12	0.02/ 0.02	48	12	-	0	0	-
1998	17	8/ 9	-	0.11	0.05/ 0.06	26	6	-	0	0	-
2000	21	7/ 7	-	0.13	0.04/ 0.04	61	17	-	15	0	-
2001	26	9/ 9	-	0.17	0.06/ 0.06	41	18	-	3	0	-
BROOD-REARING											
1993	8	1	1	0.05	0.01	13	1	1	0	0	0
1995	18	3	5	0.12	0.02	68	6	7	2	0	0
1996	20	1	1	0.13	0.01	52	13	17	10	5	8
1997	27	2	4	0.17	0.01	65	8	10	12	2	3
1998	13	5	7	0.08	0.03	66	18	21	10	5	8
2000	13	2	2	0.08	0.01	38	2	2	2	1	2
2001	17	2	2	0.11	0.01	55	3	3	5	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.

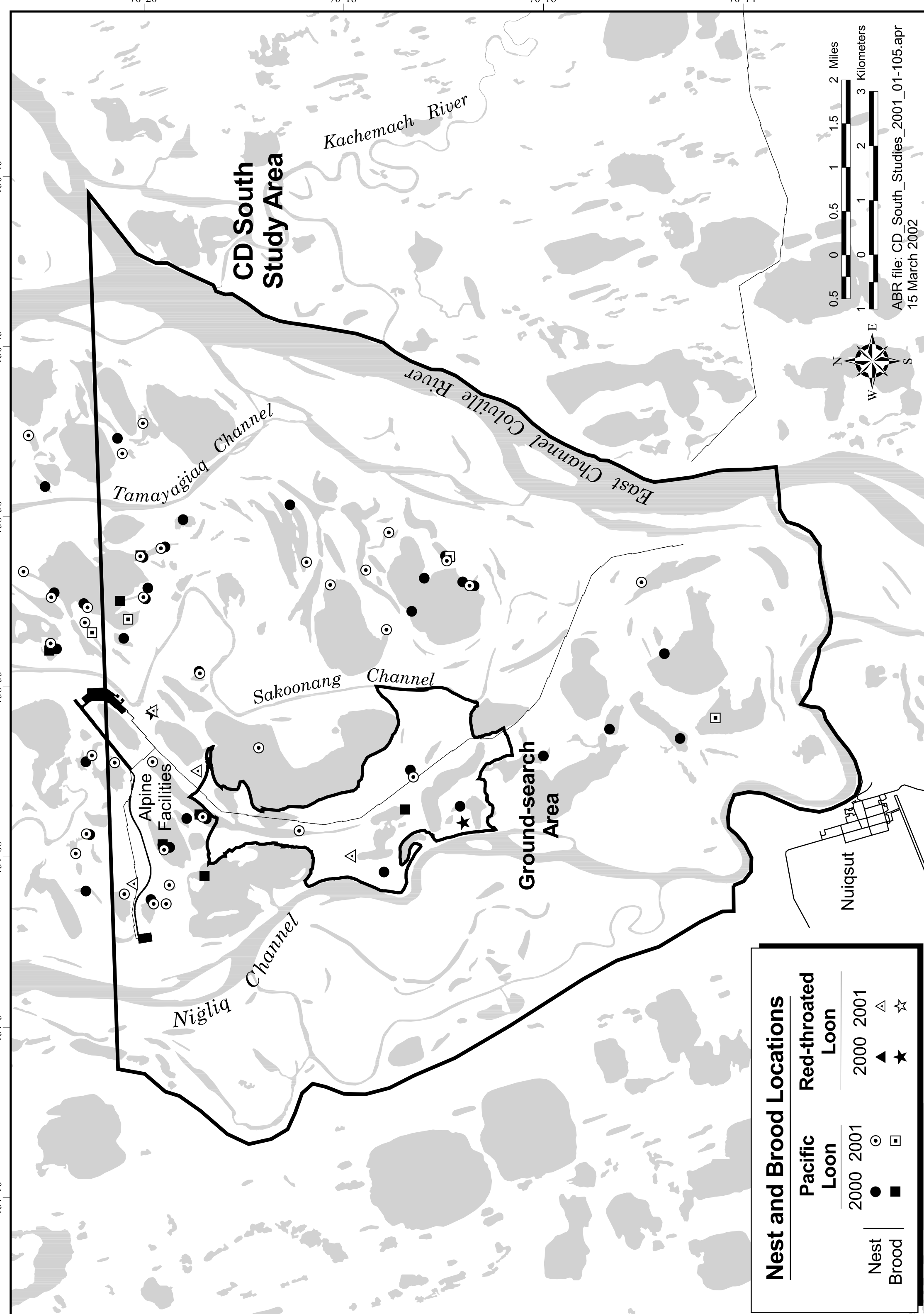

Figure 9. Distribution of Pacific and Red-throated loon nests and broods in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon in the CD South study area during most years of study (Table 15). Rothe et al. (1983) estimated from sample plots on the Colville River Delta in 1981 densities of 1.5 birds/km² for Pacific Loons and 0.6 birds/km² for Red-throated Loon, and suggested that these densities were comparable to other areas on the Arctic Coastal Plain.

Brood-rearing

During 2001, 17 adult Yellow-billed Loons and 2 broods were observed during the brood-rearing survey in the CD South study area (Table 15). In previous years, the number of loons has ranged from 8 to 27 and the number of broods has ranged from 1 to 5 (Table 15). The highest number of Yellow-billed Loon broods recorded in the CD South study area during our 7 years of surveys was in 1998 when there were 7 young in 5 broods (Appendix C11). The density of adult Yellow-billed Loons during brood-rearing in 2001 was 0.11 birds/km², while the density of broods was 0.01 broods/km². In other survey years, the density of adults ranged from 0.05 to 0.17 birds/km² and the density of broods from 0.01 to 0.03 broods/km². Most adult loons seen on the brood-rearing survey in 2001 were found on lakes where nesting occurred either in 2001, or in a previous year. North and Ryan (1988a, 1989) found that adults with young remain on or near the nest lake during brood-rearing, and that non-nesting and failed breeders also maintain their territories throughout the summer.

During the 2001 aerial survey, 3 Pacific Loon broods and no Red-throated Loon broods were observed in the CD South study area (Table 15). 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 and 2001 were noticeably lower than in the previous 4 years, the surveys were not intended to be quantitative for these 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, abundance and density cannot be compared among years for these 2 species.

Habitat Use

Nesting

During aerial surveys of the CD South study area in 2000 and 2001, a total of 16 Yellow-billed Loon nests were observed in 5 habitats (Table 16): Nonpatterned Wet Meadow (38% of nests), Wet Sedge–Willow Meadow (25%), Deep Open Water with Islands or Polygonized Margins (19%), Aquatic Sedge with Deep Polygons (13%), and Aquatic Sedge Marsh (6%). However, 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, the waterbody type (or aquatic habitat) adjacent to the nest site is more indicative of habitat selection than the terrestrial habitat on which the nest is actually built. Four types of waterbodies were associated with Yellow-billed Loon nests: Deep Open Water without Islands (50%), Deep Open Water with Islands or Polygonized Margins (25%), Tapped Lake with High-water Connection (19%), and Aquatic Sedge Marsh (6%). Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation.

During 7 years of aerial surveys on the entire Colville River Delta, 104 Yellow-billed Loon nests were found in 8 of 24 available habitats (Appendix D8). Most nests (63 nests; 60%) were located in the 2 preferred habitats: Deep Open Water with Islands or Polygonized Margins and Wet Sedge–Willow Meadow. Wet Sedge–Willow Meadow was the habitat most frequently used for nesting (39% of all nests), and it was the most abundant habitat on the delta (25% of the CD North and CD South areas combined, Appendix D8). Nesting Yellow-billed Loons significantly avoided 6 habitats: Tapped Lake with Low-water Connection, Tidal Flat, Salt-killed Tundra, River or Stream, Riverine or Upland Shrub, and Barrens. None of these habitats was used for nesting, and together they occupied 40% of the delta.

Measurements of the distance from the nest to the nearest waterbody were not recorded during aerial surveys, but all nests were close (<5 m) to water. For the 12 nests found during ground surveys, the mean distance to waterbody was

Table 16. Habitat use by nesting Yellow-billed Loons in the CD South study area, Colville River Delta, Alaska, 2000–2001 (pre-2000 data from Johnson et al. 1999a).

Habitat	Number of Nests	Habitat Use (%)
HABITAT USED		
Deep Open Water with Islands or Polygonized Margins	3	18.8
Aquatic Sedge Marsh	1	6.3
Aquatic Sedge with Deep Polygons	2	12.5
Nonpatterned Wet Meadow	6	37.5
Wet Sedge–Willow Meadow	4	25.0
TOTAL	16	100.0
NEAREST WATERBODY HABITAT		
Tapped Lake with High-water Connection	3	18.8
Deep Open Water without Islands	8	50.0
Deep Open Water with Islands or Polygonized Margins	4	25.0
Aquatic Sedge Marsh	1	6.3
TOTAL	16	100.0

0.4 m. Other ground-based studies of nesting Yellow-billed Loons on the Arctic Coastal Plain found that nests occurred 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 River Delta in 1983 and 1984. Most nests (43% of 23 nests) occurred on deep-*Arctophila* lakes, 39% were on deep-open lakes, and <1% each were on ponds <0.5 ha in size, ponds 0.5–1.0 ha, and shallow lakes >1.0 ha with emergent sedges or grasses. Deep lakes, as described by North (1986), include the 2 Deep Open Water types and Tapped Lakes with High-water Connections of this study. Although North and Ryan (1988a) 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 2001, 2 Yellow-billed Loon broods were found, one in Tapped Lake with High-water Connection and another in Deep Open Water without Islands. During aerial surveys in 1995–1998 and 2000–2001, 38 Yellow-billed Loon broods were found in 3 habitats on the delta: Tapped Lake with High-water Connection, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins. All 3 of these habitats were preferred (Appendix D8). Deep Open Water without Islands or Polygonized Margins was used by most broods (60%), followed by Tapped Lake with High-water Connection (24%) and Deep Open Water with Islands or Polygonized Margins (16%). No shallow-water habitats were used during brood-rearing. Wet Sedge–Willow Meadow and Barrens, the 2 most abundant habitats in the survey area, were the only habitats avoided by loons on the delta 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. 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 2 broods (North 1986).

GOOSE SURVEYS

Background

Brant are uncommon in the CD South study area, but they are much more abundant on the northern Colville River Delta and a thorough analysis of their distribution and abundance on the Colville River Delta can be found in the annual report for the CD North study area (Johnson et al. 2002). The Colville River 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). On the delta, most Brant nest within a colony or group of colonies of ~1,200 nests (USFWS, unpubl. data) on at least 9 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 northern delta (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a, 2002), north of the CD South study area. During aerial surveys between 1992 and 1998, 5 colonies/nesting locations of Brant were observed on the northern edge of the CD South study area: 3 colonies were occupied during 2–4 years of observation with between 1 and 6 nests annually, and 2 solitary nest locations that were occupied only during a single year of observation (Appendix C13; Johnson et al. 2000a). In 2001, 2 nests were found in the northern part of the CD South study area in the Alpine ground-search area (Appendix C13; Johnson et al., 2002a).

During brood-rearing, most Brant on the Colville River Delta move from nesting areas to salt marshes along the coast from Milne Point in the east to the Tingmeachsiovik River in the west (Smith et al. 1994, Anderson et al. 1996, Martin and Nelson 1996, Martin et al. 1997), both outside our study area. A small percentage of the regional Brant population nests at inland locations and rear their broods in small groups (<10 broods) on inland lakes (Stickney 1997). 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, 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).

The Colville River Delta is a regionally important nesting area for Greater White-fronted Geese (Rothe et al. 1983). In the early 1980s, the USFWS reported that densities of Greater White-fronted Geese and their nests on the Colville River Delta were among the highest recorded on the Arctic Coastal Plain, between 1.8–6.3 birds/km² in plots across the delta, and as high as 6.6 nests/km² at one site on the western delta (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). During 6 years (1996–2001), nest densities of 2.0–5.0 nests/km² (mean = 3.4 nests/km²) have been reported in the Alpine project area (Johnson et. al. 2002a). Greater White-fronted Geese also use the delta for both brood-rearing and fall staging and are generally distributed throughout the area, principally in lakes and along the river channels (Johnson et al. 1999a).

Early in the 1900s, 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 River Delta, occasional nests and small groups of brood-rearing and staging Snow 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 River Delta or in NPRA, although local residents have observed Canada Geese nesting in the NPRA at least since the 1980s (J. Helmericks, pers. comm.). Since 1997, 1–2 Canada Goose nests have been recorded on the Colville River Delta (Johnson et al. 1999a, 2001; 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 River Delta (Derksen et al. 1979). Although the Colville River 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). Since 1998, 1–2 Canada Goose nests were found each year in the CD South study area where it overlaps the Alpine ground-search area (Johnson et al., 2002a).

Distribution and Abundance

Brood-rearing

Systematic aerial surveys for geese were conducted in the CD South study area during brood-rearing and fall staging in 2000 and 2001. Only Greater White-fronted Geese were observed in the CD South study area during brood-rearing in either year (Figure 10). In previous surveys of the delta, brood-rearing Brant and Canada Geese were observed in the CD South study area 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 also was observed. The Brant were located in a lake just southeast of the ground-search areas at CD South.

During the brood-rearing survey of the CD South study area (50% coverage) in 2001, 274 Greater White-fronted Geese (including goslings) were observed in 6 groups (Figure 10, Table 17). During 5 years of surveys of the CD South study area, the number of Greater White-fronted Geese seen has ranged from 33 to 528 birds in 2 to 9 groups. The number of goslings has ranged from 24 in 1997 to 266 in 1998, and 36 goslings were observed in 2001. In all years, densities of Greater White-fronted Geese (0.8–7.2 birds/km²) observed in the CD South area during brood-rearing were low compared to those in the CD North area (6.4–13.1 km²) and on the entire delta (4.2–12.8 birds/km²). However, the density in the CD South area was much higher than that observed for these geese in the nearby eastern NPRA study area during 2001 (0.8 birds/km²; Burgess et al. 2002).

Fall Staging

Three species of geese have been recorded in the CD South study area during fall-staging surveys: Greater White-fronted Goose, Canada Goose, and Brant. In 5 years of surveys, Brant were observed in the CD South area during fall staging for the first time in 2001, when one group of 20 birds was observed (Figure 11). Brant typically use salt marshes and other coastal habitats during fall staging (Smith et al. 1994, Johnson et al. 2000a). Canada Geese were not observed in the CD South study area during fall staging in 2001, although they have been present in small numbers (10–94 birds) during 3 of 5 years of surveys (Table 18). Canada Geese also were recorded in the CD South study area in 1995, when 6 geese were observed during a loon survey and a flock of 75 geese was observed during a Brant staging survey. Variability in numbers of fall-staging geese 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. 2002).

The Greater White-fronted Goose was the most common of the goose species observed in the CD South study area during fall-staging surveys in 2001: 137 birds were observed in 5 groups that averaged 27 birds/group (Table 18, Figure 11). During 5 years of surveys, the number of Greater White-fronted Geese observed during fall staging has ranged from 137 to 686 birds (1.9–8.8 birds/km²). Prior to 1996, groups of fall-staging Greater White-fronted Geese also were recorded in the CD South study area during aerial surveys for other species: 84 geese in 1991, 20 in 1992, and 232 in 1995. As during brood-rearing, densities of Greater White-fronted Geese staging in the CD South study area were somewhat lower than those recorded in the CD North area (6.6–14.8 birds/km²) and across the entire delta (6.1–12.9

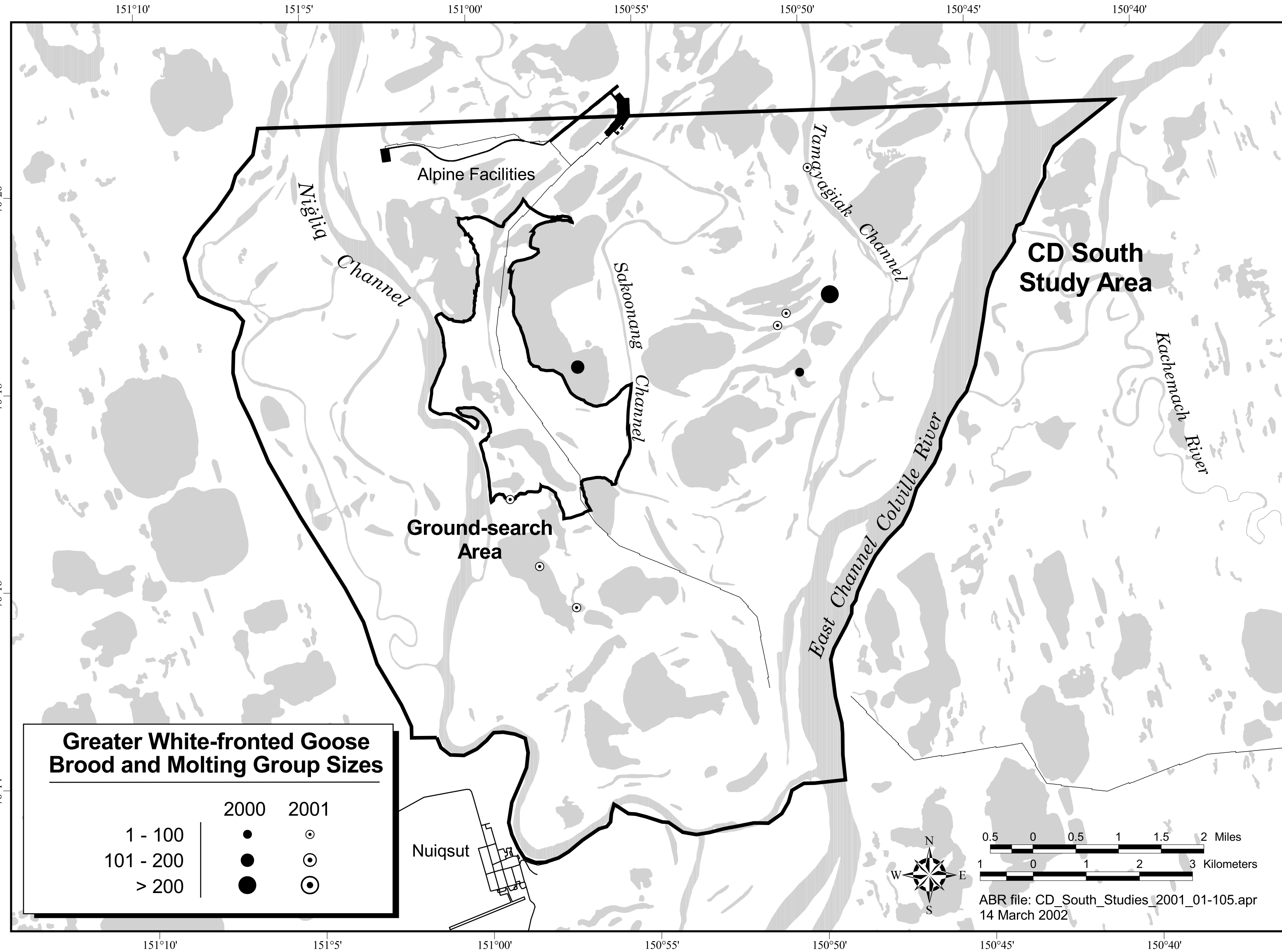

Figure 10. Distribution of brood-rearing and molting groups of Greater White-fronted Geese in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

Table 17. Numbers and density (no./km²) of Greater White-fronted Geese during brood-rearing aerial surveys in the CD South study area, Colville River Delta, Alaska, 1996–1998, and 2000–2001 (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[a]	Density	Total Groups	Group size (Range)	Total Goslings	% Groups w/ Goslings
1996	33	0.8	2	15–18	15	100
1997	263	3.4	7	11–94	24	14
1998	528	6.8	9	8–190	266	89
2000	425	7.2	4	16–220	91	75
2001	274	3.9	6	13–90	36	67

[a] Total birds equals adults plus goslings.

birds/km²), but were higher than those recorded in 2001 in the eastern NPRA study area (1.0 birds/km²; Burgess et al. 2002).

Habitat Use

Habitat use information was collected only for Brant and Greater White-fronted Geese. Brant primarily use coastal areas during nesting, brood-rearing, and fall staging, and a complete analysis of habitat selection by Brant on the outer Colville River Delta can be found in the report on the CD North wildlife studies (Johnson et al. 2002).

Data on habitat use of Greater White-fronted Geese during nesting were obtained from the ground-search area at CD South, where 76 nests were located in 4 habitats: Wet Sedge–Willow Meadow (68% of nests), Moist Sedge–Shrub Meadow (29%), Nonpatterned Wet Meadow (1%), and Riverine or Upland Shrub (1%) (Table 8). In both years, only one habitat was preferred for nesting by Greater White-fronted Geese, Wet Sedge–Willow Meadow, which was the most abundant habitat on the delta (Appendix D9, Table 3). Wet Sedge–Willow Meadow also was a preferred habitat for nesting Greater White-fronted Geese at CD North (Johnson et al. 2002b) and at Alpine (Johnson et al. 2002a). However, in those areas another habitat also was preferred—Aquatic Sedge with Deep Polygons. Aquatic Sedge with Deep Polygons was a rare habitat in the CD South area.

Broods of Greater White-fronted Geese were widespread, occurring in 8 of 14 available habitats in the ground-search area at CD South in 2000 and 2001 (Table 9). The 2 habitats most used by brood-rearing geese in the ground-search area were Aquatic Grass Marsh (36% of groups) and Tapped Lake with High-water Connection (21% of groups). However, habitat use likely was affected by human disturbance during ground searches. During brood-rearing aerial surveys in 2000 and 2001, Greater White-fronted Geese were observed using 6 of 20 habitats in the CD South study area (Table 19). Brood-rearing geese occurred mainly near the center of the study area (Figure 10), typically in or near water (Table 19). The most used habitats were Tapped Lake with High-water Connection (40% of groups) and Deep Open Water without Islands (20% of groups). Other habitats had only a single group of brood-rearing geese.

During fall-staging aerial surveys, Greater White-fronted Geese were observed in 7 of 20 habitats in the CD South study area (Table 19). As during the brood-rearing period, staging Greater White-fronted Geese were found primarily in lake habitats (both types of Tapped Lakes and Deep Open Water, and River or Stream) or in other terrestrial habitats adjacent to lakes or river channels.

GULL SURVEYS

Background

The Glaucous Gull is a common migrant and breeder in the Beaufort Sea area (Johnson and Herter 1989). Glaucous Gulls arrive in mid-May and are commonly found near offshore leads and

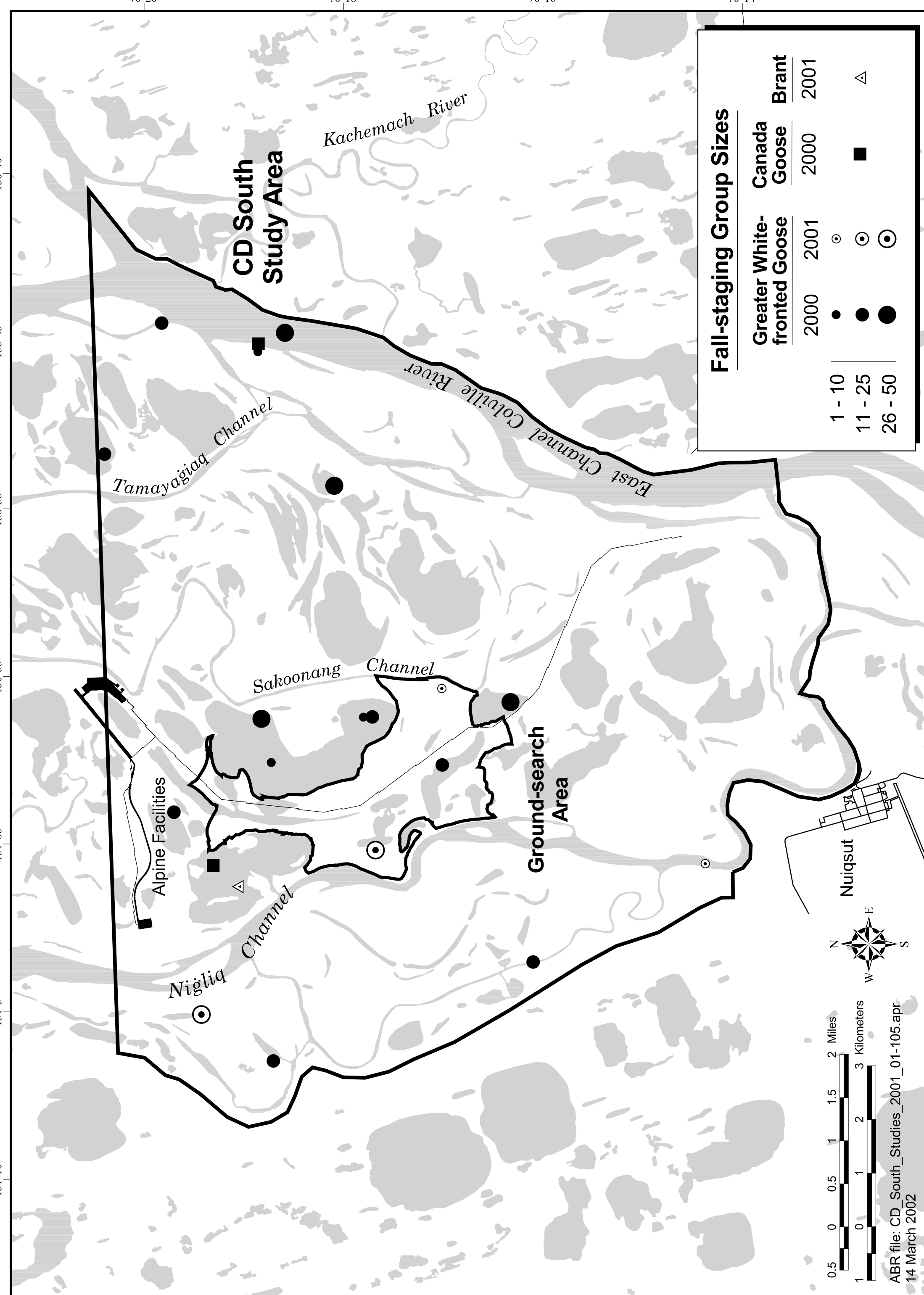

Figure 11. Distribution of fall-staging groups of Greater White-fronted and Canada geese and Brant in the CD South study area, Colville River Delta, Alaska, 2000 and 2001.

Table 18. Numbers and density (no./km²) 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 2000–2001 (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	Density	Total Groups	Mean Group Size	Range	Total Birds	Density	Total Groups	Mean Group Size	Range
1996	181	4.6	8	22.6	7–35	10	0.3	1	10.0	–
1997	686	8.8	10	68.6	1–500	0	0	0	–	–
1998	607	7.8	17	35.7	5–150	94	1.2	3	31.3	10–70
2000	307	5.2	14	21.9	4–40	45	0.8	2	22.5	20–25
2001	137	1.9	5	27.4	3–60	0	0	0	–	–

Table 19. Habitat use by Greater White-fronted Geese during brood-rearing and fall staging in the CD South study area, Colville River Delta, Alaska, 2000–2001.

	Brood-rearing /Molting		Fall Staging	
Habitat Type	Number of Groups	Habitat Use (%)	Number of Groups	Habitat Use (%)
Tapped Lake with Low-water Connection	1	10.0	1	7.1
Tapped Lake with High-water Connection	4	40.0	4	28.6
Deep Open Water without Islands	2	20.0	2	14.3
Deep Open Water with Islands or Polygonized Margins	1	10.0	0	0
River or Stream	1	10.0	2	14.3
Wet Sedge–Willow Meadow	0	0	1	7.1
Moist Sedge–Shrub Meadow	0	0	1	7.1
Barrens	1	10.0	3	21.4
TOTAL	10	100.0	14	100.0

along island and mainland shorelines (Richardson and Johnson 1981). Pairs nest either solitarily or colonially on islands and cliffs on or near the coast (Larson 1960); on inland river bars (Sage 1974); or on small islands in lakes (Martin and Moitoret 1981). Egg laying begins by mid-June and continues into the last week of June (Johnson and Herter 1989). Hatching begins in mid-July and fledging occurs in late August to early September (Bergman et al. 1977). During the breeding season, Glaucous Gulls prey heavily on the eggs and chicks of other birds, especially those of waterfowl (Johnson and Herter 1989). However, some studies have found that waterfowl nesting in association with predatory gulls have high nesting success, but broods of these nests often are taken by gulls (Vermeer 1968, North and Ryan 1988b).

Distribution and Abundance

Fourteen Glaucous Gull nests were located during aerial surveys for Tundra Swans and Yellow-billed Loons in the CD South study area during 2001 (Figure 12). An additional 3 nests were found during ground surveys in the CD South study area and aerial surveys of lakes in the Alpine project area. Thirteen of the 17 nests were part of a Glaucous Gull colony located ~6 km east of the ground-search area at CD South. Counts at this colony have ranged from 10 to 18 nests during 3 years of surveys (1998, 2000, 2001). The density of Glaucous Gull nests in the CD South study area was 0.1 nests/km² in 2001. Because Glaucous Gulls were counted on aerial surveys designed to survey other species, some nests probably were missed.

Habitat Use

Habitat information is available for the 17 nests in the CD South study area in 2001 and for an additional 13 nests that were located in the area in 2000. In 2000, 10 Glaucous Gull nests were located in one colony in the CD South study area, one Glaucous Gull nest was located in the ground-search area at CD South, and 2 additional nests were found in the Alpine ground-search area, which overlaps parts of the CD South study area. All 30 Glaucous Gull nests found in the CD South study area in 2000 and 2001 were located on islands in Tapped Lake with High-water Connection, both Deep and Shallow Open Water with Islands or Polygonized Margins, Wet Sedge–Willow Meadow, and Barrens. On aerial surveys during brood-rearing in 2001, 7 young were seen at the colony site east of the ground-search area and 2 broods (4 young) were seen at separate locations in the CD South study area.

FOX SURVEYS

Background

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are much more common on the coastal plain and

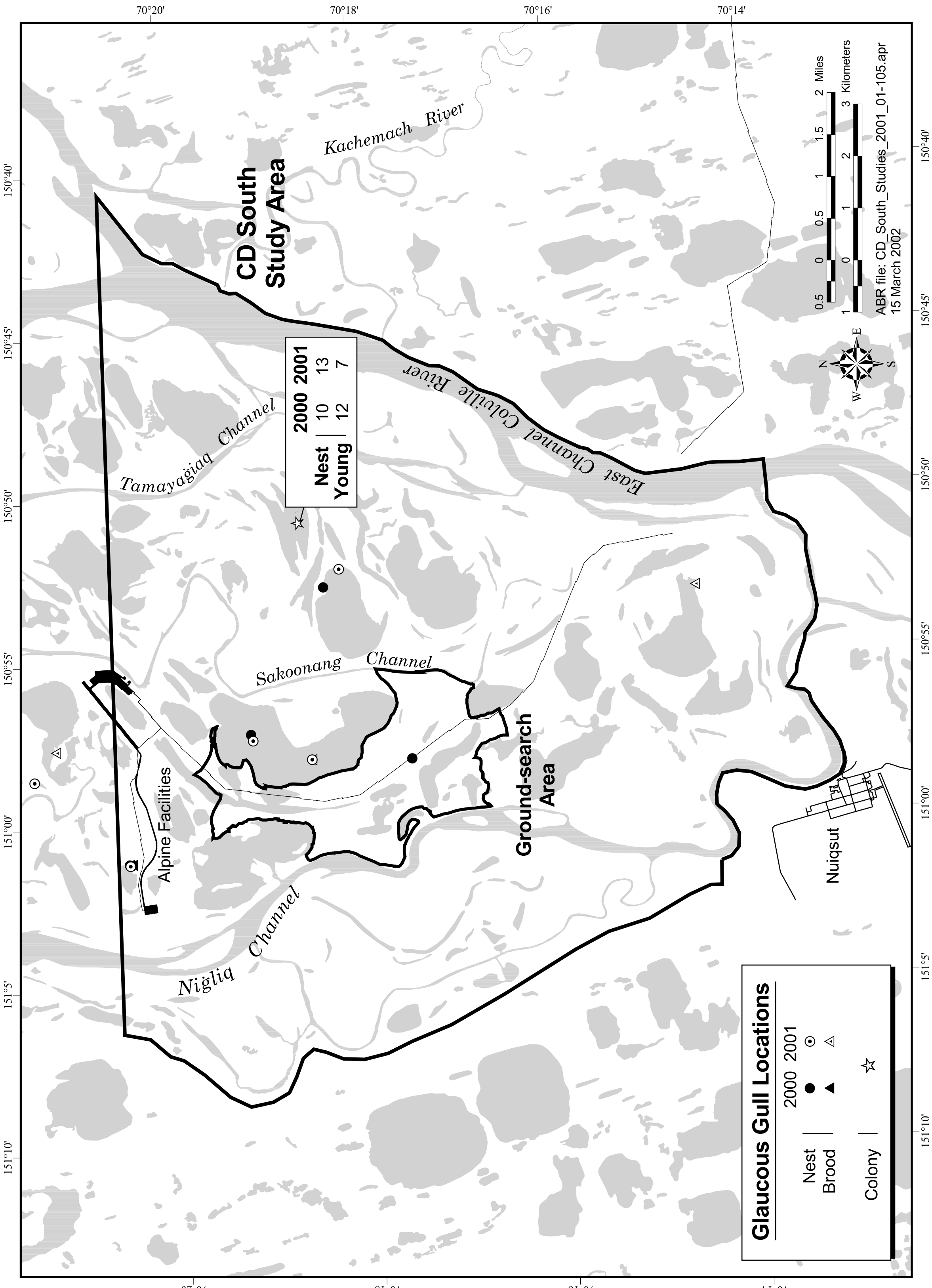

Figure 12. Distribution of Glaucous Gull nests and broods in the CD South study area, Colville River Delta, Alaska, 2001.

red foxes are more common in the foothills and mountains of the Brooks Range. On the coastal plain, red foxes are restricted largely to major drainages (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; Rodrigues 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 River 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 in 1992 (Smith et al. 1993). In 9 years of surveys (none were conducted in 1994) and through contacts with other observers, we have located 75 fox dens between the western edge of the Colville River Delta and the western edge of the Kuparuk Oilfield (Appendix C18). In 2001, 65 dens (87%) were classified as arctic fox dens and the remaining 10 dens (13%) were occupied by red foxes; 4 of the dens used by red foxes were former arctic fox dens.

Distribution and Abundance of Dens

To date, 9 dens have been found in the CD South study area (Figure 13): 1 each in 1992, 1993, 1997, and 2001, and 5 in 1995. Additional dens may be 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. The 9 fox dens in the CD South study area included active and inactive sites of both species (Table 20). Five of the dens were arctic fox sites and 4 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 as common as arctic fox dens in the CD South study area. The annual density of active red fox dens (2–4 dens; Table 21) ranged from 1 den/39 km² to 1 den/78 km². The density of arctic fox dens active annually (0–2 dens; Table 21) was low, at 1 den/78 km² or less. In view of the 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 21), for a combined density of 1 den/31 km².

The total density of fox dens (active and inactive for both species) in the CD South study area (156 km²) was 1 den/17 km². The densities of arctic and red fox dens were similar, at 1 den/31 km² for the former and 1 den/39 km² for the latter. In contrast, the density of red fox dens in the entire Colville River Delta area was 1 den/69 km²; 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 was slightly lower than the regional average of 1 den/26 km² for the combined Colville River Delta (551 km²) and Alpine Transportation Corridor (343 km²) survey areas. The density of arctic fox dens in the CD South area was similar to the 1 den/34 km²

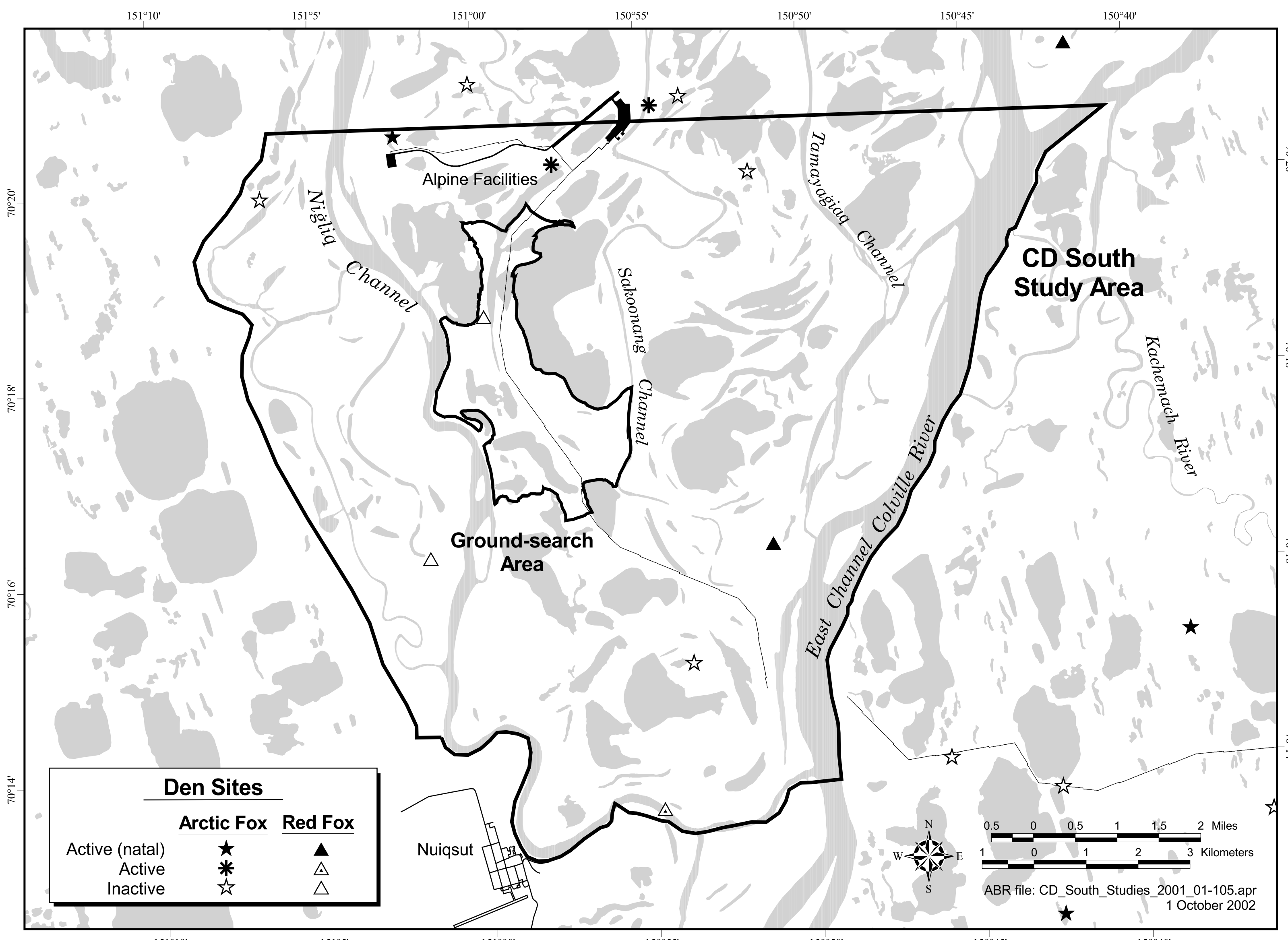

Figure 13. Distribution of arctic and red fox dens in the CD South study area, Colville River Delta, Alaska, 2000 and 2001. .

Table 20. Annual status of arctic and red fox dens in the CD South study area, Colville River Delta, Alaska, 1993 and 1995–2001 (pre–2000 data from Johnson et al. 2000b). Numbers in parentheses indicate the number of pups observed at active dens; zeroes indicate dens were observed but no pups were seen; dashes indicate no data.

SPECIES Landform	1993	1995	1996	1997	1998	1999	2000	2001
ARCTIC FOX								
Old dune	Natal (3)	Natal (-)	Inactive	Inactive?	Inactive	Inactive?	Active (0)	Inactive
Dune mound	--	Inactive	Inactive	Inactive?	Inactive	Inactive	Inactive	Inactive
Low ridge	--	Secondary? (-)	Secondary? (5)	Active (0)	Natal (3)	Secondary (4)	Inactive	Natal (4)
Low mound	--	--	--	Inactive	Natal? (0)	Inactive	Inactive	Inactive
Old channel bank	--	--	--	--	--	--	--	Active
RED FOX								
Dune/lake bank[a]	Inactive	Inactive	Inactive	Inactive?	Active (0)	Inactive?	Inactive?	Inactive
Sand dune	--	Secondary? (0)	Natal (2)	Active (0)	Natal (2)	Natal (2)	Inactive	Natal (3)
Dune/river bank	--	Natal (5)	Natal (1)	Inactive	Natal? (0)	Natal? (0)	Natal (4)	Active (0)
Sand dune	--	Natal (2)	Natal (5)	Active? (0)	Natal (6)	Natal (2)	Natal (1)	Inactive (0)

[a] Arctic fox den until 1998.

Table 21. Occupancy status of arctic and red fox dens in the CD South study area, Colville River Delta, Alaska, 1993 and 1995–2001 (pre–2000 data from Johnson et al. 2000b).

SPECIES	1993		1995		1996		1997		1998		1999		2000		2001	
Status	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ARCTIC FOX																
Active natal	1	50	1	33	0	--	0	--	1	33	0	--	0	--	1	20
Active secondary	0	--	0	--	0	--	0	--	0	--	1	33	0	--	0	--
Active[a]	0	--	0	--	0	--	0	--	0	--	0	--	1	25	1	20
Inactive[b]	1	50	2	67	3	100	3	100	2	67	2	67	3	75	3	60
Total	2		3		3		3		3		3		4		5	
RED FOX																
Active natal	0	--	2	67	3	100	0	--	2	50	2	50	2	50	1	25
Active[a]	0	--	1	33	0	--	2	67	2	50	1	25	0	--	1	25
Inactive[b]	0	--	0	--	0	--	1	33	0	--	1	25	2	50	2	50
Total	0		3		3		3		4		4		4		4	

[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.

reported by Eberhardt et al. (1983) for their 1,700-km² Colville study area (which extended farther east and west than ours, but not as far inland). The density of arctic fox dens in the CD South area was near the high end of the range reported for a 1,876 km² undeveloped areas bordering the Prudhoe Bay Oilfield (1 den/28–72 km²), but was lower than that reported for the 805-km² developed area of the Prudhoe field (1 den/12–15 km²) (Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues 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 4 red fox dens (50–100%; Table 21) 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 comparison 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 21). 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).

Based on brief visits at 8 of the 9 fox dens during 28–30 June 2001 and longer observations at 3 red fox dens and 1 arctic fox den during 11–15 July 2001, we concluded that pups were present at 1 red fox den (at least 3 pups) and 1 arctic fox den (4 pups) (Table 20). 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). We found no indication that litters were moved between den sites in the CD South area in 2000 or 2001, however.

Habitat Use

In the CD South study area, the habitat type used most often for denning was Riverine or Upland Shrub (7 of 9 dens, or 78%); the only other habitat type used was 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 20). 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 River Delta (Appendix D10), updating the analysis by Johnson et al. (1999a). Sixteen dens (70% of the delta 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 were smaller than the minimal mapping size of habitat areas. Foxes did not den in the extensive river bars and mudflats on the delta.

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 River Delta, the latter species dens almost exclusively in sand dunes. On the Colville River 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 20; 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). Chesemore (1969) reported that low mounds were used most often for den sites in the Teshekpuk Lake area of NPRA west of the Colville River Delta. 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.

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Appendix A. Common and scientific names of birds and mammals observed on the Colville River Delta, Alaska, 1992–2001.

BIRDS

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

MAMMALS

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

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

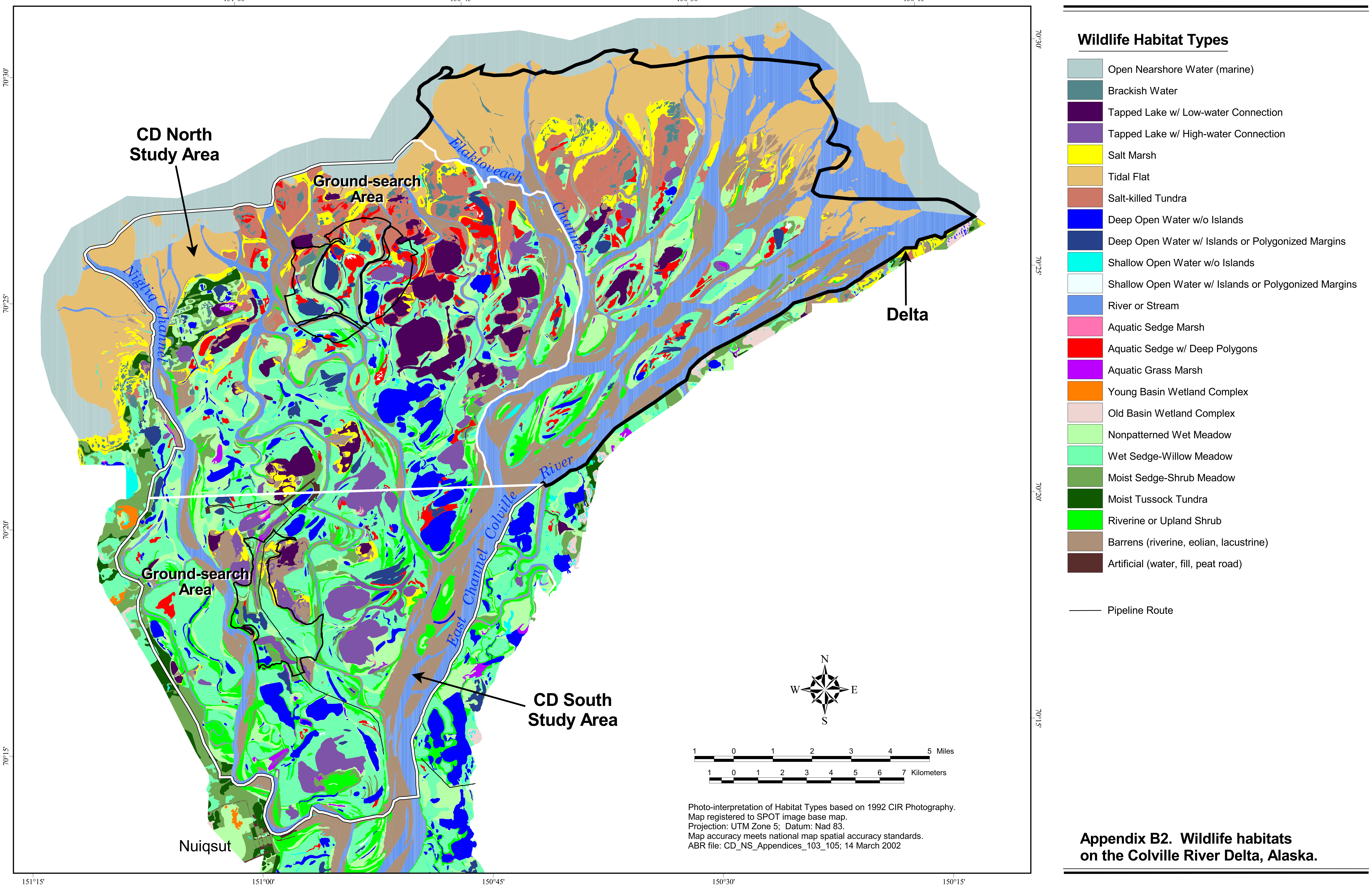
Habitat	Description
Open Nearshore Water (Marine)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced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

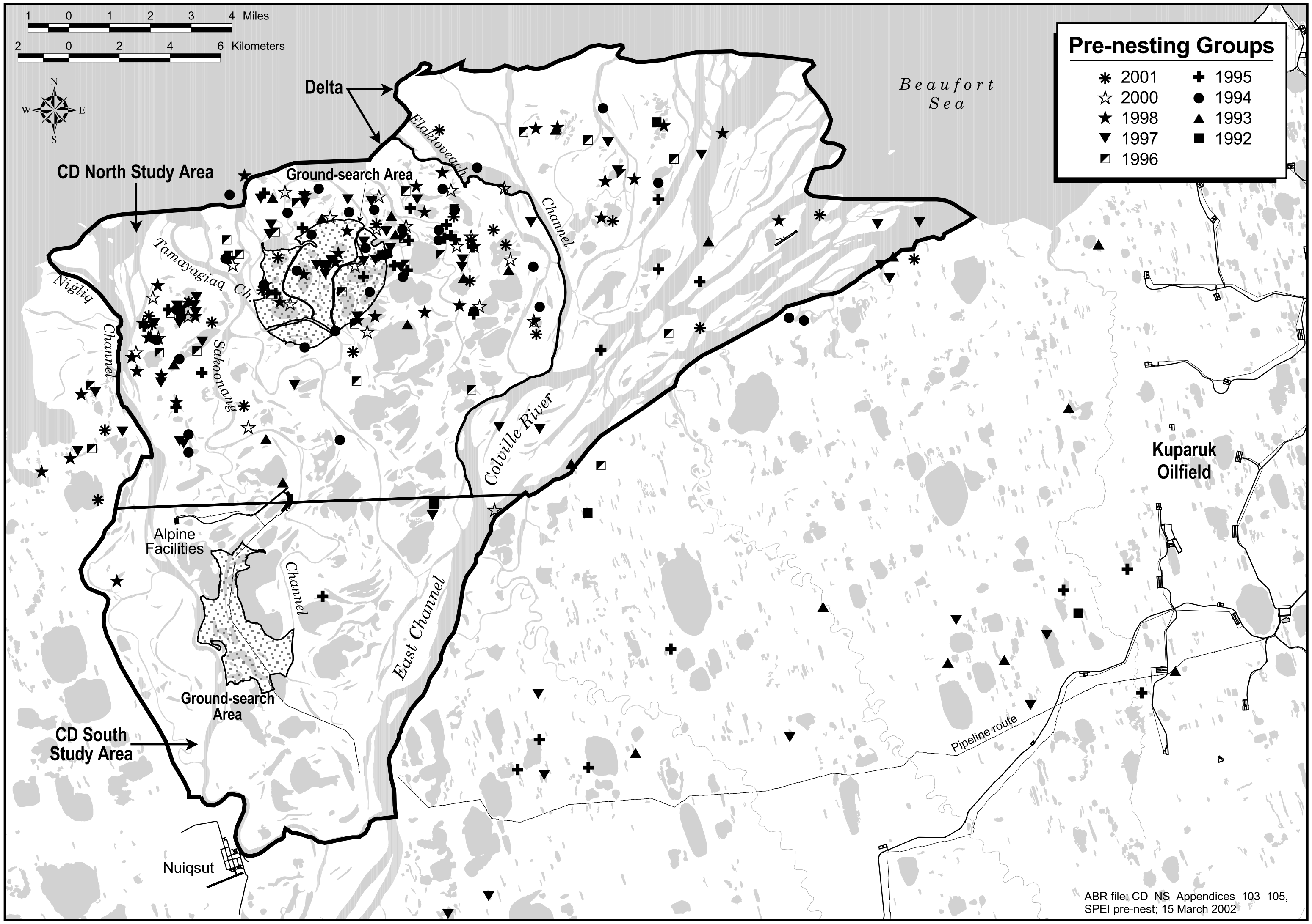
Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many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

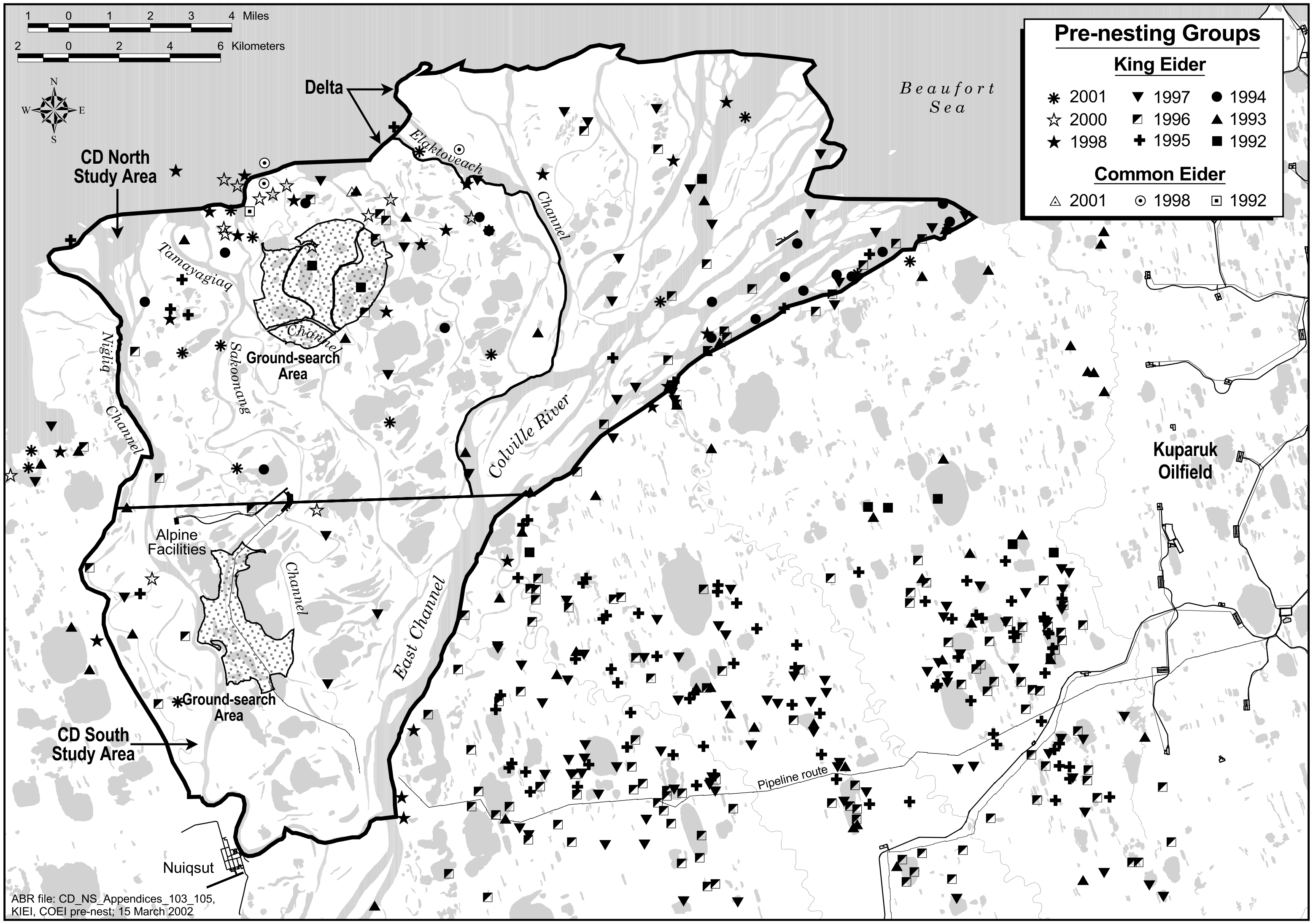
Habitat	Description
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims 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.



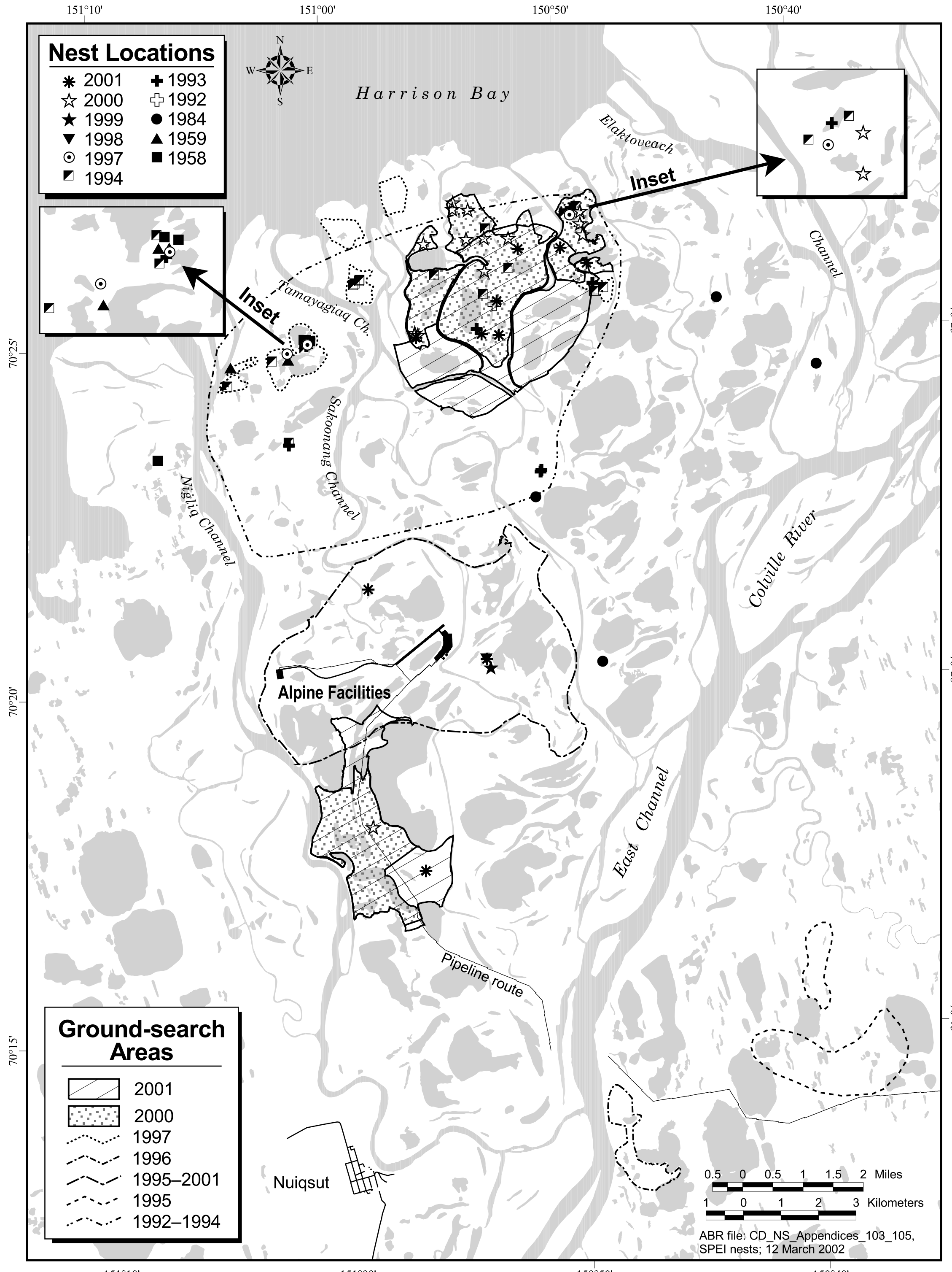
Appendix B2. Wildlife habitats on the Colville River Delta, Alaska.



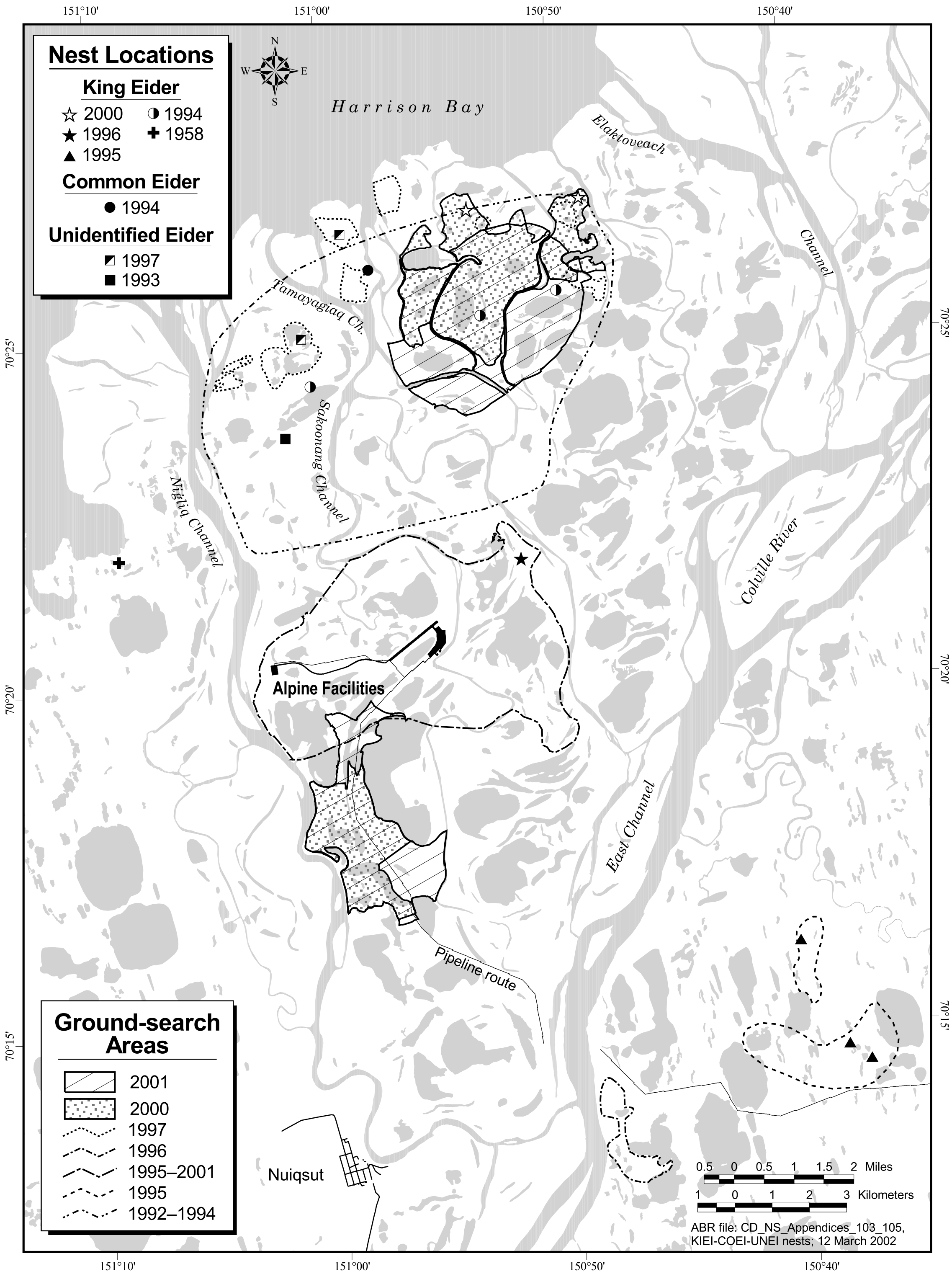
Appendix C1. Distribution of Spectacled Eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–1998, and 2000–2001 (pre–2000 data from Johnson et al. 1999a).



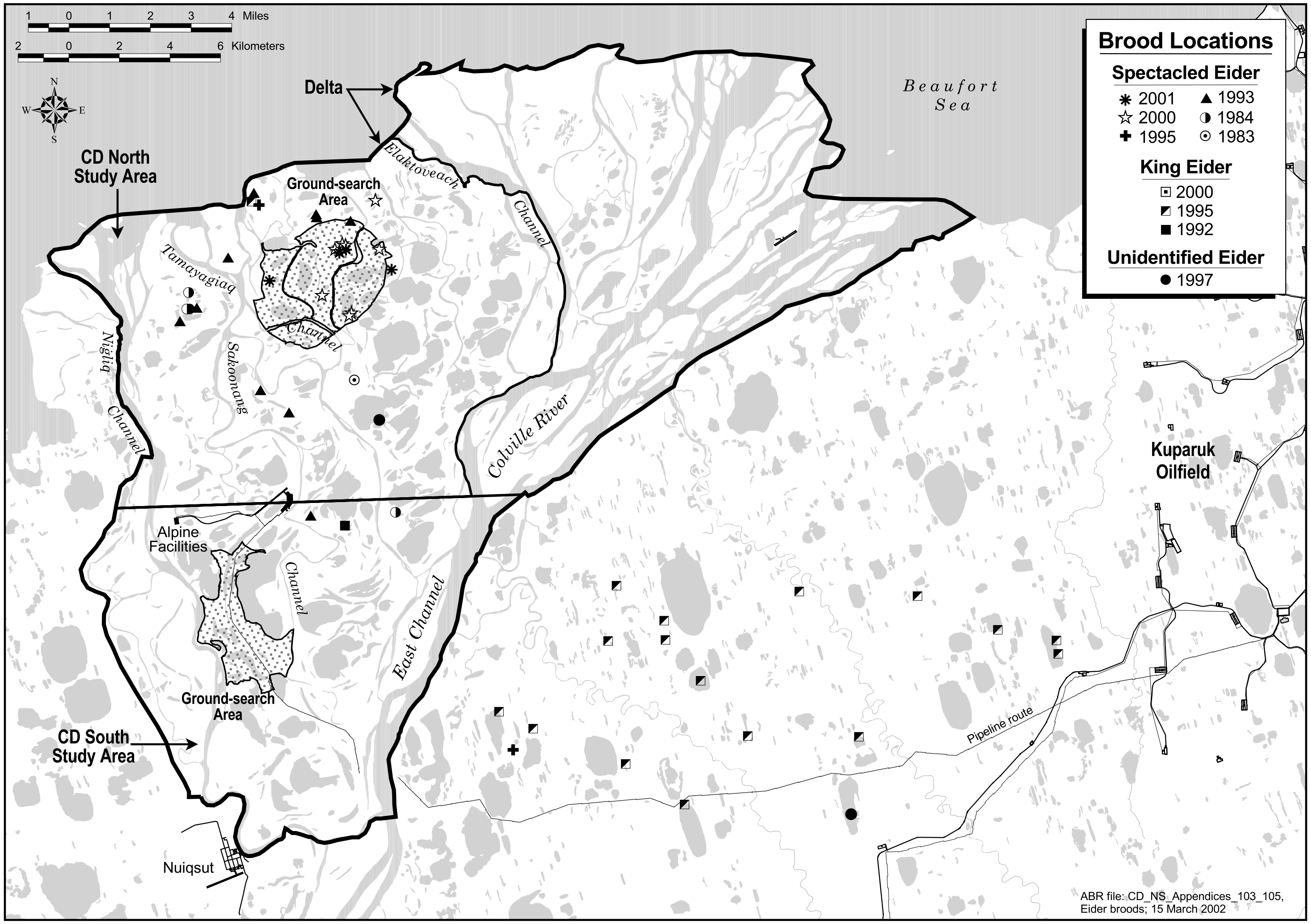
Appendix C2. Distribution of King and Common eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–1998, and 2000–2001 (pre-2000 data from Johnson et al. 1999a).



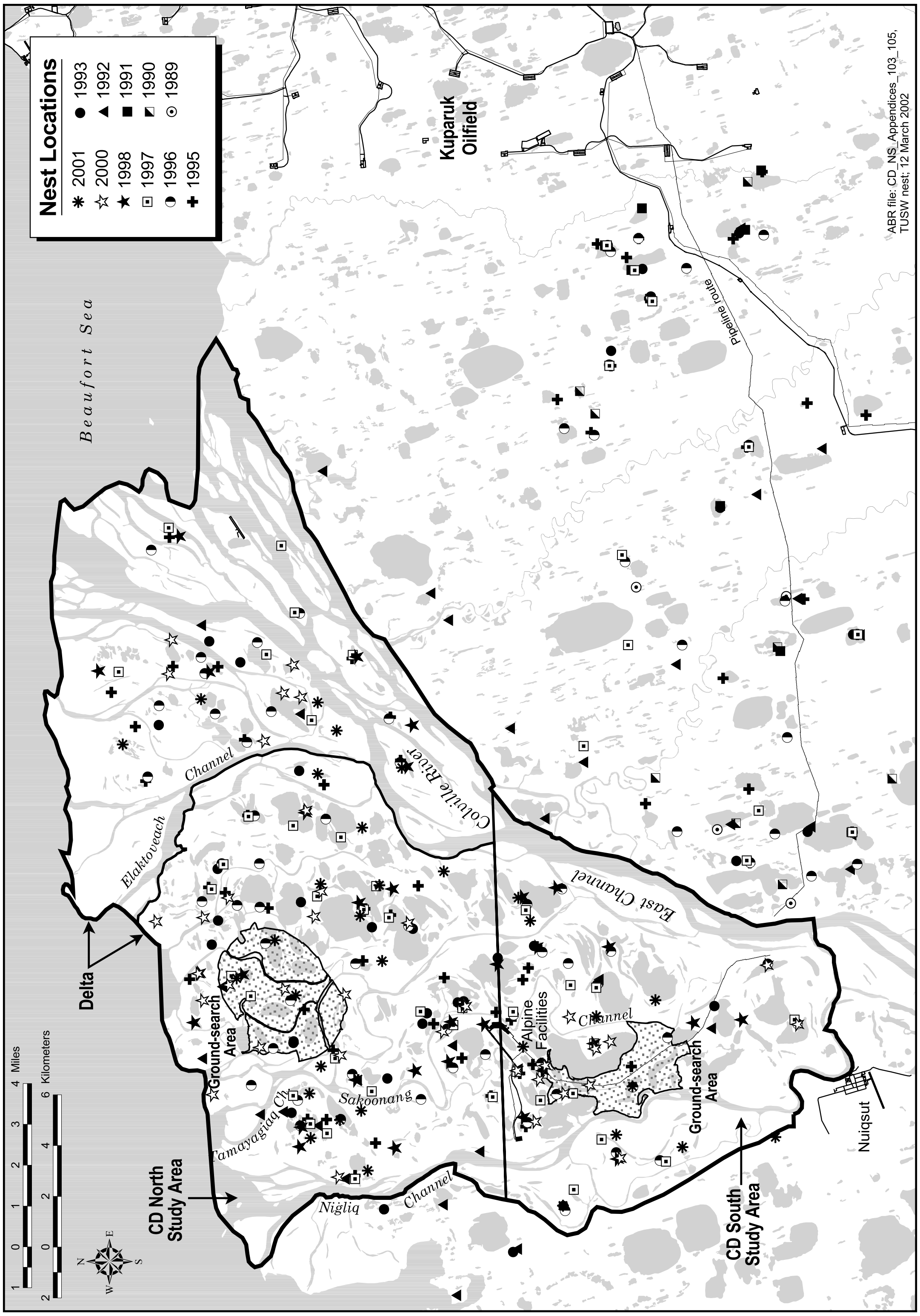
Appendix C3. Distribution of Spectacled Eider nests during ground searches on the Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–2001 (pre–2000 data from unpublished data of T. Myres [1958 and 1959] and M. North [1984]; Smith et al. 1993, 1994; and Johnson et al. 1999a, 2000b).



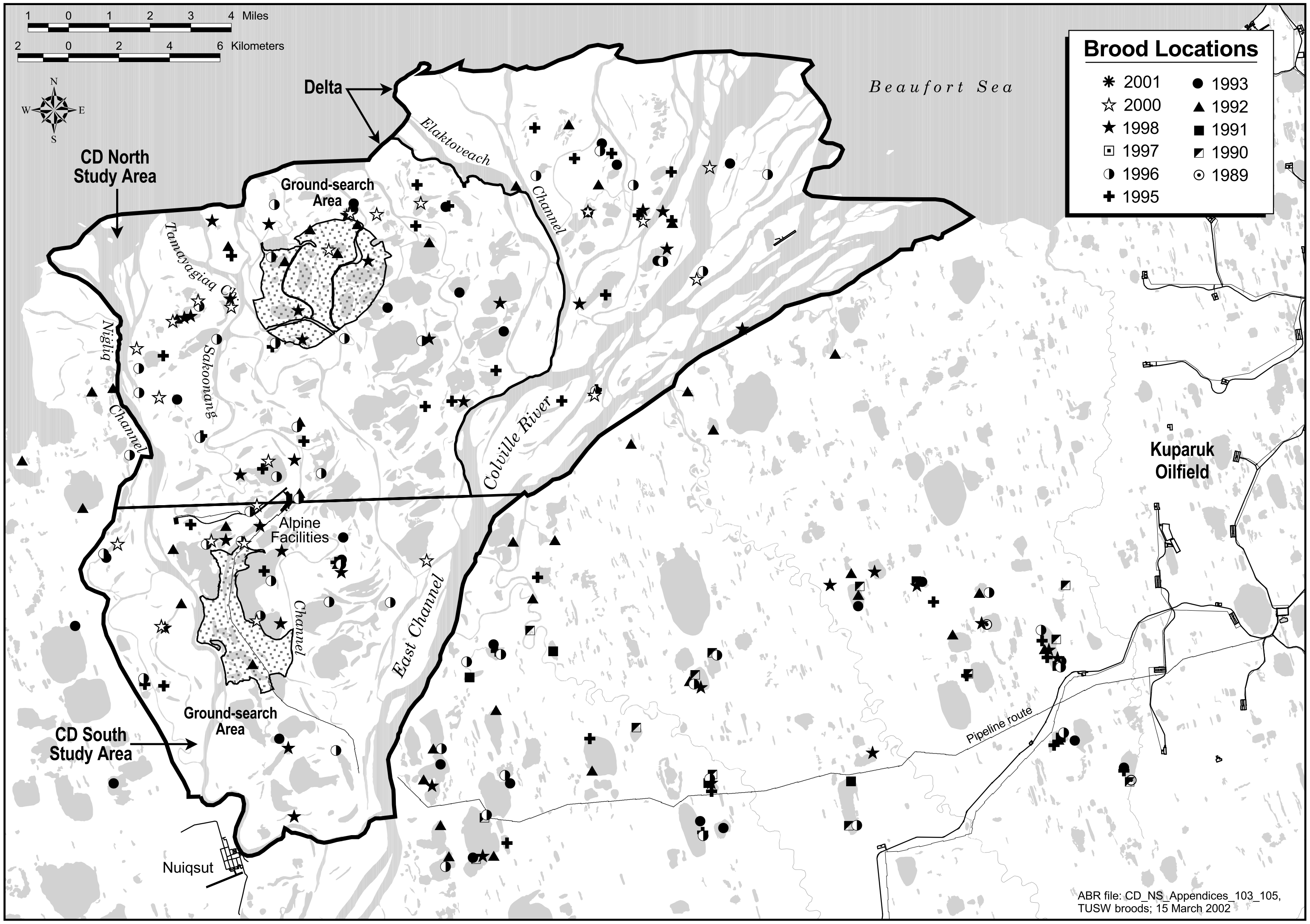
Appendix C4. Distribution of King, Common, and unidentified eider nests during ground searches on the Colville River Delta, Alaska, 1958 and 1992–2001 (pre–2000 data from unpublished data of T. Myres [1958]; Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



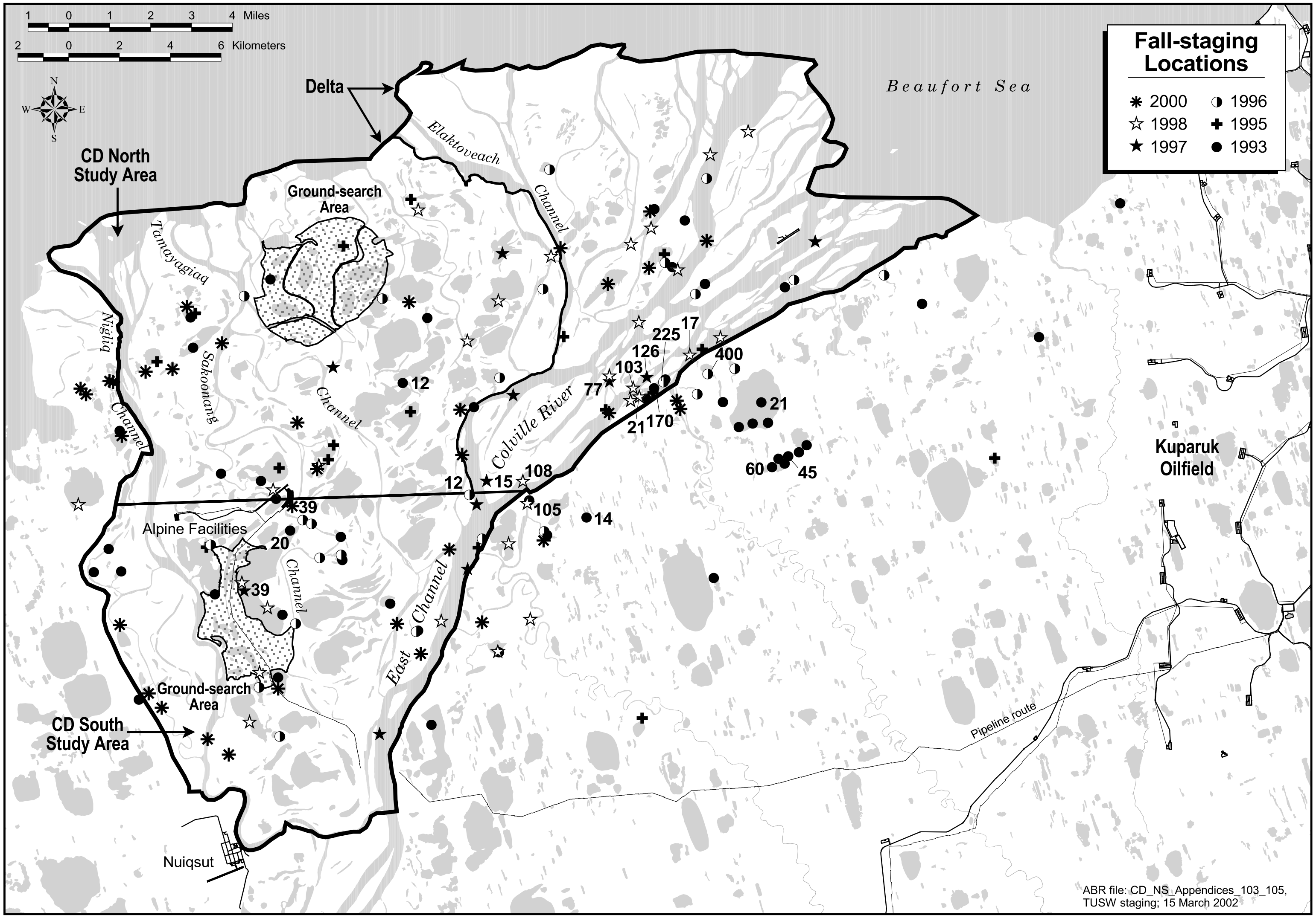
Appendix C5. Distribution of Spectacled, King, and unidentified eider broods during aerial and ground surveys of the CD North and CD South study areas, Colville River Delta, Alaska, 1983–1984, 1992–1993, 1995, 1997, and 2000–2001 (pre–2000 data from unpublished data of M. North [1983 and 1984]; Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



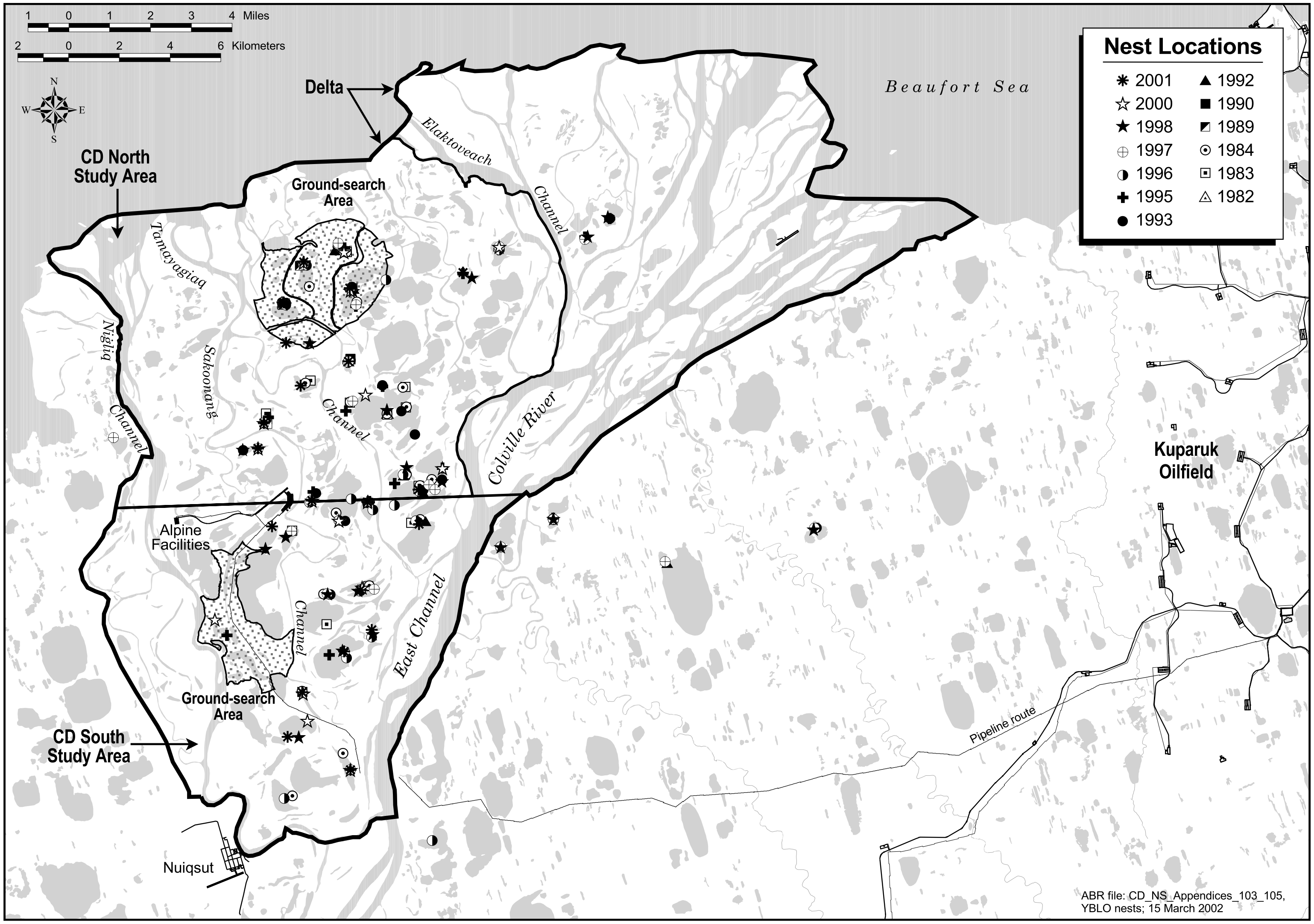
Appendix C6. Distribution of Tundra Swan nests during aerial and ground surveys on the Colville River Delta, Alaska, 1989–1993, 1995–1998, and 2000–2001 (pre–2000 data from Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Smith et al. 1993, 1994; and Johnson et al. 1999a).



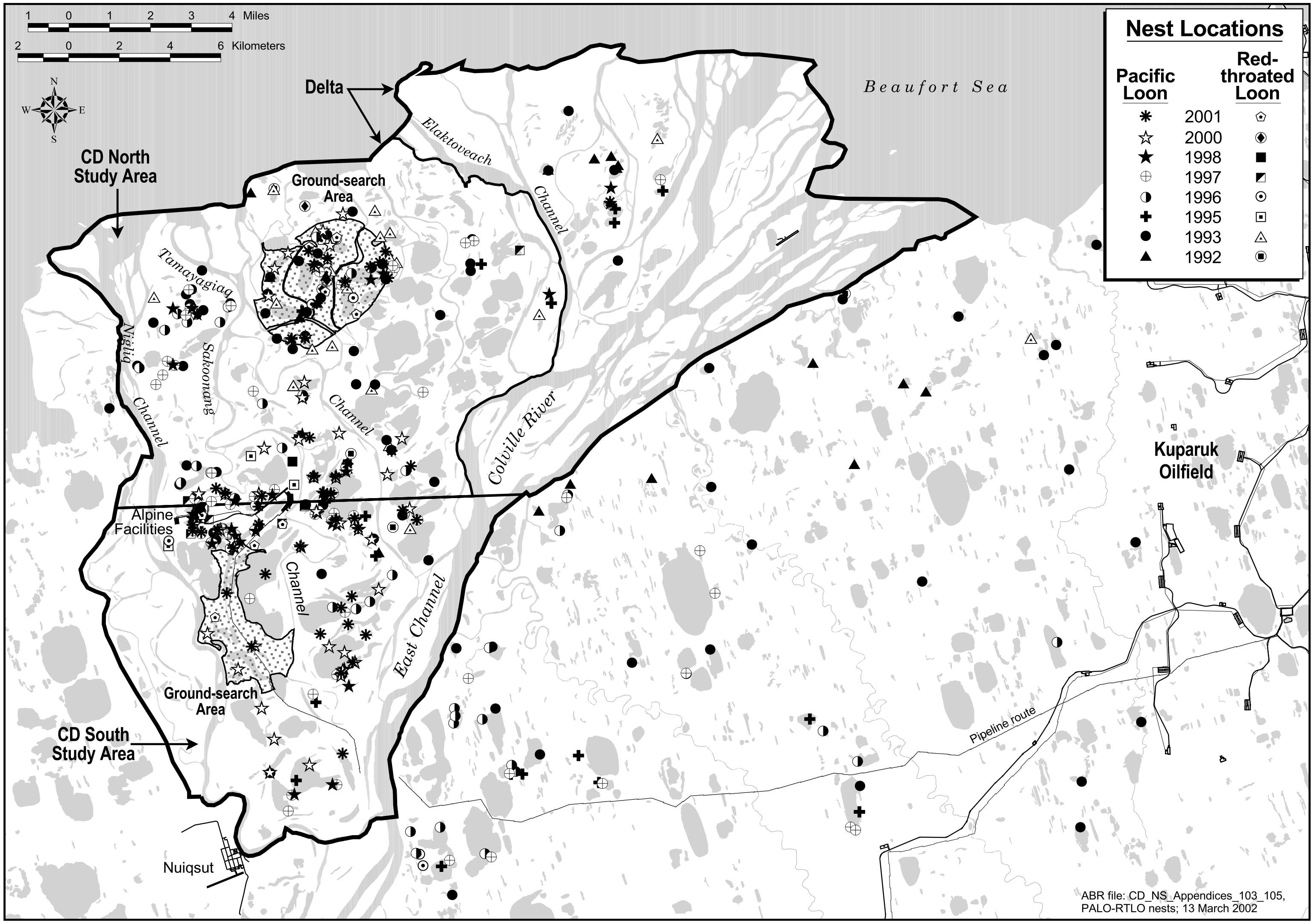
Appendix C7. Distribution of Tundra Swan broods during aerial and ground surveys on the Colville River Delta, Alaska, 1989–1993, 1995–1998, and 2000–2001 (pre–2000 data from Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Smith et al. 1993, 1994; and Johnson et al. 1999a).



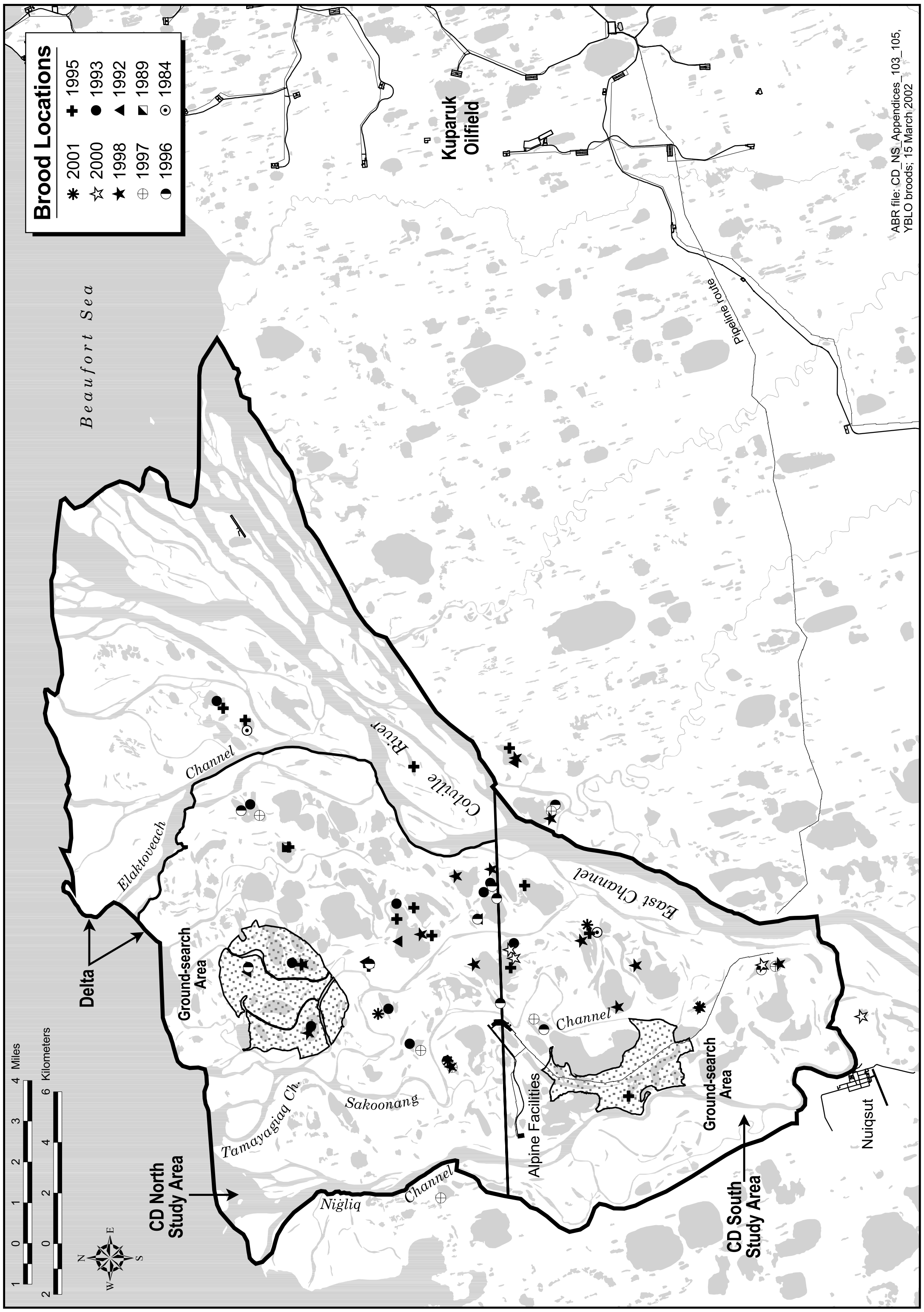
Appendix C8. Distribution of Tundra Swan fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1993, 1995–1998, and 2000–2001 (pre–2000 data from Smith et al. 1994; and Johnson et al. 1999a). Numbers indicate size of groups >10.



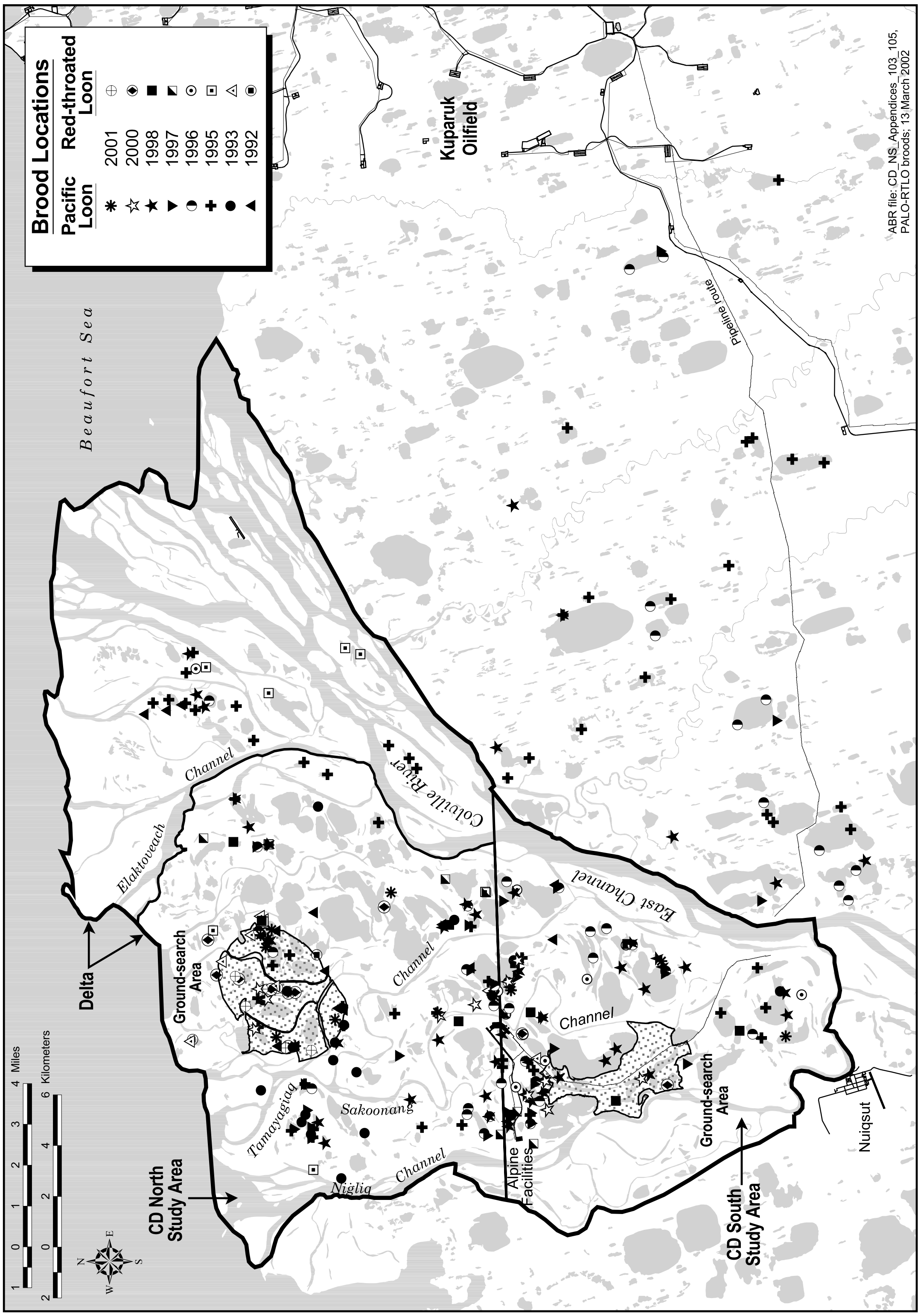
Appendix C9. Distribution of Yellow-billed Loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1982–1984, 1989–1990, 1992–1993, 1995–1998, and 2000–2001 (pre–2000 data from unpublished data of M. North [1982–1984, 1989, and 1990] and S. Earnst [1995–1997]; Smith et al. 1993, 1994; and Johnson et al. 1999a).



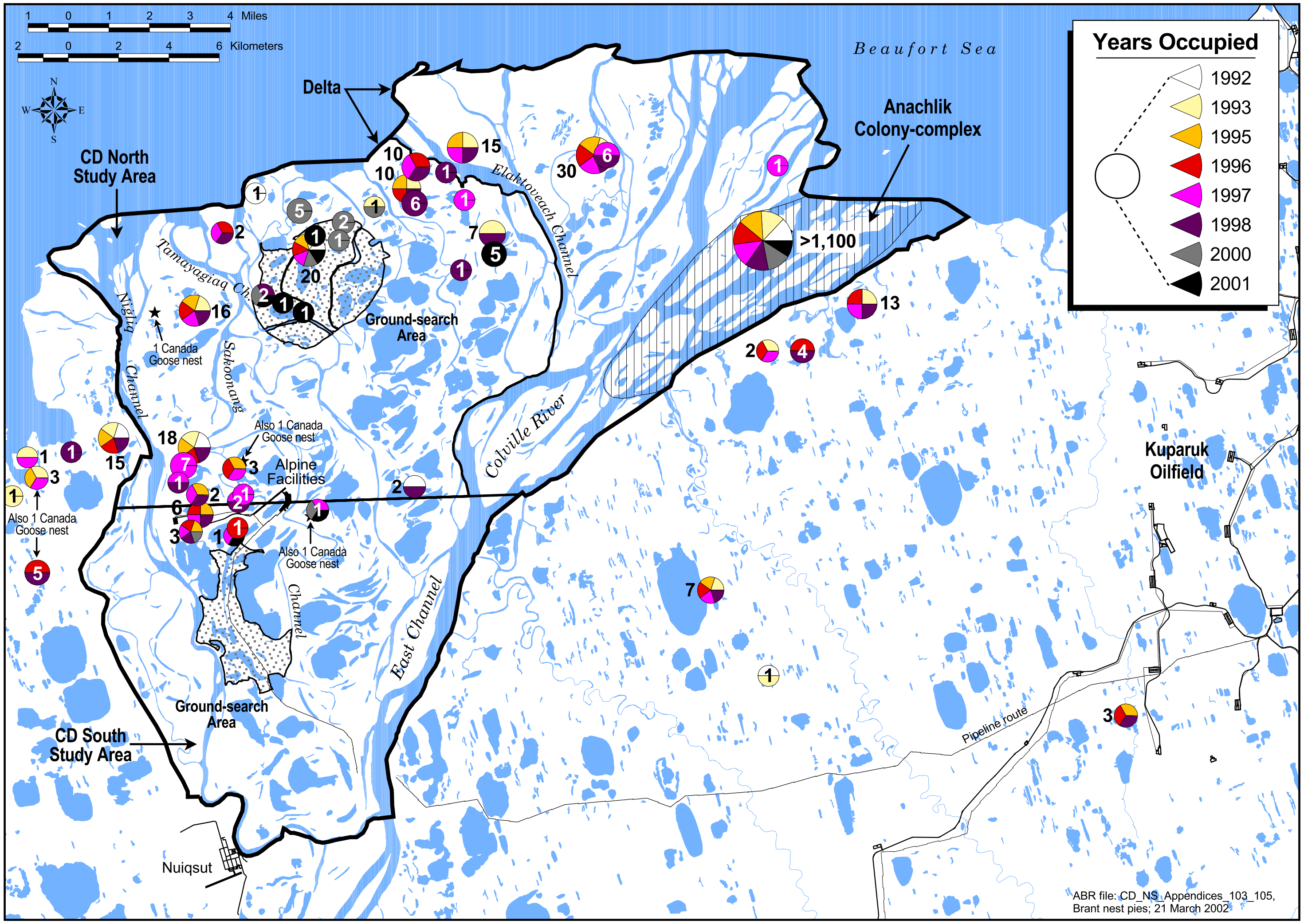
Appendix C10. Distribution of Pacific and Red-throated loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1992–1993, 1995–1998, and 2000–2001 (pre-2000 data from Smith et al. 1993, 1994 and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



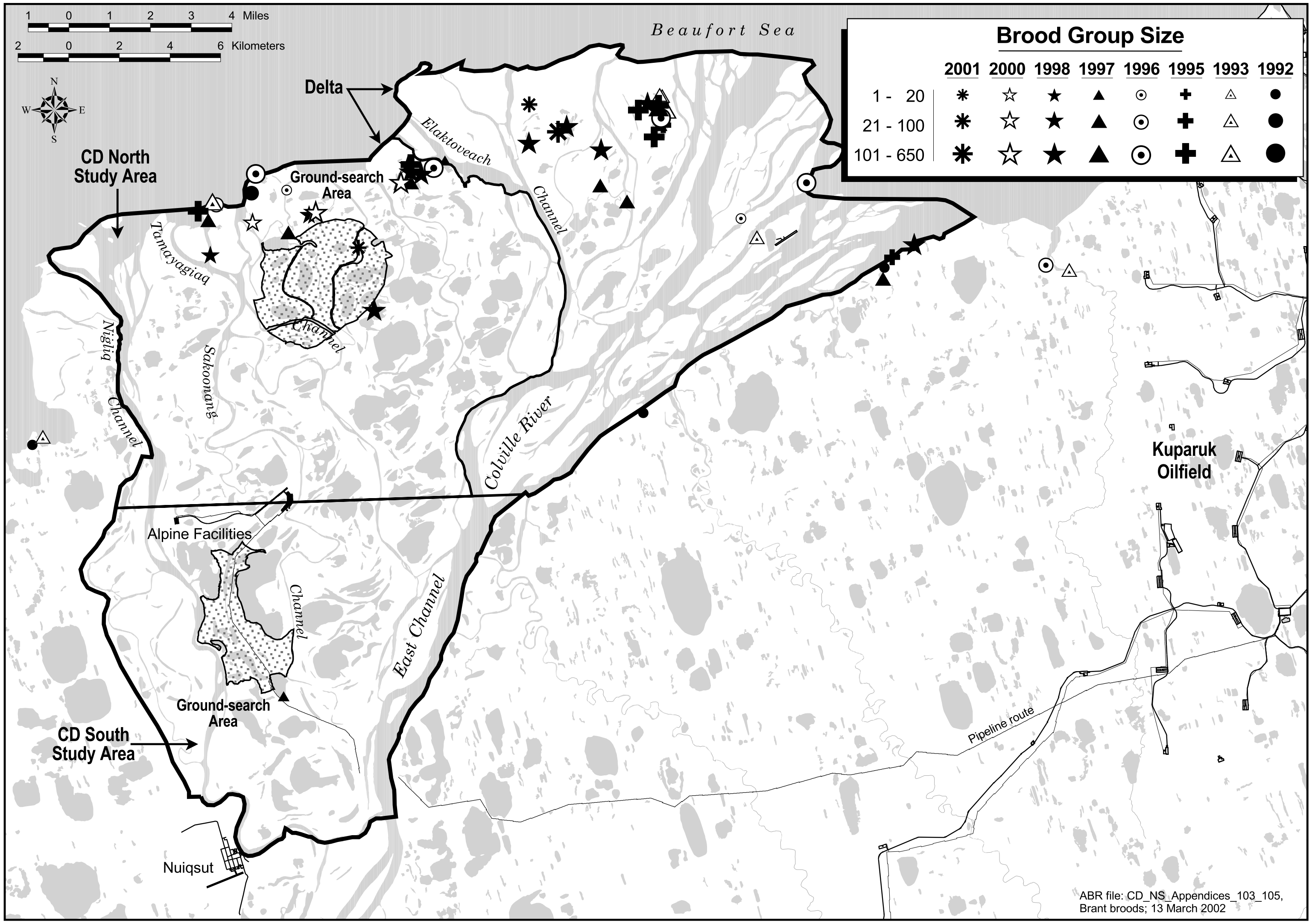
Appendix C11. Distribution of Yellow-billed Loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1984, 1989, 1992–1993, 1995–1998, and 2000–2001 (pre–2000 data from unpublished data of M. North [1984 and 1989] and S. Earnst [1996]; Smith et al. 1993, 1994; and Johnson et al. 1999a).



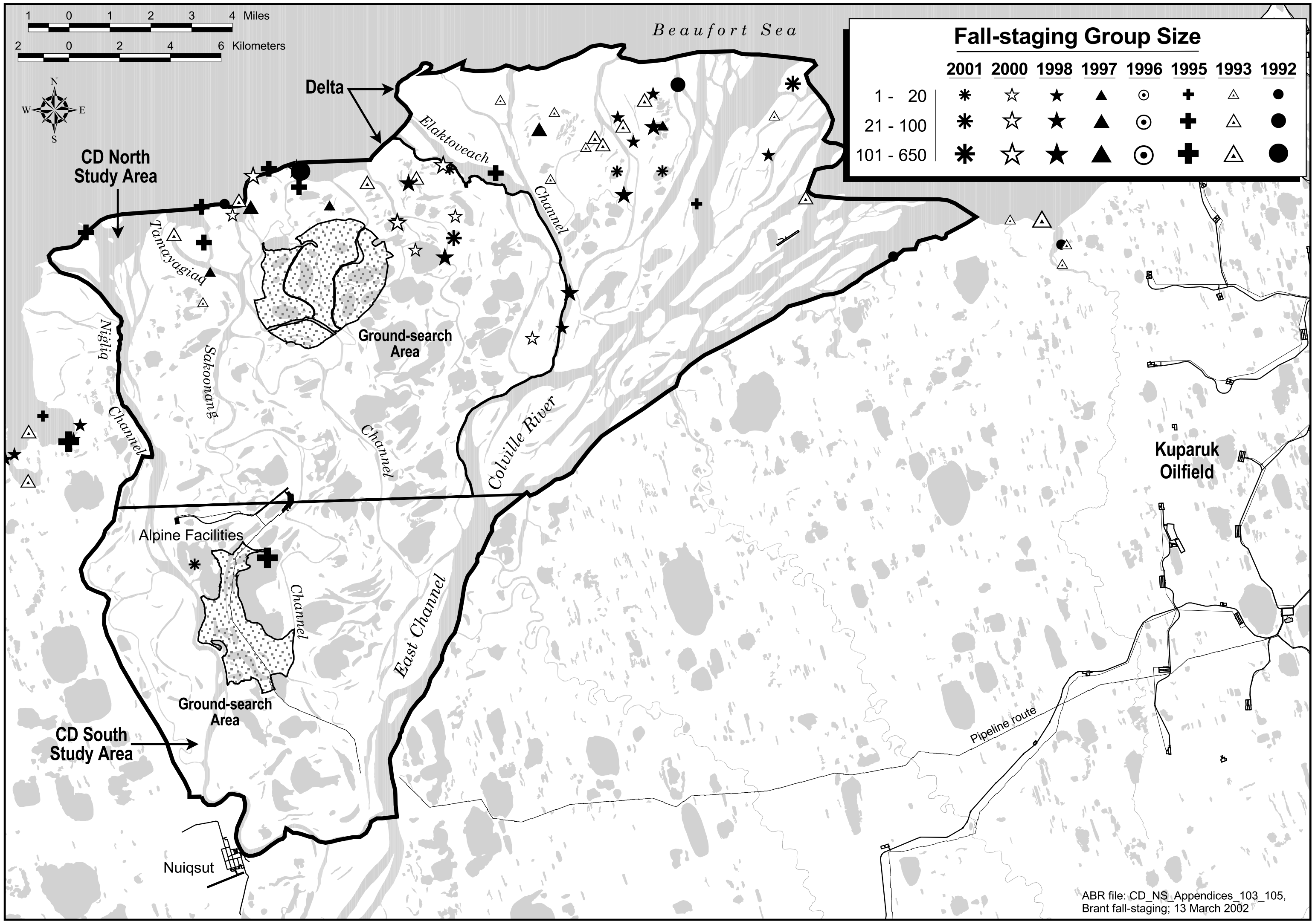
Appendix C12. Distribution of Pacific and Red-throated loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1992–1993, 1995–1998, and 2000–2001 (pre–2000 data from Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



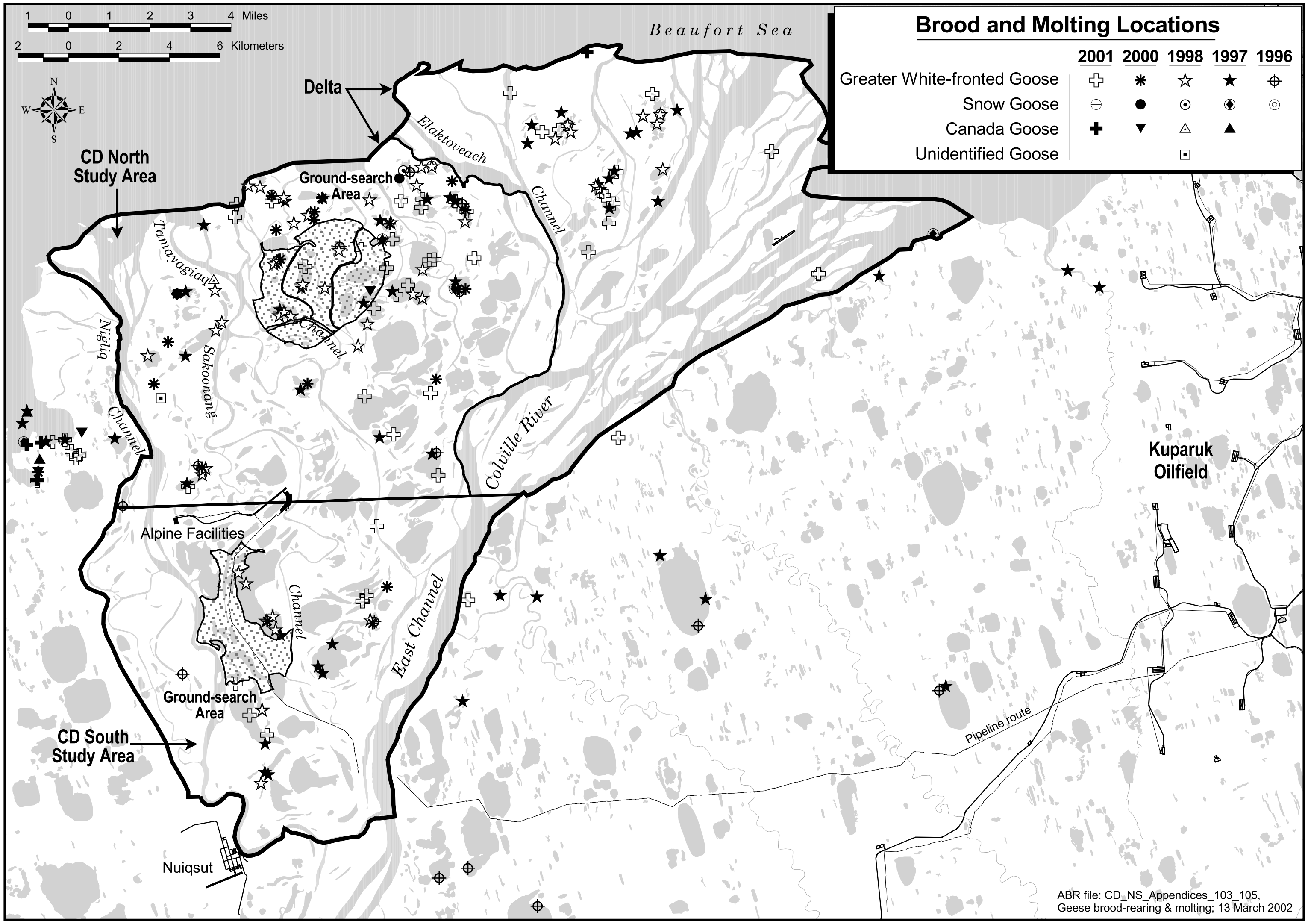
Appendix C13. Distribution and size of Brant colonies and locations of 4 Canada Goose nests during aerial and ground surveys on the Colville River Delta, Alaska, 1992–1993, and 1995–1998 (data from Smith et al. 1993, 1994; and Johnson et al. 1999a). The number near each circle represents the maximal number of nests counted during the five years of study. Surveys were not conducted during 2000 or 2001..



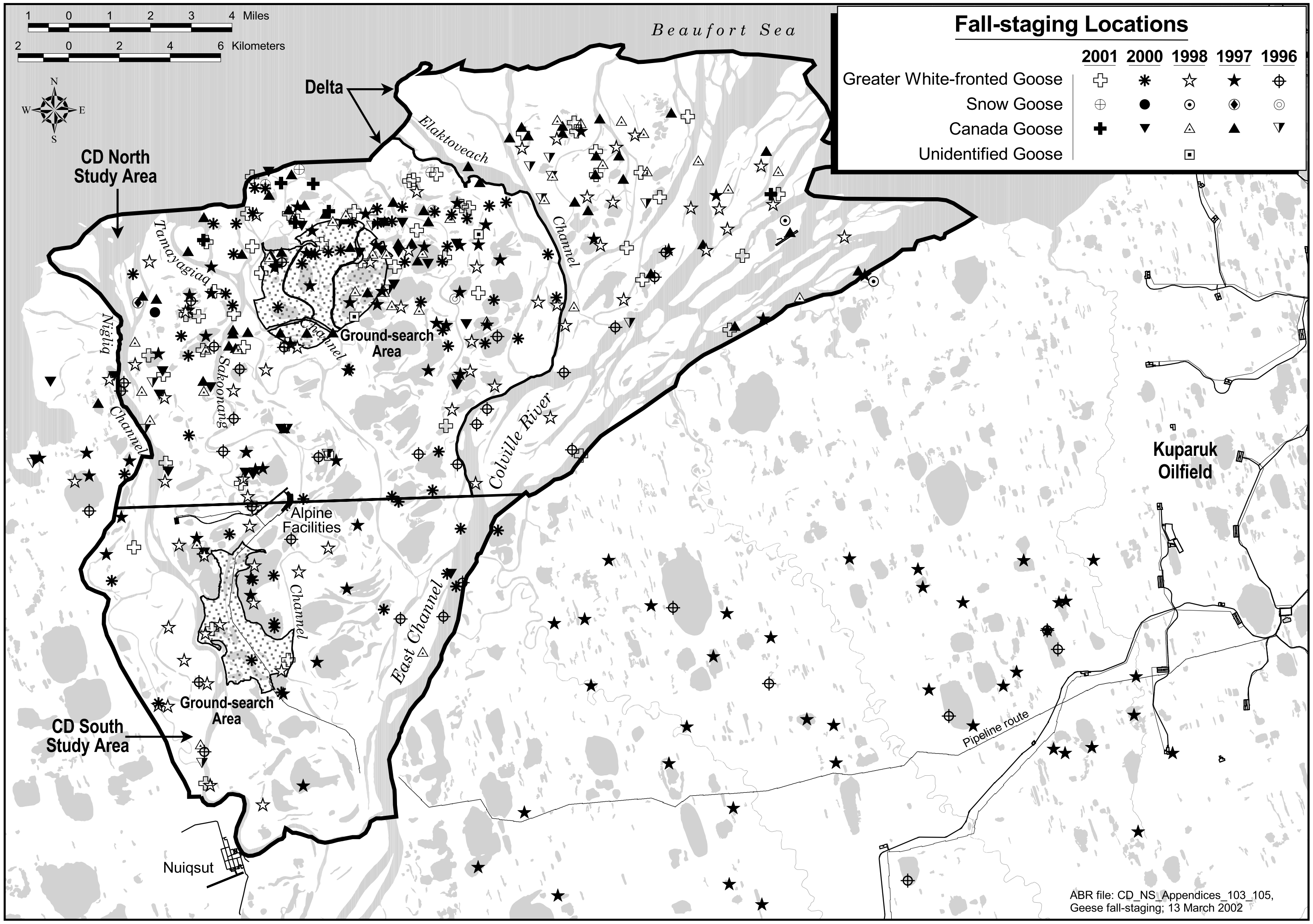
Appendix C14. Distribution and size of Brant brood-rearing groups during aerial surveys on the Colville River Delta, Alaska, 1992–1993, 1995–1998, and 2000–2001 (pre–2000 data from Smith et al. 1993, 1994; and Johnson et al. 1999a).



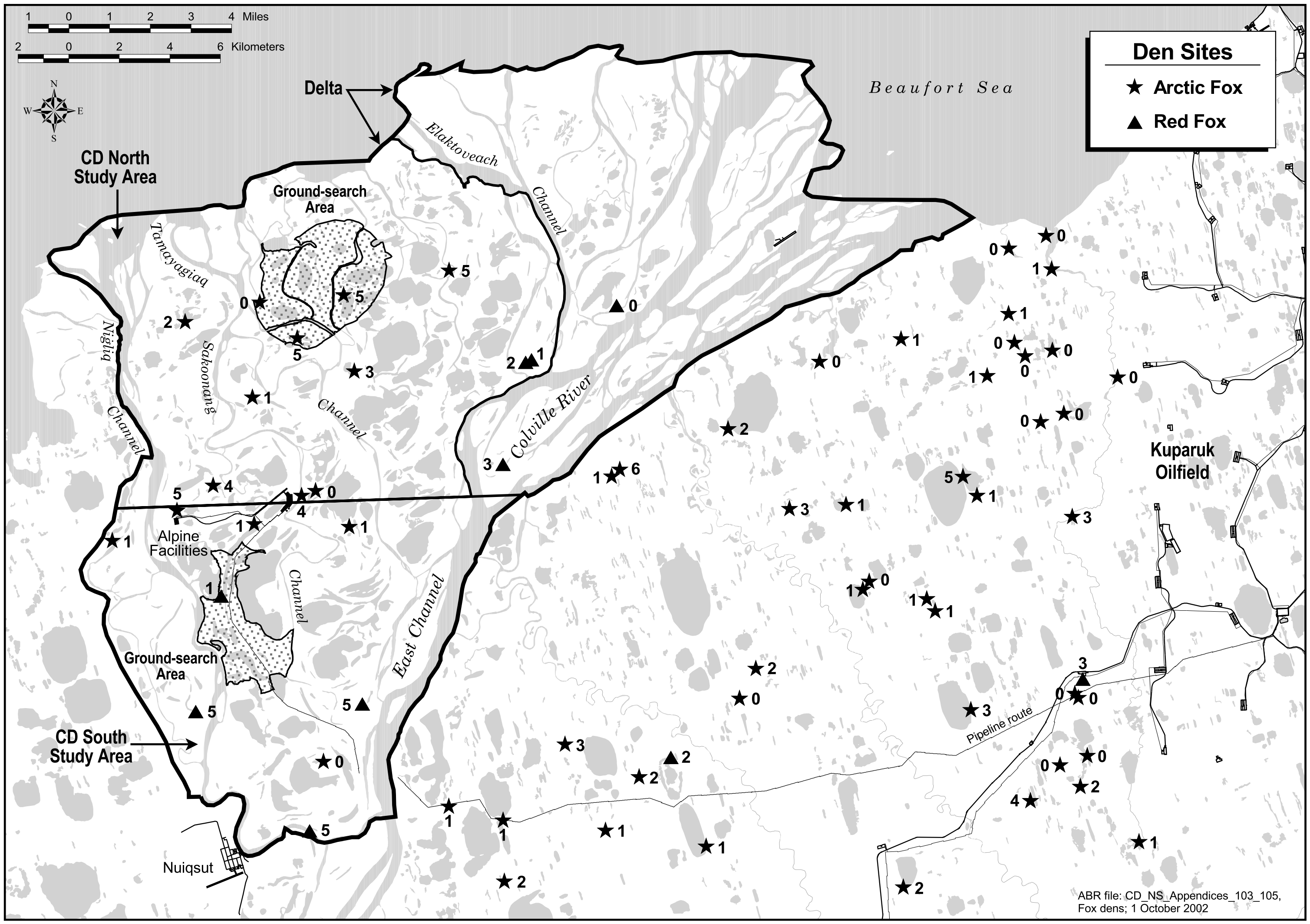
Appendix C15. Distribution and size of Brant fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1992–1993, 1995–1998, and 2000–2001 (pre–2000 data from Smith et al. 1993, 1994; and Johnson et al. 1999a).



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 2000–2001 (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 2000–2001 (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 foxes on the Colville River Delta, Alaska, 1992–1993 and 1995–2001 (pre–2000 data from Johnson et al. 2000b). 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, 1993–1998 and 2000–2001 (pre–2000 data from Johnson et al. 1999a).

SPECIES Habitat	Total Groups	Total Adults	Use (%)
SPECTACLED EIDER			
Tapped Lake with Low-water Connection	1	2	25.0
Tapped Lake with High-water Connection	1	2	25.0
River or Stream	1	2	25.0
Aquatic Sedge with Deep Polygons	1	2	25.0
TOTAL	4	8	100
KING EIDER			
Tapped Lake with Low-water Connection	1	2	7.7
Tapped Lake with High-water Connection	2	6	15.4
River or Stream	7	19	53.9
Wet Sedge–Willow Meadow	2	2	15.4
Riverine or Upland Shrub	1	2	7.7
TOTAL	13	31	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 2000–2001 (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	0	0	0.0	1.5	ns
Brackish Water	50	21	13.1	1.3	prefer
Tapped Lake with Low-water Connection	27	11	6.9	4.4	ns
Tapped Lake with High-water Connection	10	6	3.8	4.0	ns
Salt Marsh	25	12	7.5	3.2	prefer
Tidal Flat	0	0	0.0	6.9	avoid
Salt-killed Tundra	29	16	10.0	5.0	prefer
Deep Open Water without Islands	9	6	3.8	4.0	ns
Deep Open Water with Islands or Polygonized Margins	13	8	5.0	1.6	prefer
Shallow Open Water without Islands	4	2	1.3	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	3	2	1.3	0.1	prefer
River or Stream	12	6	3.8	14.0	avoid
Aquatic Sedge Marsh	0	0	0.0	0.0	ns
Aquatic Sedge with Deep Polygons	68	37	23.1	2.6	prefer
Aquatic Grass Marsh	2	2	1.3	0.3	ns
Young Basin Wetland Complex	0	0	0.0	0.0	ns
Old Basin Wetland Complex	0	0	0.0	0.0	ns
Nonpatterned Wet Meadow	31	15	9.4	8.1	ns
Wet Sedge–Willow Meadow	33	14	8.8	19.6	avoid
Moist Sedge–Shrub Meadow	0	0	0.0	2.5	avoid
Moist Tussock Tundra	0	0	0.0	0.5	ns
Riverine or Upland Shrub	0	0	0.0	5.1	avoid
Barrens	4	2	1.3	14.9	avoid
Artificial	0	0	0.0	0.0	ns
TOTAL	320	160	100	100	
KING EIDERS					
Open Nearshore Water	10	2	2.4	1.5	ns
Brackish Water	6	4	4.9	1.3	prefer
Tapped Lake with Low-water Connection	13	6	7.3	4.4	ns
Tapped Lake with High-water Connection	8	3	3.7	4.0	ns
Salt Marsh	2	1	1.2	3.2	ns
Tidal Flat	4	2	2.4	6.9	ns
Salt-killed Tundra	12	7	8.5	5.0	ns
Deep Open Water without Islands	4	1	1.2	4.0	ns
Deep Open Water with Islands or Polygonized Margins	5	2	2.4	1.6	ns
Shallow Open Water without Islands	0	0	0.0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.0	0.1	ns
River or Stream	132	41	50.0	14.0	prefer
Aquatic Sedge Marsh	0	0	0.0	0.0	ns
Aquatic Sedge with Deep Polygons	6	3	3.7	2.6	ns
Aquatic Grass Marsh	0	0	0.0	0.3	ns
Young Basin Wetland Complex	0	0	0.0	0.0	ns
Old Basin Wetland Complex	0	0	0.0	0.0	ns
Nonpatterned Wet Meadow	1	1	1.2	8.1	avoid
Wet Sedge–Willow Meadow	12	7	8.5	19.6	avoid
Moist Sedge–Shrub Meadow	0	0	0.0	2.5	ns
Moist Tussock Tundra	0	0	0.0	0.5	ns
Riverine or Upland Shrub	2	1	1.2	5.1	avoid
Barrens	1	1	1.2	14.9	avoid
Artificial	0	0	0.0	0.0	ns
TOTAL	218	82	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 and 1997–2001 (pre–2000 data from Johnson et al. 1999a, 2000b).

Habitat	No. of Nests[a]	Use (%)
HABITAT USED		
Brackish Water	6	10.9
Tapped Lake with High-water Connection	1	1.8
Salt Marsh	1	1.8
Salt-killed Tundra	14	25.5
Deep Open Water with Islands or Polygonized Margins	5	9.1
Shallow Open Water without Islands	1	1.8
Aquatic Sedge with Deep Polygons	12	21.8
Nonpatterned Wet Meadow	7	12.7
Wet Sedge–Willow Meadow	8	14.5
TOTAL	55	100
NEAREST WATERBODY HABITAT [b]		
Brackish Water	22	40.0
Tapped Lake with Low-water Connection	2	3.6
Tapped Lake with High-water Connection	6	10.9
Deep Open Water without Islands	3	5.5
Deep Open Water with Islands or Polygonized Margins	17	30.9
Shallow Open Water without Islands	2	3.6
Shallow Open Water with Islands or Polygonized Margins	2	3.6
River or Stream	1	1.8
TOTAL	55	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, 1983, 1984, 1992, 1993, 1995, 2000, and 2001 (pre–2000 data from unpublished data of M. North [1983 and 1984], and Johnson et al. 1999a). Broods were located during both aerial and ground surveys.

SPECIES Habitat Type	Total Brood-rearing Groups	Total Young[a]	Use (%)
SPECTACLED EIDER			
Brackish Water	3	11	10.3
Tapped Lake with Low-water Connection	3	3	10.3
Tapped Lake with High-water Connection	1	4	3.4
Salt-killed Tundra	5	24	17.2
Deep Open Water without Islands or Polygonized Margins	3	8	10.3
Deep Open Water with Islands or Polygonized Margins	7	16	24.1
Aquatic Sedge with Deep Polygons	2	4	6.9
Aquatic Grass Marsh	1	4	3.4
Wet Sedge–Willow Meadow	4	14	13.8
TOTAL	29	88	100
KING EIDER			
Aquatic Sedge with Deep Polygons	1	7	50.0
Wet Sedge–Willow Meadow	1	5	50.0
TOTAL	2	12	100

[a] Number of young not recorded for 2 broods in Tapped Lake with Low-water Connection, 1 brood in Deep Open Water with Islands or Polygonized Margin, 1 in Aquatic Sedge with Deep Polygons, and 1 in Wet Sedge–Willow Meadow (M. North, unpubl. data).

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 2000–2001 (pre–2000 data from Johnson et al. 1999a).

Year	Nests		Broods		Nesting Success[a] (%)	Mean Brood Size
	Total	Density	No.	Density		
1992	14	0.03	16	0.03	114	2.4
1993	20	0.04	14	0.03	70	2.6
1995	38	0.07	25	0.05	66	3.7
1996	45	0.08	32	0.06	71	3.4
1997	32	0.06	24	0.04	75	2.5
1998	31	0.06	22	0.04	71	2.4
2000	32	0.06	20	0.04	63	1.9
2001	27	0.05	22	0.04	81	1.7

[a] Estimated as the number of broods divided by the number of nests (see text).

Appendix D6. Numbers and densities (no./km²) of Tundra Swan adults and young during fall-staging surveys of the Colville River Delta, Alaska, 1992–2000 (pre–2000 data from Johnson et al. 1999a; surveys were not conducted during 2001).

	Adults		Young		Number of Groups
Year	Total	Density	Total	Density	
1992	0	–	0	–	0
1993	260	0.47	35	0.06	28
1995	28	0.05	36	0.07	15
1996	314	0.57	41	0.07	21
1997	194	0.35	92	0.17	11
1998	411	0.75	20	0.04	26
2000	66	0.12	23	0.04	34
2001	No data	No data	No data	No data	No data

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 2000–2001 (pre–2000 data from Johnson et al. 1999a).

Season Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results
NESTING				
Open Nearshore Water	0	0	1.9	avoid
Brackish Water	0	0	1.2	ns
Tapped Lake with Low-water Connection	2	0.8	3.9	avoid
Tapped Lake with High-water Connection	4	1.7	3.7	ns
Salt Marsh	14	5.9	3.0	ns
Tidal Flat	4	1.7	10.2	avoid
Salt-killed Tundra	27	11.3	4.6	prefer
Deep Open Water without Islands	4	1.7	4.2	avoid
Deep Open Water with Islands or Polygonized Margins	10	4.2	0.9	prefer
Shallow Open Water without Islands	1	0.4	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	1	0.4	0.1	ns
River or Stream	0	0	14.8	avoid
Aquatic Sedge Marsh	1	0.4	0	ns
Aquatic Sedge with Deep Polygons	17	7.1	2.5	prefer
Aquatic Grass Marsh	2	0.8	0.2	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	27	11.3	7.6	ns
Wet Sedge–Willow Meadow	92	38.5	18.6	prefer
Moist Sedge–Shrub Meadow	18	7.5	2.4	prefer
Moist Tussock Tundra	3	1.3	0.5	ns
Riverine or Upland Shrub	5	2.1	5.0	avoid
Barrens	7	2.9	14.3	avoid
Artificial	0	0	<0.1	ns
TOTAL	239	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	1.9	ns
Brackish Water	10	5.7	1.2	prefer
Tapped Lake with Low-water Connection	23	13.1	3.9	prefer
Tapped Lake with High-water Connection	13	7.4	3.7	prefer
Salt Marsh	15	8.6	3.0	prefer
Tidal Flat	2	1.1	10.2	avoid
Salt-killed Tundra	12	6.9	4.6	ns
Deep Open Water without Islands	18	10.3	4.2	prefer
Deep Open Water with Islands or Polygonized Margins	9	5.1	0.9	prefer
Shallow Open Water without Islands	1	0.6	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	1	0.6	0.1	ns
River or Stream	6	3.4	14.8	avoid
Aquatic Sedge Marsh	0	0	0	ns
Aquatic Sedge with Deep Polygons	6	3.4	2.5	ns
Aquatic Grass Marsh	2	1.1	0.2	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	10	5.7	7.6	ns
Wet Sedge–Willow Meadow	31	17.7	18.6	ns
Moist Sedge–Shrub Meadow	3	1.7	2.4	ns
Moist Tussock Tundra	0	0	0.5	ns
Riverine or Upland Shrub	3	1.7	5.0	avoid
Barrens	10	5.7	14.3	avoid
Artificial	0	0	<0.1	ns
TOTAL	175	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 2000–2001 (pre–2000 data from Johnson et al. 1999a).

SEASON Habitat	No. Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results
NESTING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.3	avoid
Tapped Lake with High-water Connection	10	9.6	5.4	ns
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	avoid
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water without Islands	8	7.7	5.5	ns
Deep Open Water with Islands or Polygonized Margins	22	21.1	1.8	prefer
Shallow Open Water without Islands	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	1	1.0	<0.1	ns
Aquatic Sedge with Deep Polygons	6	5.8	2.9	ns
Aquatic Grass Marsh	1	1.0	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	15	14.4	8.7	ns
Wet Sedge–Willow Meadow	41	39.4	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	0	0	12.2	avoid
Artificial	0	0	<0.1	ns
TOTAL	104	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.3	ns
Tapped Lake with High-water Connection	9	23.7	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 without Islands	23	61.5	5.5	prefer
Deep Open Water with Islands or Polygonized Margins	6	15.8	1.8	prefer
Shallow Open Water without Islands	0	0	0.4	ns
Shallow Open Water with 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 with 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	0	0	12.2	avoid
Artificial	0	0	<0.1	ns
TOTAL	38	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 Greater White-fronted Geese during nesting in the CD South ground-search area, 2000 and 2001.

	2000				2001			
Habitat	No. Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results	No. Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results
Tapped Lake with Low-water Connection	0	0	<0.1	ns	0	0.0	<0.1	ns
Tapped Lake with High-water Connection	0	0	9.3	ns	0	0.0	6.6	ns
Salt Marsh	0	0	<0.1	ns	0	0.0	2.5	ns
Deep Open Water without Islands	0	0	3.8	ns	0	0.0	2.3	ns
Deep Open Water with Islands or Polygonized Margins	0	0	6.7	ns	0	0.0	4.5	ns
Shallow Open Water without Islands	0	0	0.2	ns	0	0.0	0.2	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns	0	0.0	0.1	ns
Aquatic Sedge with Deep Polygons	0	0	0.3	ns	0	0.0	0.2	ns
Aquatic Grass Marsh	0	0	0.4	ns	0	0.0	1.1	ns
Nonpatterned Wet Meadow	0	0	4.8	ns	1	2.5	4.0	ns
Wet Sedge–Willow Meadow	23	63.9	37.6	prefer	29	72.5	41.2	prefer
Moist Sedge–Shrub Meadow	13	36.1	21.8	ns	9	22.5	22.5	ns
Riverine or Upland Shrub	0	0	14.6	avoid	1	2.5	11.9	avoid
Barrens	0	0	0.5	ns	0	0.0	3.0	ns
TOTAL	36	100.0	100.0		40	100.0	100.0	

Appendix D10. Habitat selection by foxes, as indicated by den site locations on the Colville River Delta, Alaska, 2001 (pre–2000 data from Johnson et al. 2000b). 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	0	-	-	0	-
Brackish Water	0	-	-	0	-
Tapped Lake with Low-water Connection	0	-	-	0	-
Tapped Lake with High-water Connection	0	-	-	0	-
Salt Marsh	16.6	0	0	4.4	ns
Tidal Flat	56.0	0	0	14.8	avoid
Salt-killed Tundra	25.6	0	0	6.8	ns
Deep Open Water without Islands	0	-	-	0	-
Deep Open Water with Islands or Polygonized Margins	0	-	-	0	-
Shallow Open Water without Islands	0	-	-	0	-
Shallow Open Water with Islands or Polygonized Margins	0	-	-	0	-
River or Stream	0	-	-	0	-
Aquatic Sedge Marsh	0	-	-	0	-
Aquatic Sedge with Deep Polygons	13.2	0	0	3.5	ns
Aquatic Grass Marsh	0	-	-	0	-
Young Basin Wetland Complex	<0.1	0	0	<0.1	ns
Old Basin Wetland Complex	<0.1	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.5	2	8.7	11.0	ns
Wet Sedge–Willow Meadow	102.6	3	13.4	27.1	avoid
Moist Sedge–Shrub Meadow	13.2	1	4.5	3.5	ns
Moist Tussock Tundra	2.6	0	0	0.7	ns
Riverine or Upland Shrub	27.6	16	69.6	7.3	prefer
Barrens	78.7	1	4.4	20.8	avoid
Artificial	0.4	0	0	0.1	ns
TOTAL	378.0	23	100.0	100.0	

[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.