WILDLIFE STUDIES IN THE CD NORTH STUDY AREA, 2001

FINAL REPORT

Prepared for

ConocoPhillips Alaska, Inc.
P. O. Box 100360
Anchorage, AK 99510

Prepared by

Charles B. Johnson
Robert M. Burgess
Brian E. Lawhead
John R. Rose
Alice A. Stickney
Ann M. Wildman

ABR, Inc.
P. O. Box 80410
Fairbanks, AK 99708

December 2002

Printed on recycled paper.

EXECUTIVE SUMMARY

During spring 2000, ABR, Inc. was contracted to conduct wildlife studies for 2 new oil prospects on the Colville River Delta, Fiord and Nanuq, as part of the planning process for potential oil development. The CD North study area encompasses Fiord. Beginning in 1992, ARCO Alaska, Inc. (now ConocoPhillips Alaska, Inc.) initiated studies to examine the biological, physical, and cultural resources of the delta. The Alpine Development Project, on the central delta, received its federal permits in 1998, and with the establishment of the Alpine facilities and pipeline, oil development on other parts of the delta became more feasible. In this annual report on the 2001 field season, the results are presented from the second year of study of the wildlife resources in the CD North study area and the tenth year of studies on the Colville Delta.

The CD North study area is located on the outer portion of the Colville River Delta and is delimited by the Beaufort Sea on the north, the Alpine airstrip on the south, the Elaktoveach and East channels of the Colville River on the east and the Nigliq Channel on the west. The Colville Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fishes that are found there. The delta is a regionally important nesting area for Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders, and it 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. The delta occasionally is used for denning by both brown and polar bears. The Colville Delta has attracted 2 permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family home site, both of which rely heavily on these fish and wildlife resources.

The primary goal of the CD North wildlife studies was to collect data on the distribution, abundance, and habitat use of selected species of birds and mammals from late spring to early fall to be used as a baseline for conditions prior to oil development. Six focal species were originally selected during meetings with the U.S. Fish and Wildlife Service in 1992 based on status as threatened or endangered species, the importance of the Colville Delta as breeding habitat, or special concern from agencies: Spectacled Eiders, Tundra Swans, Brant, Yellow-billed Loons, arctic foxes, and caribou. After 1992, 3 additional species were targeted for more focused attention: King Eider, Greater White-fronted Goose, and Bar-tailed Godwit. During surveys for focal species, other species were monitored opportunistically: Red-throated and Pacific loons, gulls, red foxes, muskox and brown bears. Caribou were not included in surveys of CD North, but were monitored as part of a separate study of the Central Arctic Herd. Surveys of the CD North study area (207 km²) were conducted throughout the summer from aircraft for focal species and with intensive foot searches for nests and broods of large waterbirds and ptarmigan in the ground-search area (17.9 km²), where development is expected to be located.

HABITAT AVAILABILITY

The outer delta is subject to more extensive river flooding during spring break-up and marine flooding from storm surges than the rest of the delta, and, therefore, contains younger surfaces with more mineral deposition, higher salinity, and less organic accumulation than the rest of the delta. Because CD North is on the outer delta, it contains larger proportions of coastal habitats than the entire delta. Twenty-four habitats were classified and mapped on the delta, of which 21 occur in the CD North study area and 17 occur in the ground-search area.

CONDITIONS IN THE STUDY AREA

The 2001 breeding season was similar to 2000 but both these years were unusual among previous years because of the extent that weather and river conditions delayed the onset of nesting for birds in much of the study area. Spring temperatures were cold and snowmelt was late relative to other years we have worked 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.

NESTS IN THE GROUND-SEARCH AREA

In 2001, 299 nests of 14 species were recorded in the CD North ground-search area. Nest density was almost twice that of other areas on the delta that were similarly searched and the overall nest success was 52%. In both 2000 and 2001, habitats with polygonal surface forms contained the highest numbers of nests: Wet Sedge–Willow Meadow, Aquatic Sedge with Deep Polygons, Deep Open Water with Islands or Polygonized Margins, and Salt-killed Tundra. More than half of the nests in each year belonged to geese, with Greater White-fronted Geese the most abundant (120–177 nests), followed by Brant (24–30 nests). Duck nests were abundant in both years and primarily consisted of Long-tailed Duck (18–21 nests) and Spectacled Eider (7–14 nests). Three Tundra Swan and 2–4 Yellow-billed Loon nests were found each year in the ground-search area.

SPECTACLED EIDERS

Spectacled Eiders on the Colville Delta were closely associated with coastal areas during pre-nesting surveys conducted every year since 1992. The mean distance from the coast of Spectacled Eiders in 2001 was 4.5 km, which was similar to the mean distance of all sightings since 1993 (mean = 4.0 km). Thirty Spectacled Eiders were counted on pre-nesting aerial surveys in 2001, for the lowest density on record since delta-wide surveys began in 1993. The cool spring temperatures in May delayed snowmelt and caused flooding, which may have discouraged Spectacled Eiders from using the delta during the survey period. The average density of Spectacled Eiders in the CD North area is similar to the average density on the Arctic Coastal Plain. The CD North study area supports a higher density of Spectacled Eiders than do more inland portions of the delta, probably because of its coastal location and brackish habitats. During pre-nesting in 2001, Spectacled Eiders were recorded most often in Brackish Water, Salt-killed Tundra, and Deep Open Water with Islands or Polygonized Margins. All of these habitats, along with Salt Marsh, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons, were significantly preferred according to an analysis for the entire delta. The coastal portion of the delta also is where Spectacled Eiders nest most commonly. On an intensive nest survey during 2001 of the CD North ground-search area, 7 Spectacled Eider nests were found and 1 (14%) of those nests hatched successfully. Fourteen Spectacled Eider nests were found during 2000 in an overlapping search area. Nesting Spectacled Eiders in the CD North study area used many of the same habitats that were used during pre-nesting; most nests were found in Salt-killed Tundra, which was the only significantly preferred habitat for nesting. The results of pre-nesting and nesting habitat analyses emphasize the importance to breeding Spectacled Eiders of saline and polygonized habitats, which are more prevalent on the outer delta.

KING EIDERS

The Colville Delta does not attract concentrations of breeding King Eiders. The CD North study area supports less than one fourth of the density of King Eiders that occur in the adjacent Kuparuk Oilfield and the entire Arctic Coastal Plain. The density of King Eiders during pre-nesting in 2001 in the CD North study area was 1 of the 2 highest densities recorded since 1993. Brackish Water and River or Stream were the only habitats preferred by pre-nesting King Eiders on the delta. Only 6 King Eider nests and 2 broods have been found during 10 years of surveys on the delta.

TUNDRA SWANS

In 2001, 13 Tundra Swan nests were counted during aerial surveys in the CD North study area, about half the number counted on the entire delta. Preferred nesting habitats included 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. Eight swan broods were counted in the CD North study area in 2001. Nest success, estimated by dividing numbers of broods by the number of nests, was 62%, about mid-range of the values from previous years. Mean brood size for the CD North study area was 1.4 young/brood, which was the smallest brood size recorded in 8 years of surveys. Six habitats were preferred during brood-rearing: Brackish Water, Salt Marsh, both types of Tapped Lake, and both types of Deep Open Water.

YELLOW-BILLED LOONS

In 2001, 11 nests were counted during combined aerial surveys and ground searches in the CD North study area, which was one of the highest counts recorded during 7 years of surveys. Densities similar to that found in the CD North study area in 2001 (0.14 birds/km²) have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska. All 10 nests found during aerial surveys in 2001 were on lakes where we have recorded nesting by Yellow-billed Loons in previous years. Four of the nests were within the CD North ground-search area, where nesting occurred in all prior years of study. Two habitats were preferred during nesting (Deep Open Water with Islands or Polygonized Margins and Wet Sedge–Willow Meadow), whereas 3 habitats were preferred during brood-rearing (Tapped Lake with High-water Connection and both types of Deep Open Water). For the second year in a row, production of Yellow-billed Loons was poor in 2001. Only 2 broods were seen in the CD North study area in 2001 and none were seen in 2000. In previous years, at least 3 broods have been found in the same area. The late thaw and cool spring temperatures in 2000 and 2001 probably delayed nest initiation and reduced nest success.

PACIFIC AND RED-THROATED LOONS

In 2001 in the CD North ground-search area, 11 Pacific and 6 Red-throated loon nests were found and we assumed from the number and locations of broods that 3 additional Red-throated Loon nests were in the area. Within the ground-search area, 7 Pacific and 6 Red-throated loon broods were counted during an intensive foot survey.

BRANT

Brant were the second most numerous nesting species in the CD North ground-search area. Thirty nests were found in 2000, and 24 nests were found in 2001. During the nest search in 2001, 2 colonies with 3 and 16 nests each were recorded. Aerial surveys between 1992 and 1998 found ≥14 colonies containing 2–18 nests in the CD North study area, and each colony was occupied for 1–5 years. Over 90% of the nests in 2000 and 2001 were in aquatic habitats with 72% in Deep Open Water with Islands or Polygonized Margins. Brant preferred to nest in Salt-killed Tundra and Aquatic Sedge with Deep Polygons. In 2001, 20 adults and 12 gosling Brant were recorded in the CD North study area, the lowest number since 1992. The mean percentage of goslings was 38%, which was lower than previous years (46–60% goslings). Brackish Water was used by the most Brant brood-rearing groups (38%) and was the only preferred habitat. During fall staging in 2001, 46 Brant were seen in the CD North study area, which was lower than in any previous year.

GREATER WHITE-FRONTED GEESE

The nests of Greater White-fronted Geese accounted for almost half of the nests found in the ground search areas in 2000 and 2001. The density of Greater White-fronted Goose nests (≥9.8 nests/km²) was greater than any density previously reported for the delta and >60% of the nests hatched in both years. Greater White-fronted Geese in the CD North ground-search area preferred to nest in habitats with polygonal surface forms: Wet Sedge–Willow Meadow and Aquatic Sedge with Deep Polygons. In the CD North ground-search areas in 2000 and 2001, a combined total of 13 broods of Greater White-fronted Geese were observed with 49 young. During the brood-rearing aerial survey (50% coverage) of the CD North study area in 2001, 1,118 Greater White-fronted Geese were recorded and goslings comprised 37% of the total number of geese. On the fall-staging aerial survey in 2001, 1,379 geese were counted.

CANADA GEESE

No Canada Goose nests were found during the nest searches in the CD North ground-search area in either 2000 or 2001. In 1997, a Canada Goose nest was found near the Nigliq Channel, which was the first record of Canada Geese nesting on the delta, and 2 nests were found just west of the delta in the NPRA during aerial surveys. Since 1998, Canada Geese have been observed nesting in low numbers (1–2 nests) in the vicinity of the Alpine project area. There have only been 3 records of these geese on the delta during the brood-rearing/molting period. During fall staging, Canada Geese occur in large numbers and use coastal areas of the outer delta (including the CD North study area) more than other areas on the delta. In 2001, 420 Canada Geese were observed in the CD North study area during fall staging. The highest fall-staging count was obtained in 1992, when ~4,600 geese were counted.

FOXES

Twelve fox dens have been located in the CD North study area since 1992; 10 of the dens were arctic fox sites in 2001 (1 den/21 km^2), and 2 were red fox dens. The highest density of active dens occurred in 1996, a year of high microtine rodent populations, when a large proportion of dens were occupied across the entire delta and adjacent coastal plain. The density of arctic fox dens in the CD North study area is slightly higher than the density for the combined Colville Delta and Transportation Corridor survey areas (1 den/26 km^2), but within the range of densities reported for other areas. Pups were observed at 2 natal dens and suspected at 2 other active dens. Thus an estimated 40% of the dens in the CD North study area were occupied by arctic fox litters in 2001, which was at the lower end of the range observed since 1993 (40–89%). Five arctic fox pups were counted at the 2 confirmed natal dens, for a mean litter size of 2.5 pups, which was near the low end of the range observed since 1993 (2.0–5.3 pups/litter). In the CD North study area, the habitat type used most often for denning was Riverine or Upland Shrub (7 of 12 dens). On the entire Colville Delta, 16 dens were located in Riverine or Upland Shrub, the only denning habitat that was preferred.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

The CD North wildlife studies required the combined effort of a large number of people in the field and office: Sally Anderson, Julie Betsch, Bob Burgess, Larry Byrne, Renee Crain, Melissa Cunningham, Cathy Egan, J.J. Frost, Beth Hahn, Mark Hopey, Jim King, Mike Knoche, Pat Lovely, Matt Macander, Randy Mullen, Julie Neville, Jason Ontjes, Julie Parrett, Lincoln Parrett, Bob Ritchie, Karen Seginak, Pam Seiser, Una Swain, Teresa Troyer, and Rich Young spent long, hard hours on the tundra or in aircraft collecting data. Sandy Hamilton returned to pilot our aerial surveys through another season on the Colville River, ably assisted by Jay Martin. Helicopter pilots Howard Reed, Mike Fell, Rick Farish, and Jim Dell of Maritime Helicopters safely transported us around the study area. Justin Harth and Derek Helmericks facilitated our daily field travel. Will Lentz, Matt Macander, and Allison Zusi-Cobb digitized wildlife locations, summarized map data, and produced clear, concise figures. Jennifer Felkay and Jennifer Roof performed word processing and document production. Caryn Rea, Environmental Studies Coordinator for ConocoPhillips Alaska, Inc., managed and promoted the continuation of biological studies on the Colville River Delta; her support and guidance ensured the success of these studies. Finally, the coauthors would like to acknowledge and thank all the ConocoPhillips staff and contractors in the Alpine oil field whose support was crucial to the success of these environmental studies.

INTRODUCTION

During spring 2000, ABR, Inc., was contracted to conduct wildlife studies for 2 new oil prospects on the Colville River Delta, CD North and CD South, to support the planning process for potential oil development. An environmental evaluation for both CD North and CD South was conducted to support oil development permit applications submitted during spring 2002 (PHILLIPS 2002), which incorporated the results of this current report. The proposed CD North Development Project is located on the Colville River Delta, 10.1 km north and east of the Alpine Development. The CD North study area encompasses the Fiord prospect, whose discovery was announced in 1992 and again in 1998. The CD South study area encompasses the Nanuq prospect, which was drilled in 1996 and 2000. This annual report of the 2001 field season presents the results from the second year of study of the wildlife resources in the CD North study area. Similar investigations for the CD South area are reported elsewhere (Burgess et al. 2000, 2002).

Wildlife studies have been conducted by ARCO Alaska, Inc. (now ConocoPhillips Alaska, Inc. [CPA]) in the Colville River Delta region since 1992 when studies were initiated to examine the biological, physical, and cultural resources of the delta. 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 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 Delta since 1992 has been to describe the distribution, abundance, and habitat use of selected species before, during, and after development-related construction. During a meeting with the U.S. Fish and Wildlife Service (USFWS) in spring 1992, CPA agreed to focus on select species, based primarily on the following criteria: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, or 3) special concern of regulatory agencies. Accordingly, 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. A separate study was conducted for caribou in the western segment of the Central Arctic Herd during 2001 (Lawhead and Prichard 2002). Evaluation of habitat use and selection by focal and some non-focal species began in 1995 (Johnson et al. 1996). A map of wildlife habitats was derived from an ecological land classification of the entire delta (Jorgensen et al. 1997), which mapped the distribution of surface forms, vegetation, and surficial geology. The wildlife habitat map was the basis for analyses of habitat selection, which have incorporated wildlife locations since 1992 (depending on the survey coverage each year) to identify habitats that are important to individual species during different portions of the breeding season.

Although baseline studies on the delta have been conducted since 1992, the focal species and the boundaries of study areas have differed somewhat among years. The general boundaries of the wildlife study area in 1992 included several exploratory drill sites and extended from Kalubik Creek on the east to the Nigliq (Nechelik) Channel on the west; thus, it included the entire delta and a large area of adjacent coastal plain (Figure 1). Although the study area included the entire delta in 1992, systematic aerial surveys for most of the focal species were conducted on 6 plots ranging from 46 to 61 km² in area. The entire delta was surveyed for Tundra Swans and caribou, and the coastal portion was surveyed for Brant. Ground-based nest searches were conducted for eiders and other waterfowl in 2 10-ha plots; one 10-ha plot, one larger aerial survey plot, and a portion of one aerial survey plot occurred in what is now the CD North project area. In 1993, the aerial survey area for all focal species was expanded to include the entire delta region (except

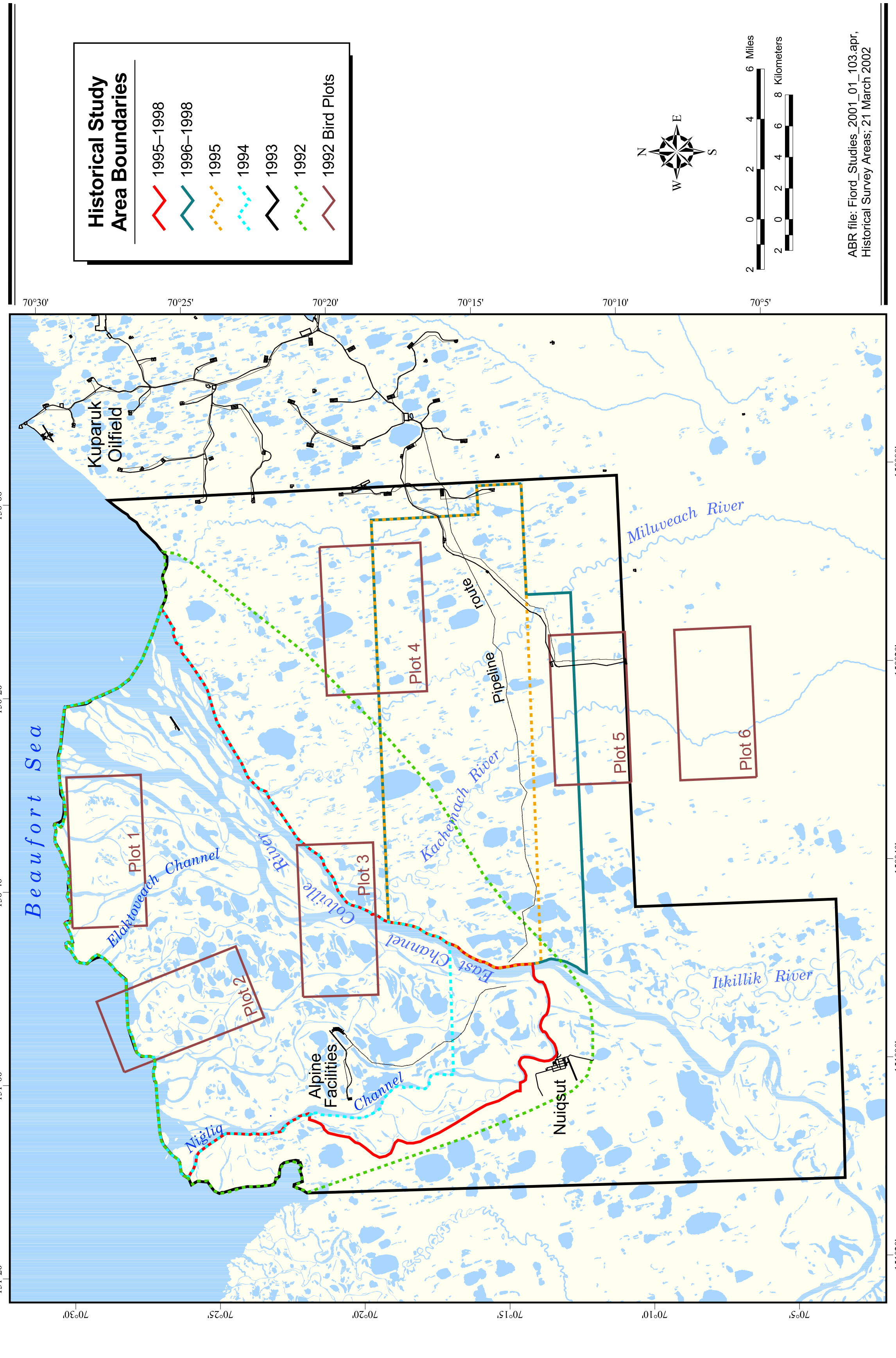


Figure 1. Wildlife study areas on the Colville River Delta and adjacent areas, Alaska, 1992–1998.

Brant, which have a coastal distribution; Smith et al. 1994). In 1994, the entire delta was surveyed, but only for eiders (Johnson 1995). In 1995, the study expanded to monitor the distribution and abundance of the same suite of species investigated in 1992 and 1993, included a new survey area (transportation corridor) that encompassed the pipeline route from Alpine to the Kuparuk Oilfield, and began an investigation of habitat use by the focal species (Johnson et al. 1996). Similar surveys were continued from 1996 to 1998 (Johnson et al. 1997, 1998, 1999a). After federal and state permits were granted for the Alpine Development Project in 1998, a multi-year monitoring study was initiated to assess the effects of aircraft disturbance on birds around the newly built airstrip (Johnson et al. 1999b, 2000b, 2001). No delta-wide surveys for wildlife were conducted in 1999. Surveys were resumed in 2000–2001 and data again were collected on the distribution and abundance of the focal species studied in previous years, with the exception of caribou. The western segment of the Central Arctic Herd, of which only a few animals use the delta during calving but does use the delta in large numbers occasionally during July–August, was the focus of a separate more wide-ranging caribou study (Lawhead and Prichard 2001, 2002).

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

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

STUDY AREA

The CD North study area (207 km²) is located on the outer portion of the Colville River Delta (hereafter, Colville Delta or the delta) and is delimited by the Beaufort Sea on the north, the Alpine airstrip on the south, the Elaktoveach and East channels of the Colville River on the east and the Nigliq (Nechelik) and western-most distributary channels on the west (Figure 2). The Colville Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fishes that are found there. The Colville Delta also has attracted 2 permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family home site, both of which rely heavily on these fish and wildlife resources.

The Colville River drains a watershed of ~53,000 km², or ~29% of the Arctic Coastal Plain of Alaska (Walker 1976). The high-volume flow and heavy sediment load of the Colville River create a large (551 km²), dynamic deltaic system in which geomorphological and biological processes have created a diversity of lakes, wetlands, and terrestrial habitats. The delta supports a wide array of wildlife and is a regionally important nesting area for Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders (Rothe et al. 1983, North 1986, Meehan and Jennings 1988; see Appendix A for scientific names). The delta also provides breeding habitat for ptarmigan, passerines, shorebirds, gulls, and predatory birds such as jaegers and owls. In spring, the delta provides some of the earliest open water and snow-free areas on the Arctic Coastal Plain for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for feeding and staging. In addition to use by birds, the delta is used seasonally by caribou for insect-relief habitat, by arctic and red foxes for denning, and by spotted seals for fishing and for haul-out sites (Seaman et al. 1981). In recent years, the delta and adjacent areas have been visited increasingly by muskoxen and brown bears, and the delta occasionally is used for denning by both brown and polar bears (see reviews in Johnson et al. 1997).

The Colville River has 2 main distributaries: 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). Several smaller distributaries branch from the East

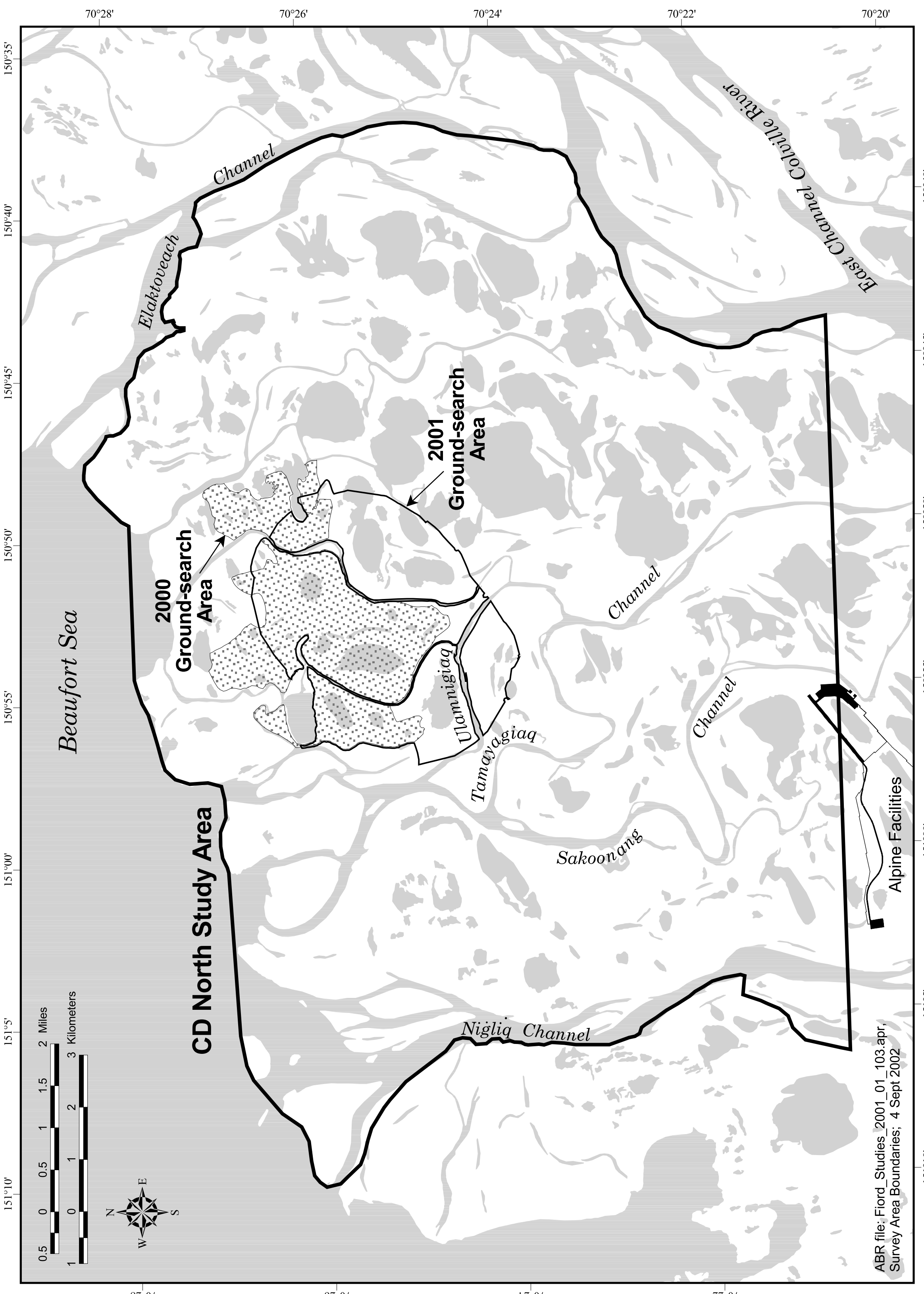


Figure 2. Boundaries for wildlife surveys in the CD North study area on the Colville River Delta, Alaska, 2000 and 2001.

Channel, including the Sakoonang, Tamayayak, and Elaktoveach channels. In addition to river channels, the delta is characterized by numerous lakes and ponds, sandbars, mudflats, sand dunes, and low- and high-centered polygons (Walker 1983). The East Channel is deep and flows under ice during winter, whereas the 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). The Colville River flows through continuous permafrost for its entire length. This extensive permafrost, combined with freezing of the upper layer of surface water in winter, influences the volume, timing, and character of river flow and erosion within the delta (Walker 1983).

Lakes and ponds are dominant physical features of the Colville Delta. Polygon ponds are the most numerous waterbody on the delta and are shallow (i.e., ≤2 m deep), freezing 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), in that they are connected to the river by narrow channels that are caused by thermokarst decay of ice wedges between the river and adjacent lakes and by the migration of river channels (Walker 1978). Channel connections allow water levels in tapped lakes to fluctuate more dramatically than in untapped lakes, resulting in barren or partially vegetated shorelines and allowing salt water to intrude into some of these lakes. River sediments raise the bottom of these lakes near the channel, eventually exposing previously submerged areas and reducing the flow of riverine water to the most extreme flood events. Because tapped lakes and river channels are the first areas of the delta to become flooded in spring, they constitute important staging habitat for migrating waterfowl in that season (Rothe et al. 1983).

The delta has an arctic maritime climate (Walker and Morgan 1964). Winters last ~8 months and are cold and windy. Spring is brief, lasting only ~3 weeks in late May and early June, and is characterized by the flooding and breakup of the river. In late May, water from melting snow flows both over and under the river ice, resulting in flooding that peaks during late May or the first week of June (Walker 1983). Breakup of the river ice usually occurs when floodwaters are at maximal levels. Water levels subsequently decrease in the delta throughout the summer, with the lowest levels occurring in late summer and fall, just before freeze-up (Walker 1983). Summers are cool, with temperatures ranging from –10° C in mid-May to +15° C in July and August (North 1986). Summer weather is characterized by low precipitation, overcast skies, fog, and persistent winds that come predominantly from the northeast. The rarer westerly winds usually bring storms that often are accompanied by high, wind-driven tides and rain (Walker and Morgan 1964).

METHODS

In 2000 and 2001, surveys were conducted for selected wildlife species in the CD North study area to assess their distribution, abundance, and use of specific sites proposed for development. In addition, habitat studies were done to investigate what landforms and vegetation types were most important seasonally to wildlife on the Colville Delta. Habitat studies consisted of statistical analyses of habitat selection by a subset of wildlife species and summaries of habitat use for the remaining species. Habitat classification (Table 1) and mapping (Figure 3) of the Colville Delta were initiated in 1995 (Johnson et al. 1996) and completed in 1996; the mapping and classification process are described in detail by Johnson et al. (1997) and Jorgenson et al. (1997). Descriptions of habitats and their distribution across the entire delta are provided in Appendices B1 and B2. Data from previous years (generally, 1992–1999) was included in our assessments of distribution,

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

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

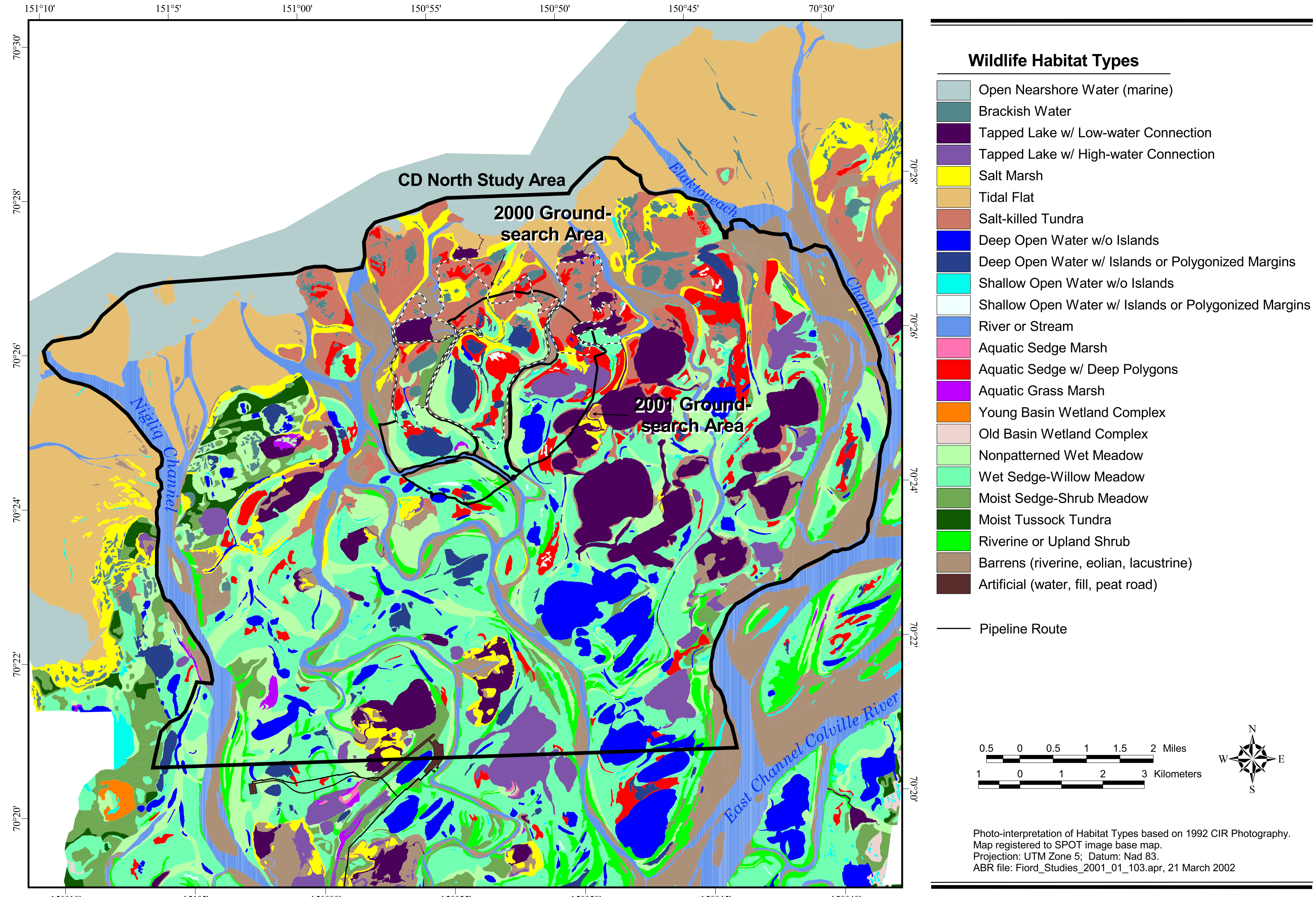


Figure 3. Habitat map of the CD North study area, Colville River Delta, Alaska.

abundance, and habitat use, where such inclusion was appropriate.

WILDLIFE SURVEYS

For the CD North wildlife studies, both fixed-wing aircraft and helicopters were used to fly aerial surveys over the Colville Delta for selected bird and mammal species (Table 2). Aerial surveys covered the CD North study area (207 km², Figure 2), which was the area used in comparisons of species abundance and distribution among years. Aerial surveys for some species extended beyond the CD North study area, but data from outside the boundaries were not reported for the CD North study area. Within the 2001 CD North study area, intensive searches were conducted on foot for nests and broods in the area proposed for oil development (ground-search area; Figure 2). The ground-search area in 2001 overlapped the ground-search area in 2000 (Johnson et al. 2000: Figure 2) and was centered on a proposed airstrip.

HABITAT USE

To evaluate the importance of various habitats to wildlife in the CD North study area, habitat use was computed from the locations of selected species recorded in 2000 and 2001. Habitat selection (i.e., tests of preference and avoidance) from aerial survey data was not analyzed specifically for the CD North study area, because it is only a portion of the Colville Delta surveyed in past years. Instead, the entire delta was used in our analysis of habitat selection, so that results and conclusions would be consistent with past analyses (Johnson et al. 1999a), and so that results would encompass other parts of the delta, such as the CD South study area (Burgess et al. 2002). These multi-year habitat selection analyses are presented in the appendices. Selection analyses also were conducted on nest locations of Spectacled Eiders and White-fronted Geese in the ground-search areas. The analyses of habitat selection were based on the locations of bird groups, bird nests, and fox dens observed during aerial surveys (and ground surveys for fox dens only). For each species, habitat use was calculated for applicable combinations of season (e.g., pre-nesting, nesting, and brood-rearing) and year of survey (different years, depending on the species). The following were calculated for each combination:

1. numbers of adults, nests, young, or dens for each habitat;
2. percent use of each habitat;
3. percent availability of each habitat; and
4. a test of selection.

Percent use was calculated as the percentage of the total number of groups of birds, nests, nesting-colony locations, broods, or dens that were observed in each habitat. Use was calculated from group locations for birds that were in flocks or broods, because independence of locations could not be assumed for individuals in these groups. For Brant colonies and fox dens (active and inactive combined), both of which generally are static in location, the cumulative number of unique locations from all years were used in the analyses. For all other species, the parameters were calculated for each year of survey. The availability of each habitat was the percentage of that habitat in the total area surveyed. Except where noted, all habitats within a survey area were considered to be available. However, where the survey areas differed among species, years, and/or seasons, the availability of habitats also differed.

Significant habitat selection (i.e., use ≠ availability) was tested by Monte Carlo simulations (Haefner 1996, Manly 1997) on multi-year data for each species. Each simulation used random numbers (range = 0–100) to choose a habitat from the cumulative frequency distribution of the percent availability of habitat. The number of "random choices" in a simulation was equal to the number of nests, dens, or groups of birds from which percent use was calculated. We conducted 1,000 simulations for each species and summarized the frequency distribution by percentiles. Habitat preference (i.e., use > availability) was defined as occurring when the observed use by a species was greater than the 97.5 percentile of simulated random use. Conversely, habitat avoidance (i.e., use < availability) was defined as occurring when the observed use was less than the 2.5 percentile of simulated random use. Habitats with nonsignificant selection (i.e., observed use ≥2.5 and ≤97.5 percentiles) were deemed to have been used approximately in proportion to their availability. These percentiles were chosen to achieve an alpha level (Type I error) of 5% for a

Table 2. Descriptions of wildlife surveys conducted in the CD North 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 NORTH GROUND-SEARCH AREA (17.9 km²)							
Large Waterbird Ground Searches[b]	Nesting	16 June–1 July	-	-	-	-	
	Brood-rearing[c]	14–18 July.	-	-	-	-	Includes loon nest search
	Brood-rearing	20, 23 August	-	-	-	-	Primarily for loons
CD NORTH STUDY AREA (207 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	Includes survey for gull nests
	Brood-rearing	16–18 August	C185	1.6	1.6	150	
Yellow-billed Loon Surveys[d]	Nesting	25, 30 June	206L& 206B	n/a	n/a	30–40	Includes survey for gull nests
	Brood-rearing[e]	20, 23 August	206L	n/a	n/a	30–70	
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, grebes, waterfowl, gulls, terns, jaegers, ptarmigan, and large shorebirds (Bar-tailed Godwit, Common Snipe, and Whimbrel).
[c] This survey also included nest searches for loons, which initiate their nests later than most other waterbirds.
[d] Pacific and Red-throated loons were recorded incidentally.
[e] Glaucous Gull broods were recorded incidentally.

2-tailed test. The simulations and calculations of percentiles were conducted in a Microsoft® Excel spreadsheet on a personal computer.

GROUND SEARCHES FOR NESTS AND BROODS

Ground-based nest searches were conducted using the same techniques used in the Colville wildlife studies in 1996–1998 and in the Alpine project area in 1999–2001 (Johnson et al. 1997, 1998, 1999a, 1999b, 2000, 2000b, 2001, 2002). The 2001 CD North ground-search area comprised the area of potential disturbance (radius = 1,920 m) around a proposed airstrip and encompassed 17.9 km² (Figure 2). The ground-search area in 2000 was smaller (12.2 km²), covering preliminary descriptions of the proposed development area, as it was understood at that time (Johnson et al. 2000). In both years, we searched on foot within 10 m of the shorelines of all waterbodies, and in all intervening habitat we searched with ~10-m spacing between observers walking zig-zag paths. Five to thirteen observers searched for nests of all ducks, geese, Tundra Swans, loons, gulls, terns, and other large birds. The following data were recorded for each nest: the species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. In 2001, the nest search was conducted between 16 June and 1 July.

All nest locations were mapped on 1:18,000-scale color aerial photographs for entry into a GIS database. In addition, the location of most nests also were recorded using a global positioning system (GPS). Down and feather samples were taken from all waterfowl nests found during the regular nest searches. For those nests that were unattended and could not be identified to species, the down and feather samples were used to make preliminary identifications. Eleven researchers experienced with nesting tundra birds compared these unknown samples with samples from known nests and identified them to species when possible. The assessments were compiled and nest samples receiving ≥75% of the assignments to one species were so identified with the modifier "probable". All others were recorded as unidentified.

Nest sites of waterbirds in the ground-search area were revisited after hatch (between 14 and 18 July for waterfowl) to determine their fate. Nests were classified as successful if egg membranes were found that had thickened and were detached from the eggshells or, for loons, if a brood was associated with a nest site. Any sign of predators at the nest (e.g., fox scats or scent, broken eggs with yolk or albumen) was identified and recorded. During the revisits to nests, broods in the area were recorded opportunistically on 1:18,000-scale color aerial photographs. On 20 and 23 August, we searched all waterbodies ≥25 m long, primarily for loon broods, and recorded all brood locations on aerial photographs.

EIDERS

Aerial surveys were flown during the pre-nesting period (Table 2), and ground-based surveys were conducted in the area of proposed oil development to search for eider nests and broods. For the pre-nesting survey in 2001, the same methods were used as in previous years (1994–1998 and 2000), although the survey areas differed in extent. In 2001, the survey over the CD North and CD South study areas included the area between the Elaktoveach and East channels (Appendix B2). The pre-nesting survey was flown with 2 observers (one on each side of the plane) and a pilot. The pilot navigated with a GPS and flew east–west transect lines spaced 400 m apart. Each observer visually searched a 200-m-wide transect, thereby covering 100% of the survey area. The strip width for this and other transect surveys was delimited visually by tape marks on the windows and wing struts or skids of the aircraft (Pennycuick and Western 1972). The locations of eiders were recorded on 1:63,360-scale USGS maps and audio tapes were used to record numbers, species, and sex of eiders, habitat, and their perpendicular distance from the flight line. The locations of eiders were entered manually into a GIS database for mapping and analysis. In 1992, the aerial survey was flown at 50% coverage (0.8 km between transects) in 3 plots (46.6 km² each) on the delta (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 plots were not representative samples of the delta or CD North study areas for eiders and underestimated eider numbers on the delta. Aerial surveys in 1993 also were 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 data collected during the pre-nesting survey, calculations were made of the observed number of birds, the observed number of pairs, the indicated number of birds, the indicated number of pairs, and densities (number/km²) for each survey area. Following the USFWS (1987a) protocol, the total indicated number of birds was calculated by first doubling the number of males not in groups (a group is defined for this calculation as >4 birds of mixed sex that cannot be separated into singles or pairs), then adding this product to the number of birds in groups. The indicated number of pairs was the number of males. Density estimates were not adjusted with a sightability correction factor.

Habitat selection was analyzed for locations of groups (i.e., singles, pairs, or flocks) of eiders that were observed on the ground during aerial surveys. For analysis of selection during the pre-nesting season, locations from aerial surveys in 1993–1998, 2000, and 2001 were used. The pre-nesting survey in 1993 was flown at 50% coverage, and the survey in 2000 was 100% coverage but not flown east of the Elaktoveach Channel; all other surveys were flown at 100% coverage. For the survey flown at 50% coverage, the habitat availability was calculated for the strips that were surveyed. The availability of habitats for each year's survey was summed and divided by the number of surveys to calculate the weighted habitat availability.

TUNDRA SWANS

Aerial surveys for Tundra Swans were flown in 2001 during the nesting and brood-rearing seasons (Table 2). Aerial surveys covered the entire Colville Delta, including the CD North study area, in accordance with USFWS protocols (USFWS 1987b, 1991). East–west transects spaced 1.6-km apart were flown in a fixed-wing airplane that was navigated with the aid of a GPS receiver. The 2 observers (one on each side of the plane) each visually searched 800-m-wide transects while the pilot navigated and scanned for swans ahead of the aircraft. Locations and counts of swans were marked on 1:63,360-scale USGS maps. The same methods were used for nesting and brood-rearing surveys on the delta in 1993, 1995–1998, and 2000–2001 (Smith et al. 1994, Johnson et al. 1998, Johnson et al. 2000a). Beginning in 1995, each nest was photographed with a 35-mm camera for site verification. During nesting and brood-rearing in 1992, surveys on the delta were conducted by the Alaska Department of Fish and Game and differed from those of subsequent years. The nesting survey was flown along east–west survey lines spaced 2.4 km apart and during the brood-rearing survey, parallel lines oriented northeast–southwest were flown at ~2.4-km intervals (Smith et al. 1993).

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

Habitat selection (using the Monte Carlo analysis described above) was calculated for Tundra Swan nest and brood locations from aerial surveys for each year surveyed. Each survey was flown at 100% coverage, so the entire Colville Delta was used for calculating available habitats. Selection indices were calculated from the locations of each nest or brood. Although some of the nest sites were used in multiple years (and thus not annually independent locations), we were not able to distinguish these sites objectively from others where nests were close, but not in exactly the same location, in consecutive years. None of the nest sites was used in all the years that surveys were conducted. Hawkins (1983) found that 21% of the swan nests on a portion of the Colville Delta were on mounds used the previous year. Monda et al. (1994) found that 49% of the nests in the Arctic National Wildlife Refuge were on mounds used previously, and that nest sites reused from previous years were slightly more successful than new nest sites. Therefore, deletion of multi-year nest sites from the habitat analysis to eliminate potential dependencies in nest locations could bias the results towards habitats used by less experienced or less successful pairs. To avoid potential bias, all nest sites were included, with the recognition that all locations may not be annually independent.

LOONS

Aerial surveys for Yellow-billed Loons in the CD North study area were conducted during nesting (25 and 30 June 2001) and brood-rearing (20 and 23 August 2001). Similar surveys have been 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). Results of those 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 North 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, an initial nesting loon survey was conducted in a lake-to-lake pattern, concentrating on lakes ≥10 ha in size (typical nesting lakes for Yellow-billed Loons [Sjolander and Agren 1976, North and Ryan 1989]) and adjacent smaller lakes. In 1996–1998 and in 2000–2001, a second nesting survey was conducted with a helicopter to visit lakes where Yellow-billed Loons were observed but no nest was found on that initial survey. Coastal lakes and tapped lakes with low-water connections to river channels were excluded, as Yellow-billed Loons are known not to use such lakes for nesting (North 1986, Johnson et al. 1999a). Observations of Pacific and Red-throated loons were recorded incidentally. Loon locations were recorded on 1:63,360-scale USGS maps.

From the survey data, the total number of adults, nests, broods, and young were calculated by season for all species of loons in the CD North study area. Density (number/km²) was calculated only for Yellow-billed Loons because survey coverage for Pacific and Red-throated loons was inadequate for estimating density. Habitat use and proximity to nearest waterbody were calculated for Yellow-billed Loon nests and broods found in 2000 and 2001 in the CD North study area. Habitat selection was evaluated (using the Monte Carlo analysis described above) for Yellow-billed Loon nests and broods that were found on aerial surveys of the entire delta. Selection indices were calculated for nest locations in 1993, 1995–1998, and 2000–2001, and for brood locations in 1995–1998 and 2000–2001.

GLAUCOUS GULLS

Glaucous Gull nests and broods were recorded during the aerial nesting and brood-rearing surveys of Tundra Swans and Yellow-billed Loons on the Colville Delta (see methods for Tundra Swans and Loons, above). All Glaucous Gull nests and broods observed on those surveys were recorded on 1:63,360-scale USGS maps. Glaucous Gull nests and broods also were recorded during aerial surveys of lakes in the Alpine project area. Those surveys were conducted by a single observer in a helicopter. Observations of nests and broods during that survey were marked on a schematic map of the study area. During ground searches in the CD North ground-search area, nest locations of Glaucous Gulls were recorded on aerial photos and/or stored in GPS units.

GEESE

In 2001, systematic aerial surveys for geese were conducted during the brood-rearing (26 July) and fall-staging (19 August) seasons. These surveys were developed originally in 1996 to count White-fronted Geese, although Brant, and Canada and Snow geese also were counted. The surveys were flown at 90 m agl on east–west flight lines that were 1.6 km apart, between the Elaktoveach and Nigliq channels. Two observers (including the pilot) searched a 400-m-wide strip on either side of the plane, thereby achieving 50% coverage of the survey area. Species, numbers, and locations were recorded on 1:63,360-scale USGS maps. Coverage during most surveys (1997, 1998 and 2000) was also 50%, although in 1996 coverage was equivalent to 25% (one observer). The aerial surveys covered the entire, delta; however, in 2000, the surveys were restricted to the area west of the Elaktoveach Channel. Information on geese also was collected opportunistically during surveys for swans and loons, and in previous years (1992–1998) coastal surveys specifically for Brant were conducted during nesting, brood-rearing, and fall staging.

FOXES

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 across the entire delta and adjacent coastal plain. The status of known dens was assessed briefly on helicopter-supported ground visits during 28 June 2001, and active dens were observed during 11–15 July 2001 to count pups (Table 2). Most survey effort was focused on checking dens found in previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a), although we also searched opportunistically for dens in suitable habitats while transiting between known dens and conducting surveys for other species. Soil disturbance from foxes digging at den sites, and fertilization resulting from feces and food remains, results 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).

During ground visits, evidence of den use was evaluated and the species using the den was confirmed. 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 2½–4 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 AVAILABILITY

Twenty-four habitats were classified and mapped on the delta (Johnson et al. 1996), of which 21 occurred in the CD North study area (Figure 3, Table 3). The habitats and their constituent terrain units, surface forms, and plant taxa are described by Johnson et al. (1996) and Jorgenson et al. (1997).

In the CD North study area, the most abundant habitats were Wet Sedge–Willow Meadow (20% of the total area), Barrens (11%), Nonpatterned Wet Meadow (11%), and Tapped Lake with Low-water Connection (9%; Table 3). The outer delta is subject to more extensive river flooding during spring break-up and marine flooding from storm surges than is the rest of the delta and, therefore, contains younger surfaces with more mineral deposition, higher salinity, and less organic accumulation than the rest of the delta (see Jorgenson et al. 1997). These geologic processes have shaped the outer delta into a region of low topographic relief, short and often depauperate vegetation cover, and many lakes that are mostly tapped or brackish from flooding. Because CD North is on the outer delta, it contains larger proportions of coastal habitats than the entire delta. Open Nearshore Water, Brackish Water, Tapped Lake with Low-water Connection, Salt Marsh, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons are more abundant in the CD North study area than on the entire delta. The CD North study area also contains more lakes than does the entire delta, with 21% of the area in lake habitats compared with 15% of the delta. The CD North study area, however, does not include the highly dissected channels and islands east of the Elaktoveach Channel, thus lower proportions of River or Stream, Riverine or Upland Shrub, Barrens, and Tide Flat occur there than on the entire delta.

The area searched for nests and broods by crews on foot in 2001 (henceforth, the ground-search area; Figure 3) contained 17 habitats, of which all but 4 occupied >1% of the search area (Table 4). Wet Sedge–Willow Meadow occurred over the most area (25% of total), followed by Nonpatterned Wet Meadow (15%), Aquatic Sedge with Deep Polygons (12%), Salt-killed Tundra (11%), and Deep Open Water with Islands or Polygonized Margins (10%).

CONDITIONS IN THE STUDY AREA IN 2001

The 2001 breeding season was similar to 2000, but both were unusual among previous years, because weather and flooding river conditions may have delayed the onset of nesting for birds on much of the Colville River Delta. Spring temperatures were colder and snow melt was later in 2001 and 2000 relative to previous years since 1992 (when many of these surveys were initiated on the delta), even more so than in 1997 and 1999, 2 years that were marked by cool temperatures and late snow melt.

During winter 2000–2001, cumulative 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 in 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 with 30-40% snow cover remaining on the tundra on 9 June in the adjacent Kuparuk Oilfield, ~25 km to the east. Ice remained on small, shallow lakes until at least mid-June, and on larger, deep lakes through late June. 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.

Temperatures in May 2001 were below average on the Colville Delta with mean daily temperatures rising above freezing only on 31 May. In the adjacent Kuparuk Oilfield, May 2001 was the coldest recorded since long-term avian studies were started there in 1988. Mean temperatures in May 2000 were only slightly warmer than in 2001. However, temperatures in early June rose higher in 2001 than in 2000. Only 54 thaw-degree days (thaw-degree days are calculated by summing the number of degrees that the daily mean temperature was above freezing [0° C] for each day during a particular period) accumulated between 15 May (approximate arrival date of birds) and 15 June 2001 (usual end of nest initiation for most geese and swans), with almost all of the accumulation in June (Figure 4). In comparison, 120 thaw-degree

Table 3. Availability of wildlife habitat types in the CD North study area, Colville River Delta, Alaska, 2001.

Habitat	CD North Study Area Area (km²)	CD North Study Area Availability (%)	Colville Delta Area (km²)	Colville Delta Availability (%)
Open Nearshore Water (marine)	7.12	3.4	10.02	1.8
Brackish Water	4.01	1.9	6.53	1.2
Tapped Lake w/ Low-water Connection	17.76	8.6	21.62	3.9
Tapped Lake w/ High-water Connection	5.88	2.8	20.77	3.8
Salt Marsh	7.79	3.8	16.55	3.0
Tidal Flat	12.95	6.3	56.01	10.2
Salt-killed Tundra	15.14	7.3	25.64	4.7
Deep Open Water w/out Islands	10.04	4.9	20.77	3.8
Deep Open Water w/ Islands or Polygonized Margins	4.21	2.0	7.76	1.4
Shallow Open Water w/out Islands	0.89	0.4	2.02	0.4
Shallow Open Water w/ Islands or Polygonized Margins	0.29	0.1	0.54	0.1
River or Stream	14.60	7.1	82.07	14.9
Aquatic Sedge Marsh	0	0	0.13	<0.1
Aquatic Sedge w/ Deep Polygons	8.57	4.1	13.22	2.4
Aquatic Grass Marsh	0.34	0.2	1.45	0.3
Young Basin Wetland Complex	0	0	<0.01	<0.1
Old Basin Wetland Complex	0	0	0.01	<0.1
Nonpatterned Wet Meadow	21.69	10.5	41.54	7.5
Wet Sedge–Willow Meadow	41.81	20.2	102.63	18.6
Moist Sedge–Shrub Meadow	4.34	2.1	13.20	2.4
Moist Tussock Tundra	1.69	0.8	2.55	0.5
Riverine or Upland Shrub	5.30	2.6	27.58	5.0
Barrens (riverine, eolian, lacustrine)	22.29	10.8	78.67	14.3
Artificial (water, fill, peat road)	0.15	0.1	0.39	<0.1
TOTAL	206.87	100	551.67	100

days accumulated during the same period in 1998. Cold temperatures and late snow melt affect nesting birds by delaying the onset of nesting and increasing energy expenditure, often exerting strong impacts on breeding success.

Observations confirmed late nest initiation for some species in 2001. 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 young in some broods were still small and incapable of flying. These observations suggest that some swan young may not have survived to migrate from the breeding area in 2001.

GROUND SEARCHES FOR NESTS AND BROODS

NESTS

In 2001, 299 nests of 14 species were recorded in the CD North ground-search area and overall nest success was 52% (Table 5). In the previous year, 245 nests of 15 species were located in the smaller ground-search area, and nest success (62%) were higher than in 2001 (Table 5). In both years, habitats with polygonal surface forms contained the highest numbers of nests: Wet Sedge–Willow Meadow contained 148 nests (27–28% of the total nests in both years), Aquatic Sedge with Deep Polygons contained 132 nests

Table 4. Availability of wildlife habitat types in the CD North ground-search areas in 2000 and 2001, Colville River Delta, Alaska.

Habitat	2000 Area (km²)	2000 Availability (%)	2001 Area (km²)	2001 Availability (%)
Brackish Water	0.76	6.2	0.50	2.8
Tapped Lake w/ Low-water Connection	0.01	0.1	0.29	1.6
Tapped Lake w/ High-water Connection	0	0	0.87	4.9
Salt Marsh	0.86	7.0	0.74	4.1
Tidal Flat	<0.01	<0.1	0	0
Salt-killed Tundra	3.51	28.8	1.88	10.5
Deep Open Water w/o Islands	0.11	0.9	0.75	4.2
Deep Open Water w/ Islands or Polygonized Margins	1.19	9.7	1.81	10.1
Shallow Open Water w/o Islands	0.01	0.1	0.05	0.3
Shallow Open Water w/ Islands or Polygonized Margins	0.07	0.5	0.15	0.8
River or Stream	<0.01	<0.1	<0.01	<0.1
Aquatic Sedge w/ Deep Polygons	1.83	15.0	2.10	11.7
Aquatic Grass Marsh	0	0	0.04	0.2
Nonpatterned Wet Meadow	1.09	8.9	2.70	15.1
Wet Sedge–Willow Meadow	2.08	17.1	4.54	25.4
Moist Sedge–Shrub Meadow	0.43	3.5	0.44	2.4
Riverine or Upland Shrub	0	0	0.22	1.3
Barrens (riverine, eolian, lacustrine)	0.25	2.0	0.82	4.6
TOTAL	12.20	100	17.90	100

(24–25%), Deep Open Water with Islands or Polygonized Margins contained 80 nests (14–16%), and Salt-killed Tundra contained 71 nests (10–17%; Tables 6 and 7).

Nesting density in 2001 (16.7 nests/km²) was lower than in 2000 (20.1 nests/km²), but the ground-search areas also differed between years (Figures 5 and 6, Table 8). More than half of the nests in each year belonged to geese, with most belonging to Greater White-fronted Geese (120 nests in 2000 and 177 nests in 2001), followed by Brant (30 and 24 nests, respectively) (Table 5). Duck nests were abundant in both 2000 and 2001 in the ground-search areas and were primarily Long-tailed Duck (formerly Oldsquaw) nests (18 and 21 nests, respectively) and Spectacled Eider nests (14 and 7 nests, respectively). Three Tundra Swan nests and 2–4 Yellow-billed Loon nests were found in the ground-search areas each year. Eiders, swans, geese, and loons are discussed in more detail in later sections. Overall, the density of nests in the CD North ground-search area was almost twice the densities found in the CD South and the Alpine ground-search areas (Table 8).

Nests of Long-tailed Ducks were 3–6 times more abundant in the CD North ground-search area than in the CD South and Alpine ground-search areas (Table 8). Nesting success in both years was fair to poor (44% in 2000 and 5% in 2001). In both years, Long-tailed Duck nests occurred most frequently in Aquatic Sedge with Deep Polygons (22% of all nests in 2000 and 29% in 2001; Tables 6 and 7). Use of other habitats varied among years. Most nests in both years were found either on polygon rims (14 nests), or islands (12 nests). Nests of Northern Pintail were also found in both years: 2 in 2001 and 3 in 2000. None of the nests in either year hatched. The density of Northern Pintail nests was lower in the CD North ground-search areas than in either the CD South or Alpine ground-search areas, where they were generally the most abundant duck nests (Table 8).

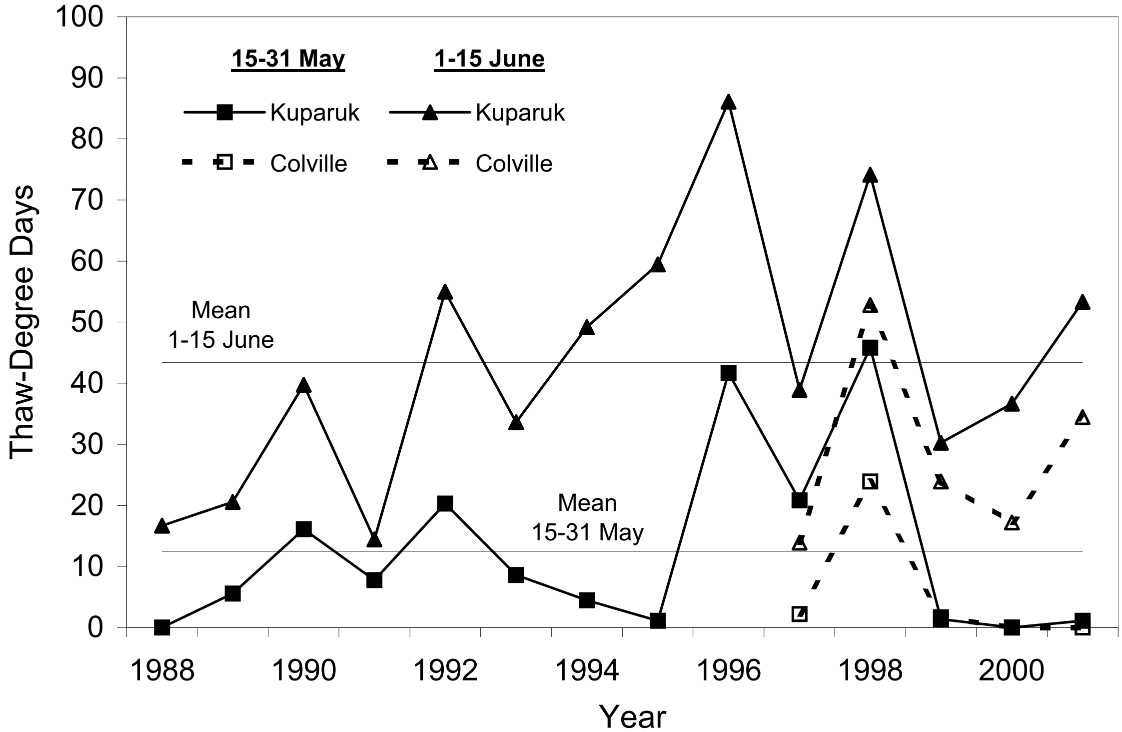


Figure 4. Cumulative number of thaw-degree days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield (1988–2001) and Colville River Delta (1997–2001), Alaska. Mean values computed from Kuparuk data (n = 14 years).

Both Long-tailed Ducks and Northern Pintails were the most abundant large birds on the Colville Delta during USFWS surveys in the 1980s; densities of both species (7.5 birds/km² and 16.6 birds/km², respectively) in June were higher than that recorded for any other location on the Arctic Coastal Plain (Rothe et al. 1983).

Gulls and terns were common in the CD North ground search areas with 24–29 nests found in both years (Figure 7, Table 5). In 2001, 3 Glaucous Gull nests were found compared with 10 nests in 2000. The nesting success of Glaucous Gulls was 89% in 2000 and 33% in 2001. More nests of both Sabine's Gulls and Arctic Terns were found in 2001 than in 2000 (Table 5). In 2000, all nests of Arctic Terns were judged to have hatched successfully, but in 2001, the fate of most nests were unknown. For Sabine's Gulls, the fate of most nests also was unknown in both years. Glaucous and Sabine's gull nests were more abundant in the CD North ground-search areas than in either the CD South or Alpine ground-search areas, but nest densities of Arctic Terns were comparable among the 3 areas (Table 8). Glaucous Gull nests were located primarily on islands in aquatic habitats; whereas the Sabine's Gull and Arctic Tern nests were located in both terrestrial and aquatic habitats (Tables 6 and 7).

One to 2 Parasitic Jaeger nests were found in the ground-search areas in each year. The nest found in 2000 hatched successfully, while the fate of the 2 nests in 2001 could not be determined (Figure 7, Table 5). Eight nests of Willow Ptarmigan were located each year, but hatching success was not calculated for ptarmigan nests because it is difficult to relocate nest bowls consistently. The density of Willow Ptarmigan nests (0.4–0.7 nests/km²) was similar to densities in the Alpine ground-search area (mean = 0.7 nests/km², $n = 6$), but less than the density in the CD South ground-search area (1.1–2.9 nests/km²; Table 8).

BROODS

During nest fate checks and ground searches for broods, 27 broods of 9 species were recorded in 2001 (Figure 8, Table 9). Fewer broods and species were seen in 2001 compared with 2000

Table 5. Number of nests and nest success of birds in the CD North ground-search areas, Colville River Delta, Alaska, 2000 (12.2 km²) and 2001 (17.9 km²).

	Number of Nests					Nesting Success (%)[a]	
	2000	2001					
Species	Total	Total	Successful	Failed	Unknown Fate	2000	2001
Red-throated Loon	10[b]	9[b]	6	0	3	–	–
Pacific Loon	9	11	7	1	3	–	–
Yellow-billed Loon	2	4[c]	1	1	2	–	–
Greater White-fronted Goose	120	177[d]	109	66	2	75	62
Brant	30	24	6	15	3	10	29
Tundra Swan	3	3	3	0	0	67	100
Northern Pintail	3[d]	2[d]	0	2	0	0	0
Spectacled Eider	14[d]	7[d]	1	6	0	43	14
King Eider	2	0	–	–	–	100	–
Long-tailed Duck	18[d]	21[d]	1	19	1	44	5
Unidentified duck	1	1	0	1	0	0	0
Willow Ptarmigan	8	8	0	0	8	–	–
Unidentified ptarmigan	0	1	0	0	1	–	–
Parasitic Jaeger	1	2	1	0	1	–	–
Glaucous Gull	10	3	1	2	0	89	33
Sabine's Gull	5	9	3	0	6	–	–
Arctic Tern	9	17	0	0	17	100	–
TOTAL	245	299	121[a]	111[a]	47	62	52

[a] Estimates are not provided for loons, ptarmigan, jaegers, Sabine's Gulls and Arctic Terns because of the large percentage of unknown nest fates. Nest success = no. successful/(no. successful+ no. failed) × 100.

[b] Includes 4 nests in 2000 and 3 in 2001 that were presumed present from the presence of broods observed during fate checks.

[c] Includes 2 nests observed during aerial survey for loons.

[d] Includes nests identified to species from down and feather characteristics.

Table 6. Relative abundance (%) of nests of each species in each habitat type in the CD North ground-search area, Colville River Delta, Alaska, 2000.

Habitat	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Brant	Tundra Swan	Northern Pintail[a]	Spectacled Eider[a]	King Eider	Long-tailed Duck[a]	Unidentified duck	Willow Ptarmigan	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Total Number of Nests
Brackish Water	17	44	0	1	13	0	0	0	0	0	0	0	0	50	0	0	6	15
Salt-killed Tundra	17	11	0	17	3	33	33	64	50	0	0	25	0	0	40	0	17	41
Deep Open Water w/out Islands	0	0	0	2	0	0	0	0	0	11	0	0	0	0	0	0	2	4
Deep Open Water w/ Islands or Polygonized Margins	0	22	100	1	63	0	33	7	0	17	0	0	0	40	40	33	16	38
Shallow Open Water w/ Islands or Polygonized Margins	0	11	0	1	0	0	0	0	0	0	0	0	0	0	0	11	1	3
Aquatic Sedge w/ Deep Polygons	33	0	0	33	13	67	0	14	50	22	0	25	100	10	0	0	24	58
Nonpatterned Wet Meadow	0	11	0	8	0	0	33	0	0	11	0	25	0	0	20	11	7	17
Wet Sedge–Willow Meadow	33	0	0	39	7	0	0	14	0	33	100	25	0	0	0	44	27	66
Moist Sedge–Shrub Meadow	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	<1	1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Total Number of Nests	6	9	2	120	30	3	3	14	2	18	1	8	1	10	5	9		241

[a] Includes nests identified to species from feather and down samples.

Table 7. Relative abundance (%) of nests of each species in each habitat type in the CD North ground-search area, Colville River Delta, Alaska, 2001.

Habitat	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Brant	Tundra Swan	Northern Pintail	Spectacled Eider[a]	Long-tailed Duck[a]	Unidentified Duck	Willow Ptarmigan	Unidentified ptarmigan	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Total Number of Nests
Brackish Water	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	<1	1
Tapped Lake w/ High-water Connection	0	18	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3
Salt Marsh	0	9	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	5
Salt-killed Tundra	17	0	0	12	0	33	50	14	0	0	13	0	0	0	33	0	10	30
Deep Open Water w/out Islands	0	18	0	1	0	0	0	0	10	0	0	0	0	0	0	0	2	6
Deep Open Water w/ Islands or Polygonized Margins	17	27	50	2	83	33	0	14	14	0	0	0	0	67	11	29	14	42
Shallow Open Water w/out Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	<1	1
Shallow Open Water w/ Islands or Polygonized Margins	17	9	0	2	4	0	0	0	14	100	0	0	0	0	0	18	4	12
Aquatic Sedge w/ Deep Polygons	50	9	0	31	0	0	50	14	29	0	0	0	0	33	11	35	25	74
Aquatic Grass Marsh	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	<1	1
Nonpatterned Wet Meadow	0	0	0	12	8	0	0	14	19	0	13	0	100	0	22	6	12	35
Wet Sedge–Willow Meadow	0	9	50	36	0	33	0	29	10	0	75	100	0	0	22	6	28	82
Moist Sedge–Shrub Meadow	0	0	0	1	0	0	0	0	10	0	0	0	0	0	0	0	1	3
Riverine or Upland Shrub	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	<1	1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Total Number of Nests	6	11	4	177	24	3	2	7	21	1	8	1	2	3	9	17		296

[a] Includes nests identified to species from feather and down samples

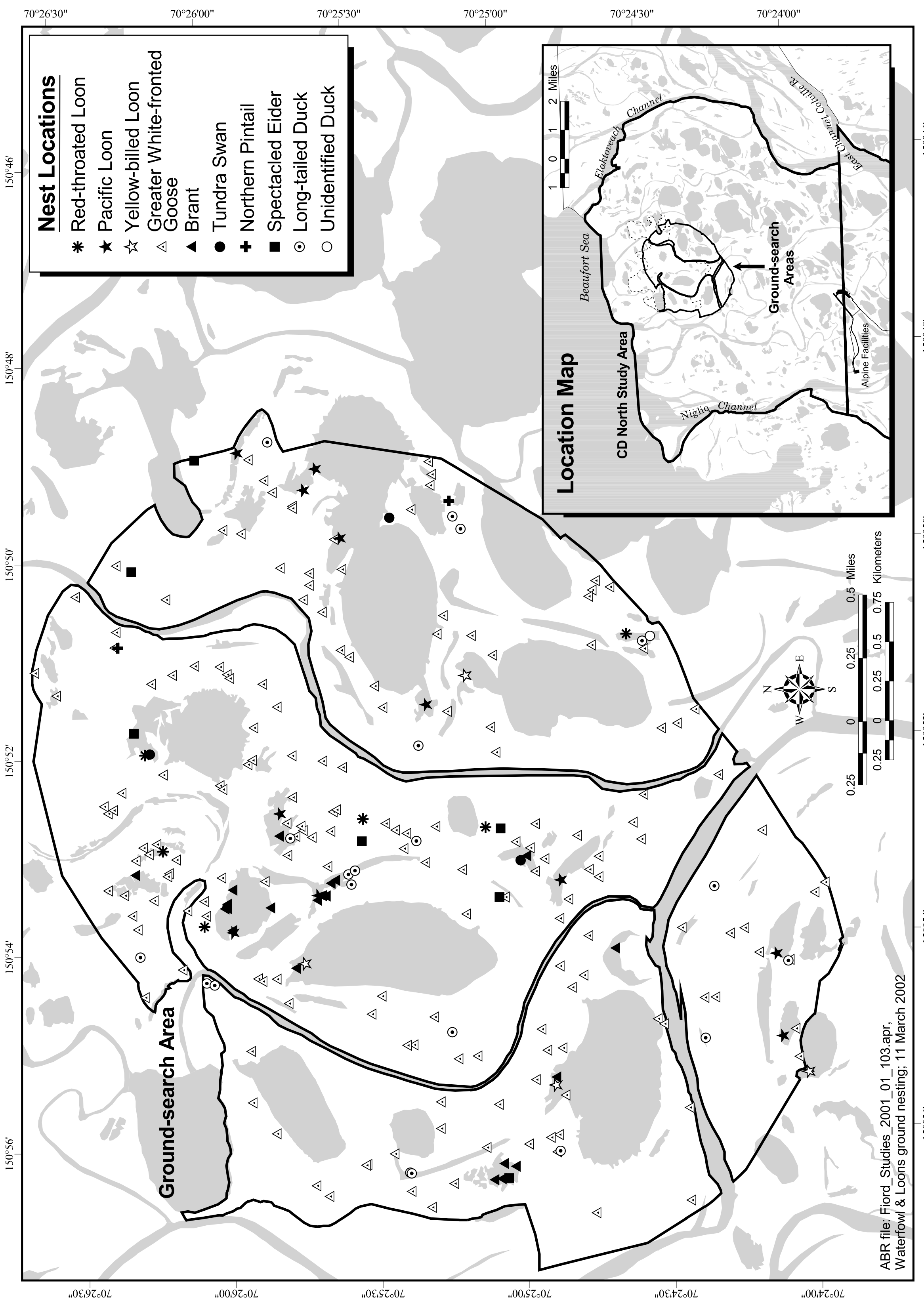


Figure 5. Distribution of waterfowl and loon nests in the CD North ground-search area, Colville River Delta, Alaska, 2001.

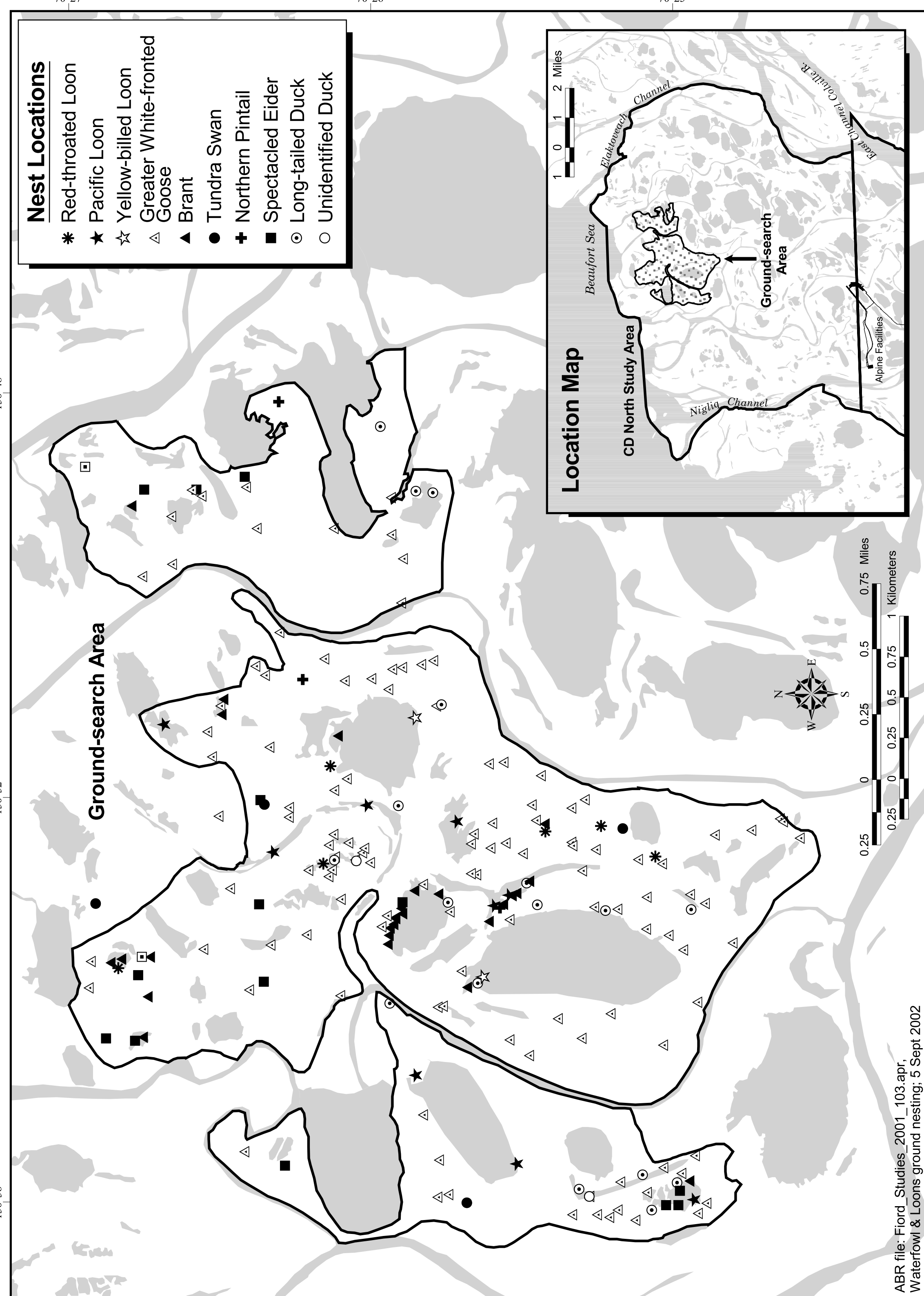


Figure 6. Distribution of waterfowl and loon nests in the CD North ground-search area, Colville River Delta, Alaska, 2000.

Table 8. Densities of nests (nests/km²) 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 are from Johnson et al., 2002; CD South data are from Burgess et al. 2002.

	CD North		CD South		Alpine
Species	2000	2001	2000	2001	6-year Mean
Red-throated Loon	0.8[a]	0.5[a]	0.2[a]	0.1	0.1
Pacific Loon	0.7	0.6	0.5	0.2	0.3
Yellow-billed Loon	0.2	0.2[b]	0.2[b]	0	<0.1
Red-necked Grebe	0	0	0	0.2	0.1
Greater White-fronted Goose	9.8	9.9[c]	6.2	4.1	3.4[c]
Canada Goose	0	0	0	0	0.1
Brant	2.5	1.3	0	0	0.2[c]
Tundra Swan	0.2	0.2	0.2	0.2	0.4
Mallard	0	0	0	0.1	0
Northern Shoveler	0	0	0	0	0.1[c]
Northern Pintail	0.2[c]	0.1[c]	2.1[c]	0.7	0.5[c]
Green-winged Teal	0	0	0	0	0.1[c]
Greater Scaup	0	0	0	0.1	0.1
Lesser Scaup	0	0	0	0	<0.1
Unidentified Scaup	0	0	0	0.1	0.1[c]
Spectacled Eider	1.1[c]	0.4[c]	0.2	0.1	<0.1
King Eider	0.2	0	0	0	<0.1
Long-tailed Duck	1.5[c]	1.2[c]	0.2	0.2	0.4[c]
Unidentified duck	0.1	0.1	0	0.1	0.1
Northern Harrier	0	0	0	0.1	0
Willow Ptarmigan	0.7	0.4	2.9	1.1	0.7
Rock Ptarmigan	0	0	0.2	0	<0.1
Unidentified ptarmigan	0	0.1	0	0	0.1
Sandhill Crane	0	0	0	0	<0.1
Whimbrel	0	0	0.2	0	0
Bar-tailed Godwit	0	0	0	0.2	0.1
Common Snipe	0	0	0	0	<0.1
Parasitic Jaeger	0.1	0.1	0	0	0.1
Long-tailed Jaeger	0	0	0.3	0.1	0.1
Glaucous Gull	0.8	0.2	0.2	0	0.1
Sabine's Gull	0.4	0.5	0	0	<0.1
Arctic Tern	0.7	0.9	0.7	0.4	0.4
Short-eared Owl	0	0	0	0.3	<0.1
Area searched (km²)	12.2	17.9	5.9	9.7	11.4–17.2
Waterbird[d] nest density	19.4	16.2	10.8	7.0	7.0
Total nest density	20.1	16.7	13.9	8.6	7.7
Total number of nests	245	299	82	83	69–177
Number of species	15	14	14	16	16–19

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

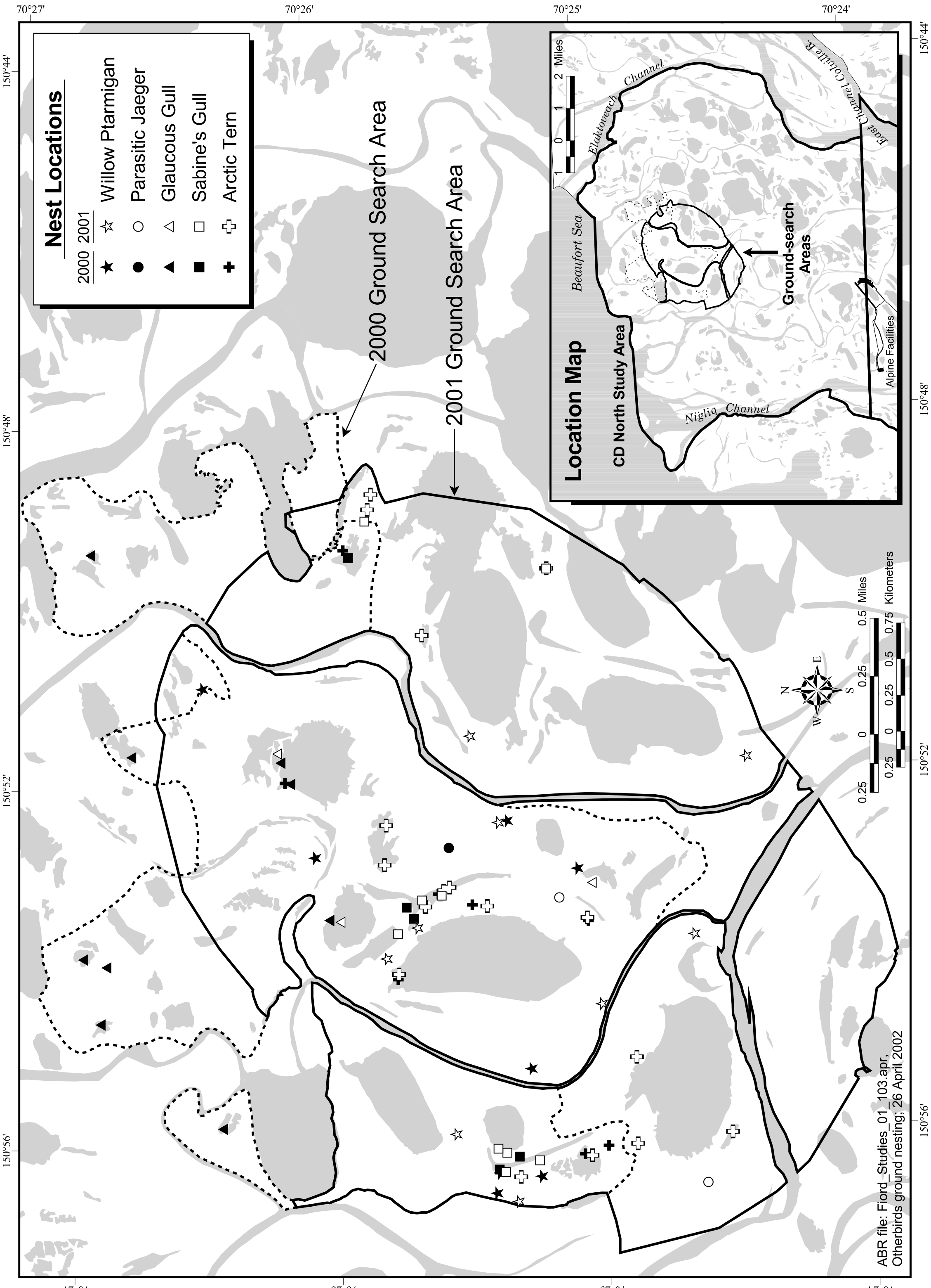


Figure 7. Distribution of nests of ptarmigan and larids in the CD North ground-search area, Colville River Delta, Alaska, 2000 and 2001.

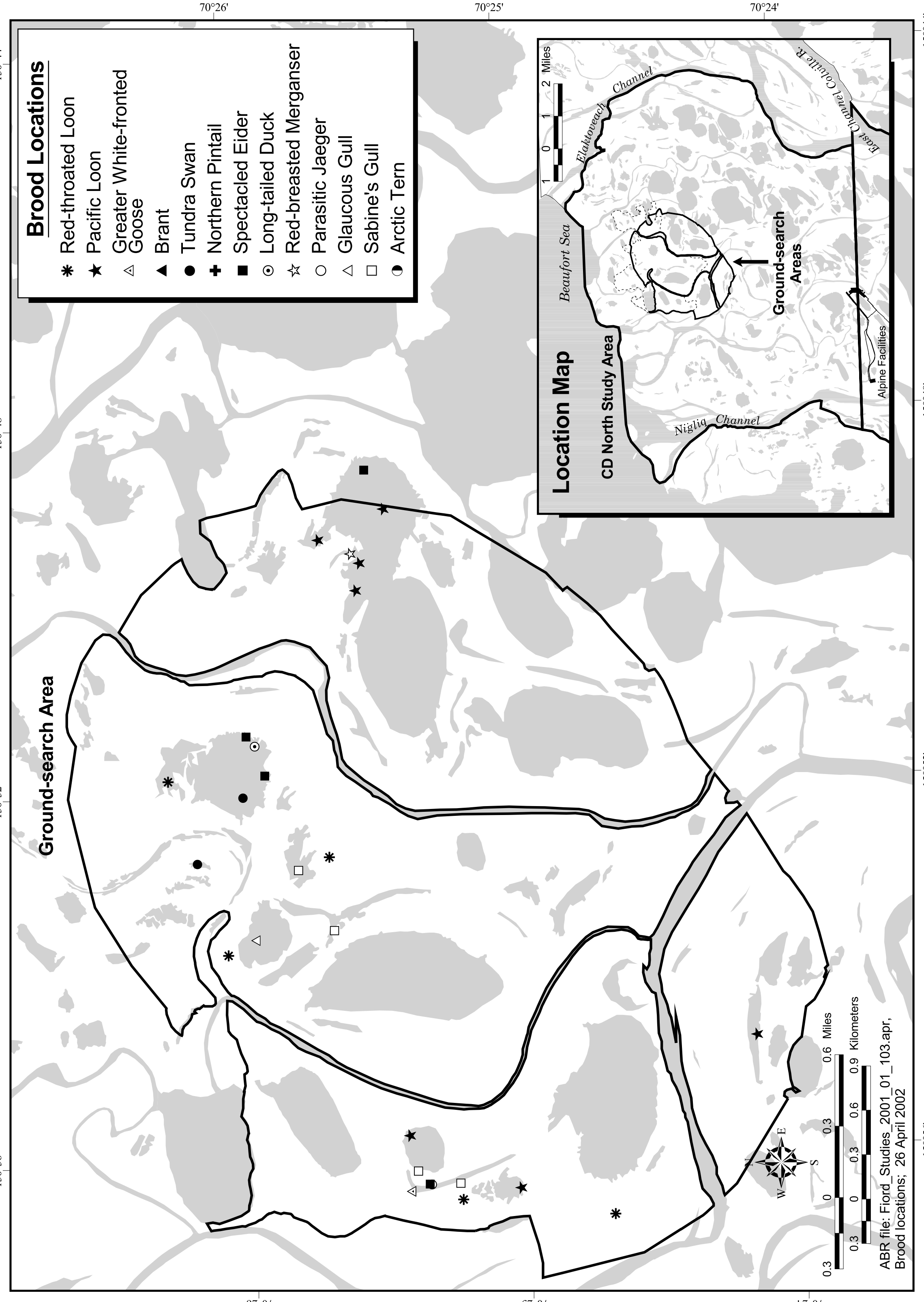


Figure 8. Distribution of broods during ground and aerial surveys in the CD North ground-search area, Colville River Delta, Alaska, July and August 2001.

Table 9. Broods or brood groups in the CD North ground-search areas, Colville River Delta, Alaska, in 2000 (12.2 km²) and in 2001 (17.9 km²).

	2000				2001			
Species	Number of Adults	Number of Young	Total Birds	Total Broods	Number of Adults	Number of Young	Total Birds	Total Broods
Red-throated Loon	8	9	17	7	7	5	12	5
Pacific Loon	5	4	9	3	9	7	16	7
Greater White-fronted Goose	25	41	64	11	3	8	11	2
Brant	1	8	9	1	0	0	0	0
Tundra Swan	0	0	0	0	4	4	8	2
Northern Pintail	2	10	12	2	0	0	0	0
Spectacled Eider	7	26	33	7[a]	4	6	10	3
Long-tailed Duck	3	8	11	3	2	10	12	2
Red-breasted Merganser	0	0	0	0	1	5	6	1
Parasitic Jaeger	1	2	3	1	0	0	0	0
Glaucous Gull	9	10	19	5	1	2	3	1
Sabine's Gull	5	4	9	3	7	7	14	4
Arctic Tern	14	10	24	7	0	0	0	0
TOTAL	80	132	210	50	38	54	92	27

[a] One brood found during helicopter survey

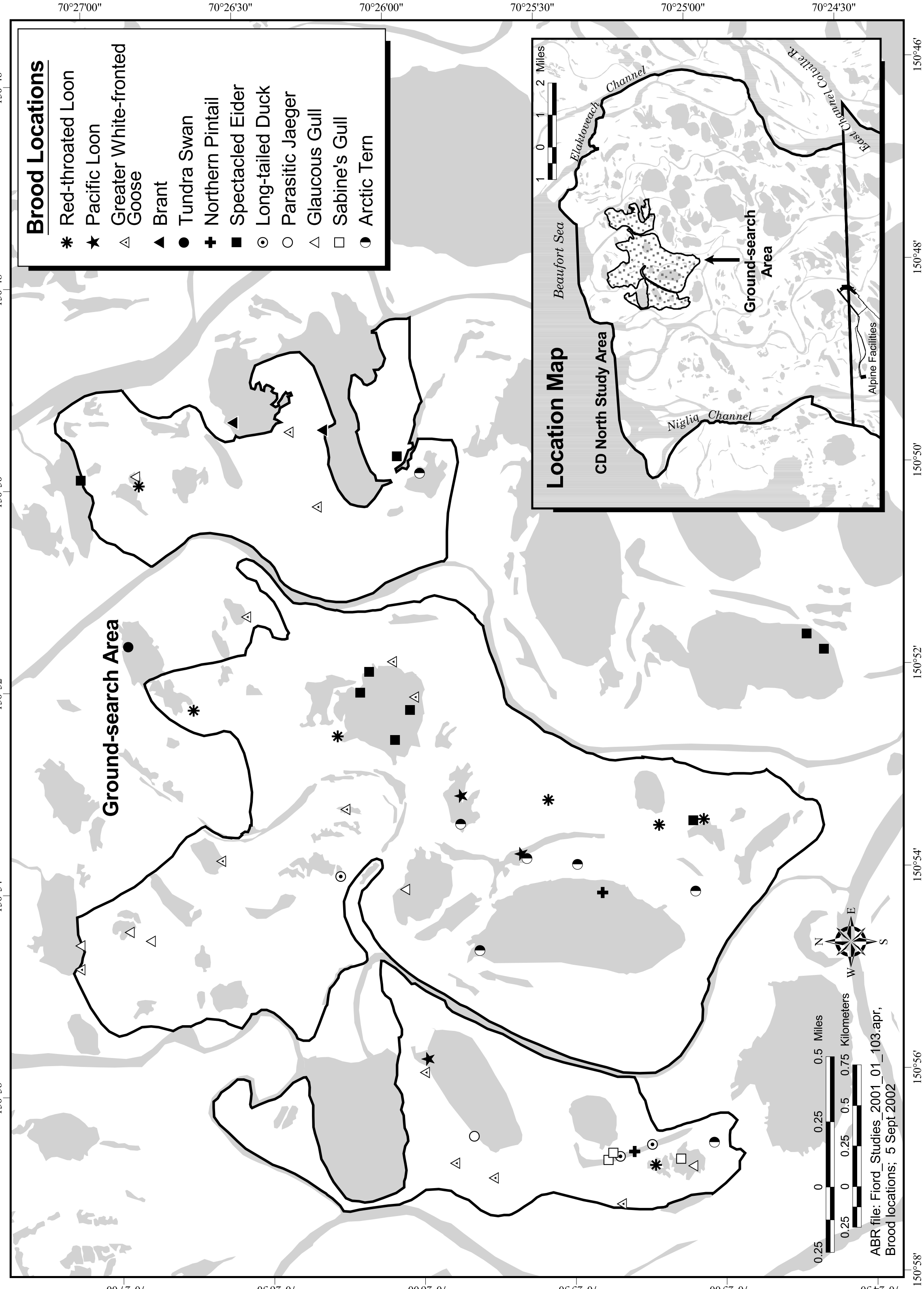


Figure 9. Distribution of broods during ground and aerial surveys in the CD North ground-search area, Colville River Delta, Alaska, July and August 2000.

Table 10. Relative abundance (%) of broods of each species in each habitat type in the CD North ground-search area, Colville River Delta, Alaska, 2000.

Habitat	Red-throated Loon	Pacific Loon	Greater White-fronted Goose	Brant	Northern Pintail[a]	Spectacled Eider[a]	Long-tailed Duck[a]	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Total Number of Broods
Brackish Water	14	33	9	0	0	0	0	0	40	0	0	10	5
Tapped Lake w/ Low Water Connection	0	0	0	0	0	14	0	0	0	0	0	2	1
Salt Marsh	0	0	9	0	0	0	0	0	0	0	0	2	1
Salt-killed Tundra	14	0	46	100	0	0	0	100	0	33	0	18	9
Deep Open Water w/out Islands	0	0	9	0	50	0	100	0	0	33	0	10	5
Deep Open Water w/ Islands or Polygonized Margins	0	33	9	0	50	57	0	0	40	33	43	28	14
Shallow Open Water w/ Islands or Polygonized Margins	14	33	0	0	0	0	0	0	0	0	14	6	3
Aquatic Sedge w/ Deep Polygons	57	0	18	0	0	14	0	0	20	0	14	18	9
Nonpatterned Wet Meadow	0	0	0	0	0	0	0	0	0	0	14	2	1
Wet Sedge–Willow Meadow	0	0	0	0	0	14	0	0	0	0	14	4	2
Total	100	100	100	100	100	100	100	100	100	100	100	100	
Total Number of Broods	7	3	11	1	2	7	3	1	5	3	7		50

[a] Includes nests identified from feather and down samples

Table 11. Relative abundance (%) of broods of each species in each habitat type in the CD North ground-search area, Colville River Delta, Alaska, 2001.

Habitat	Red-throated Loon	Pacific Loon	Greater White-fronted Goose	Tundra Swan	Spectacled Eider	Long-tailed Duck	Red-breasted Merganser	Glaucous Gull	Sabine's Gull	All Species	Total Number of Broods
Brackish Water	20	14	0	0	0	0	0	0	0	7	2
Tapped Lake w/ High-water Connection	0	57	0	0	0	0	0	0	0	15	4
Salt Marsh	0	0	0	0	0	0	1	0	0	4	1
Salt-killed Tundra	0	0	0	0	33	0	0	0	25	11	3
Deep Open Water w/ Islands or Polygonized Margins	0	14	0	100	67	50	0	100	0	26	7
Shallow Open Water w/ Islands or Polygonized Margins	0	14	0	0	0	50	0	0	25	7	2
Aquatic Sedge w/ Deep Polygons	60	0	0	0	0	0	0	0	0	11	3
Nonpatterned Wet Meadow	20	0	100	0	0	0	0	0	25	15	4
Wet Sedge–Willow Meadow	0	0	0	0	0	0	0	0	25	4	1
Total	100	100	100	100	100	100	100	100	100	100	
Total Number of Broods	5	7	2	2	3	2	1	1	4		27

when 50 broods of 11 species were observed (Figure 9, Table 9). The number of broods by species varied among years. In 2000, 11 broods of Greater White-fronted Geese were seen, but in 2001, only 2 broods were seen. Red-throated loon broods (5–7) were seen regularly in both years. Only 3 Pacific Loon broods were seen in 2000, but they were the most numerous broods (7) seen in 2001. No broods of Arctic Terns were seen in 2001, while 7 were observed in 2000. The numbers of broods were undoubtedly undercounted, because young of many species are cryptic and use vegetation to hide; thus, numbers reported here are minimal counts. Broods were recorded most often in Deep Open Water with Islands or Polygonized Margins (21 broods or 27% of all broods), Salt-killed Tundra (12 broods; 16%), and Aquatic Sedge with Deep Polygons (12 broods, 16%) (Tables 10 and 11).

EIDERS

BACKGROUND

The Spectacled Eider population on the Yukon-Kuskokwim Delta in western Alaska suffered a large decline (96%) between the 1970s and 1992 (Kertell 1991, Stehn et al. 1993), and populations also may have declined in northern Alaska and in Russia (USFWS 1996). Since 1993, the western Alaska population appears to be stable or slightly declining (Petersen et al. 2000). As a result, the Spectacled Eider was listed as a threatened species under the Endangered Species Act in 1993 (58 FR 27474–27480). Spectacled Eiders nest on the arctic coast of Siberia (Bellrose 1980) and in Alaska on the Yukon-Kuskokwim Delta and along the Beaufort Sea coast from Point Barrow to Demarcation Point (Gabrielson and Lincoln 1959, Dau and Kistchinski 1977). Spectacled Eiders are uncommon nesters (i.e., they occur regularly but are not found in all suitable habitats) on Alaska's Arctic Coastal Plain, and tend to concentrate on large river deltas (Johnson and Herter 1989). Derksen et al. (1981) described them as common breeders in the National Petroleum Reserve-Alaska (NPR-A), but uncommon at Storkersen Point, east of the Colville River. Spectacled Eiders arrive on the Colville Delta in early June, and nest as early as 8 June to as late as 24 June (Simpson et al. 1982, North et al. 1984, Nickles et al. 1987, Gerhardt et al. 1988). Male Spectacled Eiders leave their mates and nesting areas after incubation begins (Gabrielson and Lincoln 1959, Kistchinski and Flint 1974, TERA 1995). The latest record of Spectacled Eiders on the Colville Delta is 28 August (Gerhardt et al. 1988). The entire world's population of Spectacled Eiders appears to winter in restricted openings in Bering Sea ice south of St. Lawrence Island; in 1997, 363,030 birds were estimated from photographs of 18 flocks dispersed among the sea ice (Larned and Tiplady 1997).

King Eiders nest in high densities in the Prudhoe Bay area (Troy 1988) and at Storkersen Point (Bergman et al. 1977), but densities appear to decline west of the Colville River (Derksen et al. 1981). On the Colville Delta, they are common visitors but uncommon or rare nesters (Simpson et al. 1982, North et al. 1984, Johnson 1995). King Eiders occur frequently in flocks on open channels and waterbodies in early June, after Spectacled Eiders have dispersed to nesting habitats (Johnson 1995); thus, King Eiders possibly arrive on the delta slightly later and/or they use the delta as a staging area before moving to nesting areas farther east.

Common Eiders have a circumpolar distribution and along the Beaufort Sea they favor barrier islands as nesting sites (Johnson and Herter 1989). Except on the barrier islands, Common Eiders are rare on the Colville Delta (Simpson et al. 1982, Renken et al. 1983, North et al. 1984, Johnson et al. 1998). During pre-nesting surveys, a pair was seen in 1992 (Smith et al. 1993) and 7 were seen in the delta area in 1998 (Johnson et al. 1999a); one nest was found on an island in the outermost delta in 1994 (Johnson 1995).

The Steller's Eider was listed as threatened under the Endangered Species Act in 1997 (62 FR 31748–31757). Steller's Eiders breed primarily on the arctic coast of Siberia (Bellrose 1980). In Alaska, they historically nested across most or all of the coastal plain (Kertell 1991, Quakenbush and Cochrane 1993), but currently they nest primarily around Barrow (Day et al. 1995; Quakenbush et al. 1995). Sightings of Steller's Eiders have been recorded occasionally in Prudhoe Bay (USFWS 1998), the Kuparuk Oilfield (a pair in 2000 and in 2001; ABR Inc., unpubl.data) and the Colville

Delta (5 birds in 1995; J. Bart, Boise State University, pers. comm.).

DISTRIBUTION AND ABUNDANCE

Pre-nesting

In 2001, the eider pre-nesting survey was conducted on 12–14 June, within the time-frame typically flown in previous years. All Spectacled Eiders seen on the survey were singles or pairs and appeared to be dispersed into potential breeding habitat. During the 2001 survey, the tundra was inundated with melt water, although flood levels from the Colville were not as high or extensive as the record levels of 2000.

The distribution of both Spectacled and King eiders during pre-nesting in 2001 was similar to that observed in the previous 8 years of surveys between 1992 and 2000 (no survey occurred in 1999; Figure 10, Appendices C1 and C2). Spectacled and King eiders on the Colville Delta were closely associated with coastal areas in all years. During 2001, the mean (4.5 km, n =18 sightings) and maximal distance (9.8 km) of Spectacled Eiders from the coast was similar to that for all years combined (mean = 4.0 km, maximum = 14.3 km, n = 219 sightings). Derksen et al. (1981) reported that Spectacled Eiders in the NPRA also were attracted to coastal areas. On the Indigirka delta of the Russian Arctic coast, Kistchinski and Flint (1974) found the highest numbers of Spectacled Eider nests in the maritime area, although they estimated that area extended inland 40–50 km from the sea. King Eiders on the Colville Delta had a similar affinity for the coast: the maximal distance a group was found from the coast between 1992 and 2001 was 14.2 km, and the mean was 5.2 km (n = 126 sightings).

Spectacled Eiders have been the numerically dominant eider species during the pre-nesting surveys in the CD North study area in 6 out of 8 years. This pattern continued in 2001 with Spectacled Eiders making up 59% (30 birds), King Eiders 35% (18 birds), and Common Eiders 6% (3 birds) of the total eiders observed (Table 12). The indicated totals (USFWS 1987b) for Spectacled, King, and Common eiders were nearly the same as the observed totals (Table 12).

The observed density of Spectacled Eiders in the CD North study area in 2001 (0.15 birds/km², Table 13) was the lowest since 1993 (1992 was not included because the sample of plots was not representative of the delta). In 2001, and to a greater extent in 2000, frozen lakes and ponds with ice made observation conditions during the survey difficult and may have discouraged Spectacled Eiders from using the delta during the survey period. Low densities also occurred in 1996, but that year's survey was affected by the relatively early departure of males from the breeding grounds (Johnson et al. 1997).

Trends in pre-nesting Spectacled Eider densities on the CD North study area are comparable with those recorded across the entire Arctic Coastal Plain and do not indicate growth or decline of the Spectacled Eider population (Figure 11). The indicated density of Spectacled Eiders in CD North (mean = 0.20, n = 8 years) was similar to the density measured on the entire Arctic Coastal Plain (mean = 0.23, n = 9 years; Larned et al. 2001b). The regression estimate of population trend for the coastal plain is slightly negative (0.98 growth) but not significant (90% CI = 0.94–1.03) (Larned et al. 2001b). Counts of pre-nesting Spectacled Eiders in the nearby Kuparuk Oilfield also fail to display an obvious trend (Figure 11).

Relative to nearby areas, the CD North study area supports high densities of Spectacled Eiders. The CD North study area attracts higher densities of Spectacled Eiders than does the more inland CD South study area on the Colville Delta (≤0.01 birds/km²; Appendix C1), probably because of its coastal location and brackish habitats, which the CD South area lacks (Burgess et al. 2002). The CD North study area also attracts higher densities of Spectacled Eiders than the Kuparuk Oilfield immediately to the east (mean = 0.08 birds/km², n = 8 years; Anderson et al. 2002) and the NPRA development area immediately to the west (0.05 birds/km²; Burgess et al., in prep.); however, the Kuparuk and NPRA survey areas extended further inland and, thus, included areas of less favorable habitat.

King Eiders in CD North displayed different annual trends and distributions during pre-nesting than did Spectacled Eiders. The densities of King Eiders in 2000 and 2001 (0.08 birds/km² and 0.09 birds/km², respectively) in the CD North study area were the 2 highest densities recorded since 1993 (Table 13). However, the fluctuation in

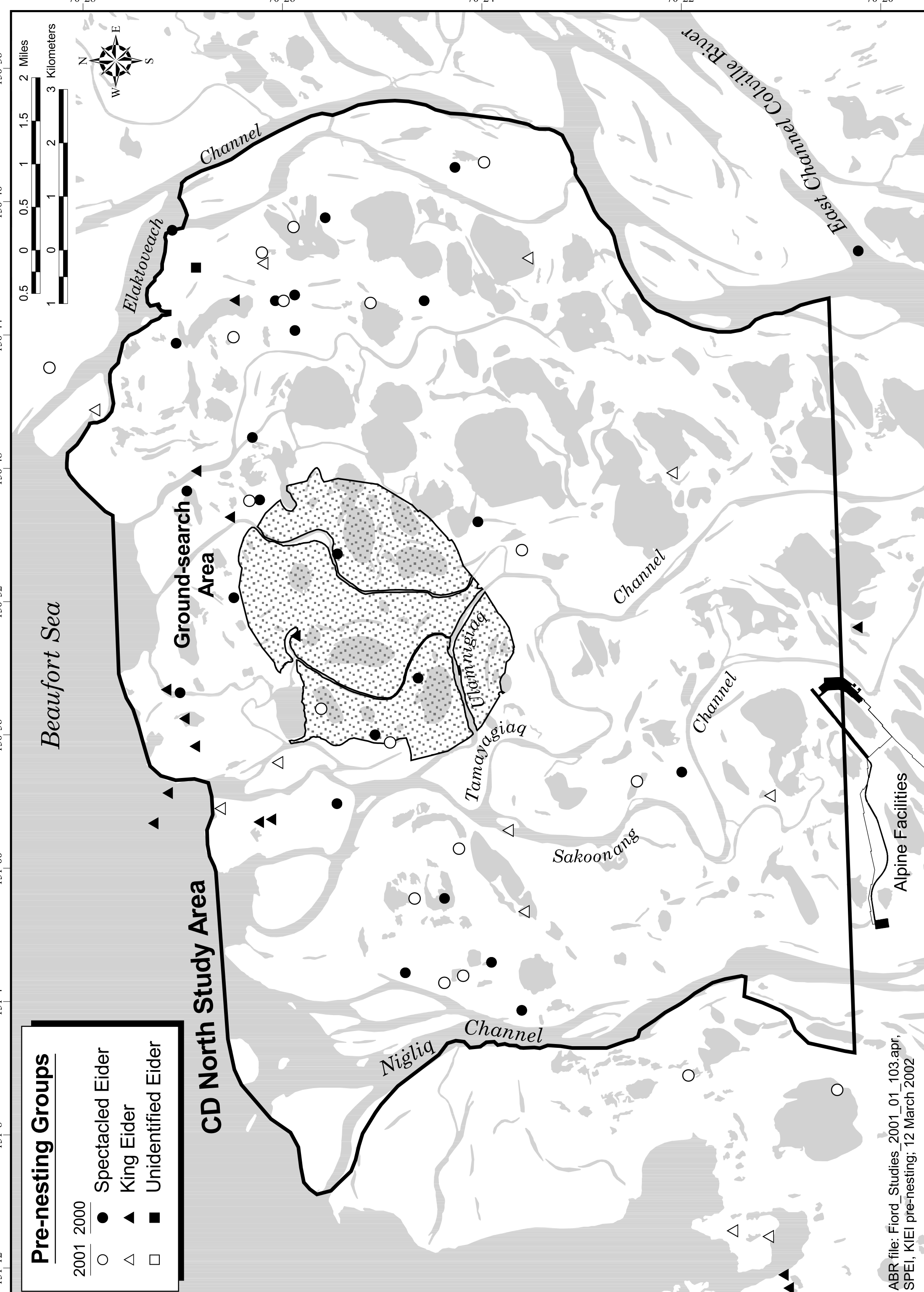


Figure 10. Distribution of Spectacled, King, and unidentified eider groups recorded during pre-nesting aerial surveys in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

Table 12. Numbers and densities (uncorrected for sightability) of eiders during pre-nesting aerial surveys (100% coverage) of the CD North study area (206.9 km²), Colville River Delta, Alaska, 12 June 2001.

	Numbers of Eiders					Density (birds or pairs/km²)		
	Observed			Indicated			Indicated	
GROUP TYPE Species	Males	Females	Total	Total[a]	Pairs[b]	Observed Total	Total[a]	Pairs[b]
NON-FLYING BIRDS								
Spectacled Eider	16	14	30	32	16	0.15	0.15	0.08
King Eider	8	9	17	16	8	0.08	0.08	0.04
FLYING BIRDS								
Spectacled Eider	0	0	0	–	–	0.00	–	–
King Eider	1	0	1	–	–	0.00	–	–
Common Eider	2	1	3	–	–	0.01	–	–
NON-FLYING + FLYING BIRDS								
Spectacled Eider	16	14	30	–	–	0.15	–	–
King Eider	9	9	18	–	–	0.09	–	–
Common Eider	2	1	3	–	–	0.01	–	–

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

actual numbers of King Eiders over 8 years in CD North is relatively small, and no trend is obvious (Figure 12). Most of the King Eiders on the delta during pre-nesting are located in the large river channels on the delta's east side (Johnson et al. 1999a), outside the CD North study area boundaries (Appendix C2). The CD North study area supports less than one-fourth of the density of King Eiders that occur in the adjacent Kuparuk Oilfield and on the entire Arctic Coastal Plain (Figure 12). The CD South study area inland on the delta supported lower densities of King Eiders than occurred at CD North; only 1–3 pairs of King Eiders (0.01–0.04 birds/km²) were sighted in the last 2 years in the CD South study area (Burgess et al. 2002).

Nesting

The coastal portion of the delta, where Spectacled Eiders concentrate during pre-nesting, also is where Spectacled Eiders nest most commonly (Figure 10, Appendices C1 and C3). The mean distances from the coast that nests were found for 3 species of eider on the delta were 3.5 km ($n = 55$) for Spectacled Eider, 3.9 km ($n = 6$) for King Eider, and 1.4 km ($n = 1$) for Common Eider. We have no records of any Spectacled Eider nests on the delta that were farther than 12.6 km from the coast, although we must emphasize that nest searching has never been complete or uniform across the entire delta.

In the CD North ground-search area (17.9 km²) during 2001, 7 Spectacled Eider nests were found (including 3 that were identified by color patterns on contour feathers in the nest; Anderson and Cooper 1994) for a density of 0.4 nests/km² (Figure 13). No nests of King Eiders were found in 2001. Nest densities of both eider species were higher in 2000 (Spectacled Eider 1.2 nests/km²; King Eider 0.16 nests/km²), but slightly different areas were searched in 2000 than in 2001 (Figure 13). Mean clutch size for Spectacled Eider nests in 2001 (3.3 eggs/nest, $n = 4$ nests) was lower than the overall mean since 1992 (4.1 eggs/nest, $n = 25$ nests); clutch sizes were counted only for those nests whose hens were

Table 13. Observed number (flying and non-flying birds), indicated number, and densities (birds/km²) of eiders during pre-nesting aerial surveys in the CD North study area (206.9 km²), Colville River Delta, Alaska, 1993–2001. Pre-2000 data are from Johnson et al. (1999a).

Year	Spectacled Eider				King Eider				Common Eider				Unidentified Eider			
	Observed Number	Indicated Number[a]	Observed Density	Indicated Density	Observed Number	Indicated Number	Observed Density	Indicated Density	Observed Number	Indicated Number	Observed Density	Indicated Density	Observed Number	Indicated Number	Observed Density	Indicated Density
1993[b]	21	26	0.20	0.25	11	8	0.11	0.08	0	0	0	0	2	0	0.02	0
1994	69	55	0.33	0.27	12	12	0.06	0.06	0	0	0	0	0	0	0	0
1995	44	28	0.21	0.14	5	2	0.02	0.01	0	0	0	0	10	4	0.05	0.02
1996	33	32	0.16	0.15	13	4	0.06	0.02	0	0	0	0	0	0	0	0
1997	47	44	0.23	0.21	7	8	0.03	0.04	0	0	0	0	0	0	0	0
1998	57	58	0.28	0.28	16	12	0.08	0.06	2	2	0.01	0.01	0	0	0	0
2000	36	36	0.17	0.17	16	18	0.08	0.09	0	0	0	0	1	0	<0.01	0
2001	30	32	0.15	0.15	18	16	0.09	0.08	3	0	0.01	0	0	0	0	0
Mean	44.7	42.1	0.22	0.20	13.6	11.0	0.07	0.05	0.6	0.2	<0.01	<0.01	1.9	0.5	0.01	<0.01

[a] Indicated number = (number of non-flying males not in groups × 2) + number of non-flying birds in groups (see USFWS 1987b).
[b] Coverage of survey area in 1993 was 50%. Numbers were doubled for calculation of overall means.

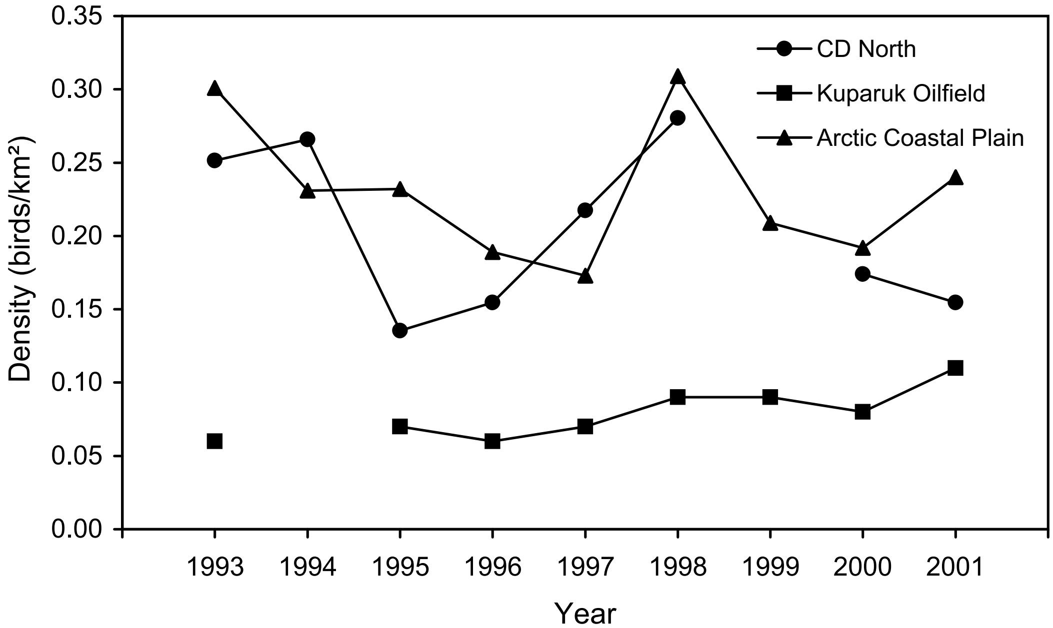


Figure 11. Trend in density of Spectacled Eiders during pre-nesting aerials surveys in the CD North study area, the Kuparuk Oilfield, and the Arctic Coastal Plain, Alaska, 1993–2001.

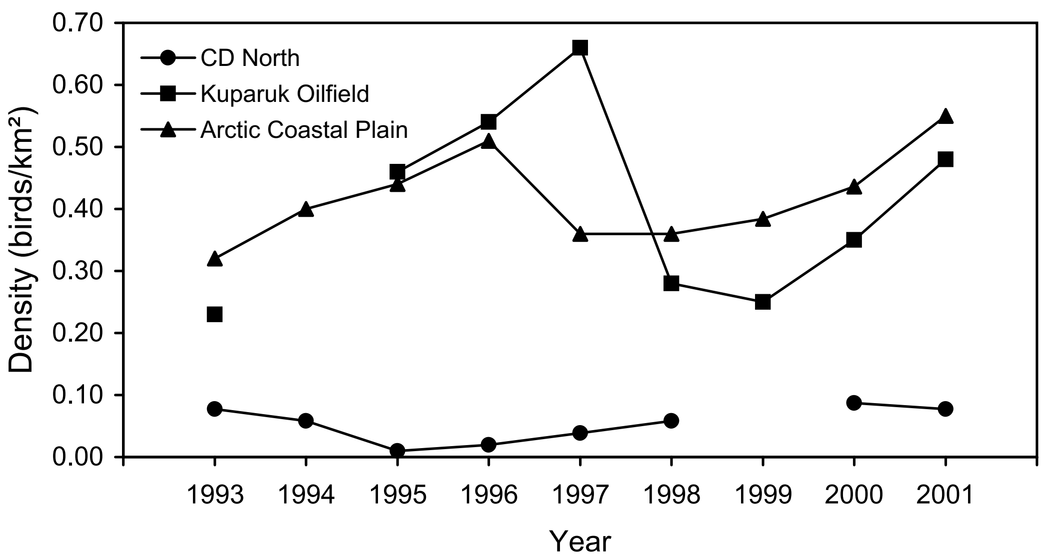


Figure 12. Trend in density of King Eiders during pre-nesting aerial surveys in the CD North study area, the Kuparuk Oilfield, and the Arctic Coastal Plain, Alaska, 1993–2001.

Figure 13. Distribution of Spectacled and King eider nests and broods in the CD North ground-search area, Colville River Delta, Alaska, 2000 and 2001.

flushed unintentionally. Nesting success for Spectacled Eiders in 2001 (14%, n = 7 nests) was poor and lower than nesting success in 2000 (43%, n = 14) and the overall success on the delta since 1992 (34%, n = 35 nests of known fate). Of the 6 nests that failed to hatch in 2001, one had failed before it was found, and 4 had their hens flushed during our nest search but were not observed long enough to determine whether they returned. To examine whether hens that were flushed were more prone to failure, from predation and/or abandonment, nesting success was evaluated for nests found since 1992 that were active when found and had known fates. Nest success for the 13 hens that were flushed was higher (54%) than nesting success of the 11 hens that remained on their nest (27%), suggesting that flushing Spectacled Eiders off their nests once did not lower nesting success. However, we emphasize that extra care was taken to cover nests where hen eiders were flushed, and occasionally we would defend nests from aerial predators if they found an exposed nest. Nonetheless, nesting success might have been higher in the absence of the disturbance caused by nest searching, but we do not have a good way to evaluate that possibility.

In 4 previous years—1992, 1993, 1994, and 1997—we searched portions of the CD North ground-search area for eider nests (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1998). Ten Spectacled Eider nests (one was identified by contour feathers in the nest) and 1 King Eider nest were found in the areas where nests were found in 2000 and 2001 (Appendices C3 and C4). During nest searches in various portions of the delta from 1992 to 2001, we have found 55 Spectacled Eider nests, 6 King Eider nests, 1 Common Eider nest, and 3 nests that were not identified to species. Eleven additional Spectacled Eider nests were recorded on the Colville Delta during bird studies conducted from 1981 to 1987 (Renken et al. 1983, Rothe et al. 1983, North et al. 1984, Nickles et al. 1987, Gerhardt et al. 1988); however, we were able to obtain the locations of only 4 of these nests (M. North, unpubl. data). The earliest records we have found for nests are of 2 Spectacled Eider nests on the outer delta in 1958 and 4 in 1959 (T. Myres, unpubl. data). Four of the nests found in 1993 and 1994 were on the same lakes as the nests from these earliest records (near the Nigliq Channel, Appendix C3).

Only 5 Spectacled Eider nests (9% of 55 nests) found on the delta since 1992 were found outside of the CD North study area, and this result was not due to lack of search effort. The vicinity of the Alpine project area has been thoroughly searched (10.6–17.2 km²) for 7 years, and only 3 Spectacled Eider nests and 1 probable King Eider nest (identification based on contour feathers in the nest) have been found (Johnson et al. 2002). Another 2 Spectacled Eider nests were found in the CD South ground-search areas (5.8–9.7 km²), one each in 2000 and 2001 (Burgess et al. 2002). The low numbers of Spectacled Eider nests in the Alpine and CD South areas contrast sharply with the concentration of nests in the CD North ground-search area and this contrast is indicative of the preference Spectacled Eiders exhibit for nesting in coastal areas of the delta.

Few nests of other eider species have been found on the delta, possibly because nest searches conducted before 1996 focused on Spectacled Eiders. More probable, however, is that the delta does not support much nesting by other eider species. In 10 years of nest searching on the delta, only 7 of 62 nests (11%) belonged to species other than Spectacled Eiders: 1 Common Eider nest and 6 King Eider nests (2 identified by contour feathers). In contrast, similar search techniques were used in the adjacent Kuparuk Oilfield on the east side of the Colville River, but 57% of the 251 eider nests found in 9 years were King Eider nests (Anderson et al. 2002).

Brood-rearing

The distribution of Spectacled Eider broods on the delta is similar to the distribution of eiders during pre-nesting and nesting surveys (Appendices C1, C3, C5); that is, no broods occurred >13 km from the coast. In 2000 and 2001, 9 and 4 Spectacled Eider broods, respectively, were observed in or near the CD North ground-search area (Figure 13). Mean brood size was 3.4 young/brood in 2000 and 2.5 young/brood in 2001. Since 1992, 29 Spectacled Eider broods have been recorded on the delta (mean = 3.7 young/brood, n = 24 broods with young counted), and they have been primarily on the outer portion (Appendix C5). Search efforts have not been consistent among years and have varied from systematic to opportunistic. The number of broods undoubtedly is undercounted during aerial and ground surveys, because the cryptic coloration and furtive behavior of female eiders and their young effectively reduce detection of broods. In 1995, only one Spectacled Eider brood and one King Eider brood were seen during a systematic helicopter survey of the entire delta. Most broods have been recorded during ground-searches or intensive lake-to-lake helicopter surveys.

HABITAT USE

Pre-nesting

During the pre-nesting season in 2001, Spectacled Eiders were found in 10 of the 21 habitats available (Tables 3 and 14). Groups of Spectacled Eiders seen during the aerial survey were recorded most often in Brackish Water (20% of all sightings), Salt-killed tundra (20%), and Deep Open Water with Islands or Polygonized Margins (13%). All 3 of these habitats were significantly preferred (i.e., habitat use was greater than availability), along with Salt Marsh, Aquatic Sedge with Deep Polygons, and Shallow Open Water with Islands or Polygonized Margins according to a habitat selection analysis of 8 years of sightings for the entire delta (1993–1998, and 2000–2001—1992 was not included because the sample of plots that year was not representative of the delta; Appendix D1). Habitat use during pre-nesting differed between 2000 and 2001. Two-thirds of the pre-nesting Spectacled Eiders in 2000 were found in Aquatic Sedge with Deep Polygons, Wet Sedge–Willow Meadow, and Deep Open Water without Islands, but in 2001 only 13 % of the pre-nesting eiders were found in those habitats (Table 14). The difference between years in habitat use may have been caused by differences in spring melt pattern and flood levels, but the transient and localized nature of these seasonal changes are difficult to compare with the data we have available.

Elsewhere, studies have emphasized the importance of emergent vegetation for eiders using waterbodies during pre-nesting. West of the Colville 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 fulva*), and aquatic sedge (*Carex aquatilis*) habitats (Anderson et al. 2001). 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 aquatic grass and sedge) and impoundments (Warnock and Troy 1992). Lakes with emergents are not abundant on the Colville Delta; however, Aquatic Sedge with Deep Polygons and Aquatic Grass Marsh are probably analogous to the emergent grass and sedge ponds described elsewhere. These habitats are not abundant in CD North study area. Aquatic Sedge with Deep Polygons occupies only 4% of the CD North study area, but in certain years such as 2000, receives disproportional use (Appendix D1.)

King Eiders during pre-nesting used some of the same habitats as those used by Spectacled Eiders but in different proportions (Table 14). The largest proportion of King Eiders in 2001 occurred in Tapped Lake with Low-water connection (2 sightings or 28.6% of the total). Brackish Water and River or Stream were the only habitats preferred by pre-nesting King Eiders on the delta over 8 years of surveys, and River or Stream was used by more groups (50% of the total) than any other habitat (Appendix D1). The high use of River or Stream and low use of typical nesting habitat (i.e., lakes and wet meadows) on the delta suggests that most King Eiders had not yet dispersed into breeding areas during the pre-nesting surveys (Johnson et al. 1999a). Furthermore, the low number of nests found in the 2000 and 2001 ground-searches indicates that the Colville Delta may be more important as a stopover for King Eiders breeding elsewhere than as a nesting area. At Storkersen Point, where King Eiders nest in relatively high densities, they preferred shallow and deep *Arctophila* wetlands, basin complexes, and coastal wetlands during pre-nesting and nearly the same habitats during nesting (Bergman et al. 1977). Nest densities also are high at Prudhoe Bay, where pre-nesting King

Table 14. Habitat use by Spectacled Eiders and King Eiders during pre-nesting on the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

	2000			2001		
SPECIES Habitat	No. of Groups	No. of Adults	Use (%)	No. of Groups	No. of Adults	Use (%)
SPECTACLED EIDER						
Brackish Water	1	2	5.6	3	7	20.0
Tapped Lake w/ Low-water Connection	1	2	5.6	1	3	6.7
Tapped Lake w/ High-water Connection	0	0	0	1	2	6.7
Salt Marsh	1	2	5.6	1	2	6.7
Salt-killed Tundra	1	2	5.6	3	5	20.0
Deep Open Water w/out Islands	2	2	11.1	1	2	6.7
Deep Open Water w/ Islands or Polygonized Margins	0	0	0	2	4	13.3
Shallow Open Water w/out Islands	1	2	5.6	0	0	0
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0	1	2	6.7
River or Stream	1	2	5.6	0	0	0
Aquatic Sedge w/ Deep Polygons	6	10	33.3	1	2	6.7
Nonpatterned Wet Meadow	0	0	0	1	1	6.7
Wet Sedge–Willow Meadow	4	6	22.2	0	0	0
TOTAL	18	30	100	15	30	100
KING EIDER						
Brackish Water	2	3	25.0	0	0	0
Tapped Lake w/ Low-water Connection	0	0	0	2	4	28.6
Salt Marsh	1	2	12.5	0	0	0
Tidal Flat	0	0	0	1	2	14.3
Salt-killed Tundra	2	3	25.0	1	2	14.3
Deep Open Water w/out Islands	0	0	0	1	4	14.3
Deep Open Water w/ Islands or Polygonized Margins	1	2	12.5	1	3	14.3
River or Stream	1	2	12.5	1	2	14.3
Aquatic Sedge w/ Deep Polygons	1	2	12.5	0	0	0
TOTAL	8	14	100	7	17	100

Eiders used almost all habitats but preferred wet, aquatic nonpatterned; aquatic strangmoor; and water with and without emergents (Warnock and Troy 1992).

Nesting

Nesting surveys were conducted on the ground because finding eider nests during aerial surveys would be difficult, if not impossible. Consequently, complete surveys of the extensive habitats available on the Colville Delta were not feasible. Search areas were chosen that either maximized chances of finding nests (1993, 1994, and 1997) or that included proposed development sites (1992 [10-ha sample], 1995–2001). Thus, a representative sample of habitats from which selection could be calculated for the Colville Delta were not searched; instead, we used the nesting data to summarize habitat associations for the delta and to evaluate habitat selection in the CD North ground-search area, which was completely searched for eider nests during 2000 and 2001.

Nesting Spectacled Eiders in the CD North study area used many of the same habitats that were used during pre-nesting (Table 15). In 2001, Spectacled Eider nests were relatively evenly distributed across 4 habitats: Salt-killed Tundra, Deep Open Water with Islands or Polygonized

Table 15. Habitat use by Spectacled Eiders and King Eiders during nesting in the CD North ground-search area, Colville River Delta, Alaska, 2000 and 2001.

SPECIES Habitat	2000 No. of Nests	2000 Use (%)	2001 No. of Nests	2001 Use (%)
SPECTACLED EIDER				
Brackish Water	1	7.1	0	0
Salt-killed Tundra	8	57.2	2	28.6
Deep Open Water w/ Islands or Polygonized Margins	3	21.4	1	14.2
Aquatic Sedge w/ Deep Polygons	2	14.3	2	28.6
Wet Sedge–Willow Meadow	0	0	2	28.6
TOTAL	14	100	7	100
KING EIDER				
Salt-killed Tundra	1	50.0	0	0
Aquatic Sedge w/ Deep Polygons	1	50.0	0	0
TOTAL	2	100	0	0

Margins, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow. In contrast, 8 of the 14 nests (57%) in 2000 were found in Salt-killed Tundra. A Monte Carlo analysis of nesting habitat selection in the CD North ground-search area in 2000 and 2001 determined that Salt-killed Tundra was the only significantly preferred nesting habitat among that sample of nests (Table 16). However, the number of nests (21) in this analysis is low relative to the number of habitats (17) available in the ground-search area, which suggests that the analysis lacks power to detect many differences between habitat use and availability. As more nests are added to the analysis, the ability to detect significant differences will improve. In 10 years of searching in various locations on the delta, 55 nests of Spectacled Eiders have been found in 9 habitats (Appendix D2). Most nests were located in Salt-killed Tundra (26% of total), Aquatic Sedge with Deep Polygons (22%), Wet Sedge-Willow Meadow (15%), Nonpatterned Wet Meadow (13%), and Brackish Water (11% [on islands]). Three of those habitats also were significantly preferred during pre-nesting on the delta.

Spectacled Eider nests in all habitats across the delta were closely associated with water, averaging 2.9 m (range = 0.1–80 m, $n = 55$) from permanent water. Brackish Water was the nearest waterbody type to 40% of the nests, and Deep Open Water with Islands or Polygonized Margins was the nearest waterbody type to 31% of the nests (Appendix D2).

Similar habitat associations were reported for other locations. Nests on the Yukon-Kuskokwim Delta averaged 2.1 m from water (Dau 1974). Annual mean distances of Spectacled Eider nests to water in the Kuparuk Oilfield ranged from 0.6 to 5.7 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 sedge and grass) (Anderson et al. 2002). 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. 2002). In Prudhoe Bay, nests were found in sedge ponds and wet, nonpatterned tundra (Warnock and Troy 1992). Spectacled Eiders at Storkersen Point preferred deep *Arctophila* lakes and ponds during both pre-nesting and nesting (Bergman et al. 1977). In the NPRA, Spectacled Eiders used shallow sedge ponds during summer (Derksen et al. 1981). Waterbodies with emergent vegetation (e.g., Aquatic Grass Marsh and Aquatic Sedge Marsh) are scarce in the CD North study area and on the Colville Delta, with the exception of Aquatic Sedge with Deep Polygons (Table 3); therefore, nesting habitat on the delta differs

Table 16. Habitat selection (pooled among years) by Spectacled Eiders during nesting in the CD North ground-search area, Colville River Delta, Alaska, 2000-2001.

Habitat	No. Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	1	4.8	4.2	ns
Tapped Lake w/ Low-water Connection	0	0	1.0	ns
Tapped Lake w/ High-water Connection	0	0	2.9	ns
Salt Marsh	0	0	5.3	ns
Tidal Flat	0	0	<0.1	ns
Salt-killed Tundra	10	47.6	17.9	prefer
Deep Open Water w/o Islands	0	0	2.9	ns
Deep Open Water w/ Islands or Polygonized Margins	4	19.0	9.9	ns
Shallow Open Water w/o Islands	0	0	0.2	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0.7	ns
River or Stream	0	0	<0.1	ns
Aquatic Sedge w/ Deep Polygons	4	19.0	13.0	ns
Aquatic Grass Marsh	0	0	0.1	ns
Nonpatterned Wet Meadow	0	0	12.6	ns
Wet Sedge–Willow Meadow	2	9.5	22.0	ns
Moist Sedge–Shrub Meadow	0	0	2.9	ns
Riverine or Upland Shrub	0	0	0.7	ns
Barrens	0	0	3.6	ns
TOTAL	21	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.

somewhat from areas with abundant emergent grass and sedge waterbodies.

King Eider nests are not common on the Colville Delta; the 2 King Eider nests found in 2000 each occurred in Salt-killed Tundra and Aquatic Sedge with Deep Polygons (Table 15). Only 6 King Eider nests (2 were identified by contour feathers) were found during 10 years of nest searches on the delta, and these nests were found in 3 habitats: Salt-killed Tundra (2 nests), Aquatic Sedge with Deep Polygons (3 nests), and Wet Sedge–Willow Meadow (1 nest). The distance of nests from permanent water was greater (mean = 14 m, $n = 6$, range = 0.2–80 m) than for nests of Spectacled Eiders. The nearest waterbodies were Brackish Water, both types of Tapped Lakes, both types of Deep Open Water, and Shallow Open Water without Islands. Anderson et al. (2002) found King Eiders in the Kuparuk Oilfield nesting near basin wetland complexes, aquatic grass, aquatic sedge, and shallow open water. At Storkersen Point, nesting King Eiders preferred shallow and deep *Arctophila* and coastal wetlands (Bergman et al. 1977). Farther east, in Prudhoe Bay, King Eiders used a wider array of non-aquatic habitats than did Spectacled Eiders and preferred moist, wet low-centered polygons and wet strangmoor (Warnock and Troy 1992).

Brood-rearing

In 2001, 4 Spectacled Eider brood-rearing groups were seen in 3 habitats in the CD North ground-search area: Deep Open Water with Islands or Polygonized Margins, Salt-killed Tundra, and Tapped Lake with High-water Connection (Table 17). The majority of the brood groups (6 of 9, 66%) seen in 2000 were found in both types of Deep Open Water. The only systematic aerial survey for eider broods was conducted during 1995, so the majority of sightings prior to 2000 have been opportunistic. Only 29 Spectacled Eider brood-rearing groups have been recorded on the entire delta since 1983 (Appendix D3). Most groups were found in Deep Open Water with Islands or Polygonized Margins (24% of all locations), Salt-killed Tundra (17%),

Table 17. Habitat use by Spectacled Eiders during brood-rearing in the CD North study area, Colville River Delta, Alaska, 2000 and 2001. Broods were located during both aerial and ground surveys.

	2000			2001		
Habitat Type	No. of Brood-rearing Groups	No. of Young	Use (%)	No. of Brood-rearing Groups	No. of Young	Use (%)
Tapped Lake w/ Low-water Connection	1	3	11.1	0	0	0
Tapped Lake w/ High-water Connection	0	0	0	1	4	25.0
Salt-killed Tundra	0	0	0	1	2	25.0
Deep Open Water w/out Islands	2	5	22.2	0	0	0
Deep Open Water w/ Islands or Polygonized Margins	4	12	44.4	2	4	50.0
Aquatic Sedge w/ Deep Polygons	1	4	11.1	0	0	0
Wet Sedge–Willow Meadow	1	7	11.1	0	0	0
TOTAL	9	31	100	4	10	100

and Wet Sedge–Willow Meadow (14%). Brood-rearing groups appear to be attracted to coastal lakes; the mean distance to the coast was 3.7 km (n = 29 groups), and most groups were seen in or near to Deep Open Water with Islands or Polygonized Margins (31% of all broods) and Brackish Water (24% of all broods). 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* (Bergman et al. 1977).

Only 2 King Eider broods have been seen on the delta since studies began in 1992. One King Eider brood was seen in 1995 in Aquatic Sedge with Deep Polygons and the other was found in 1992 in Wet Sedge–Willow Meadow (Appendix D3).

The results of habitat analyses emphasize the importance to breeding Spectacled Eiders of habitats that are more prevalent on the outer delta: Brackish Water, Salt-killed Tundra, Salt Marsh, Aquatic Sedge with Deep Polygons, and Shallow and Deep Open Water with Islands or Polygonized Margins. The features common to these habitats are saline influence and polygonized surface forms. Another polygonal habitat, Wet Sedge–Willow Meadow also was well-used, but because it was the most abundant habitat on the Colville Delta (Table 3), it was not a preferred habitat. Habitat use by King Eiders was not as well-defined as that by Spectacled Eiders, because of smaller sample sizes related to less frequent nesting on the delta. Nonetheless, King Eiders appeared to use habitats similar to those used by Spectacled Eiders for nesting and brood-rearing and also were closely associated with the coast.

TUNDRA SWANS

BACKGROUND

Tundra Swans arrive on the Colville Delta in mid- to late May (Simpson et al. 1982, Hawkins 1983). Swans occupy breeding territories and initiate nests soon after arrival, although they can be delayed by late snow melt (Lensink 1973, McLaren and McLaren 1984). Preferred nesting habitat consists of numerous lakes and associated wetlands (King and Hodges 1980, Monda et al. 1994). Tundra Swans are traditional in their selection of nesting territories and often use the same nest mounds in successive years (Palmer 1976, Monda et al. 1994, Anderson et al. 1999). Incubation begins after egg laying is completed, and hatching occurs 30–35 days later (Palmer 1976). Families then stay on or near their breeding territories until the young are fledged, after 8–10 weeks of brood-rearing (Bellrose 1976, Rothe et al. 1983, Monda and Ratti 1990). Tundra Swans leave northern Alaska by late September or early October on an easterly migration route for wintering grounds in eastern North America (Johnson and Herter 1989). Freezing temperatures and snow in early autumn can hasten their departure and cause mortality of young swans (Lensink 1973, Monda and Ratti 1990).

DISTRIBUTION AND ABUNDANCE

Nesting

Of the 27 Tundra Swan nests counted on the Colville River Delta during aerial surveys in 2001, 13 were located in the CD North study area (Figure 14, Table 18, Appendix C6). Three additional nests not recorded during the aerial survey were found during intensive ground searches within the CD North ground-search area. More nests were located in the CD North study area during aerial surveys in 1995 and 1996, a reflection of the regional increase in nesting observed at that time on the coastal plain from the Kuparuk River to the Colville Delta (Anderson et al 1996, Johnson et al 1997). In 2001, the density of swan nests in the CD north study area was 0.06 nests/km², the lowest density estimate since 1992 (Table 18). During the previous 7 survey years, nest density in the CD North study area ranged from 0.04 to 0.10 nests/km². Of the swan nests recorded during 8 years of aerial surveys on the delta, 42–70% were located within the CD North study area.

Slightly higher densities of nests have been found on the delta during intensive ground searches. In 1982, 48 nests (~0.11 nests/km²) were found on the northern 80% of the delta (Simpson et al. 1982). Nest densities recorded during aerial surveys of other areas on the coastal plain were similar to those for the Colville Delta: 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. 1999).

Brood-rearing

Eight swan broods were counted in the CD North study area in mid-August 2001 (Figure 14). The distribution of broods across the entire delta has been relatively uniform during the years surveyed (Appendix C7). Nest success in the CD North study area, estimated by dividing numbers of broods by the number of nests, was 62% in 2001 (Table 18). Nest success rates estimated for the previous 7 survey years in the study area were 36–89% (Table 18). The density of broods for the study area in 2001 was 0.04 broods/km², which was slightly below the 8-year average (Table 19). The estimated nest success for the entire delta in 2001 was 81% (22 of 27 nests), and the density of broods was 0.04 broods/km² (Appendix D4). Brood sizes in 2001 in the CD North study area and on the Colville Delta were the lowest recorded in 8 years of surveys (Table 19, Appendix D4). Mean brood size for the CD North study area in 2001 was 1.4 young/brood (n = 8), slightly less than the mean brood size for the delta as a whole (1.7 young/brood, n = 22). Similar results were recorded in the Kuparuk Oilfield during 2001, where nest success (88%) was high, but mean brood size (2.1 young/brood, n = 70) was one of the lowest estimates on record since 1988 (Anderson et al. 2002). The small brood sizes over a broad area from the Colville Delta to the Kuparuk River are indicative of a regional cause for poor nesting; we suspect the cool temperatures and late snow melt during May and June (see CONDITIONS IN THE STUDY AREA) delayed nest initiation and depressed swan productivity. In 1981, Rothe et al. (1983), using intensive ground surveys, measured 91% nest success (n = 32 nests) and 2.1 young/brood on the Colville Delta. In 1982, nest success was 71% (n = 48 nests), and mean brood size in mid-August 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 nest success was 76% (n = 110 nests) (Monda et al. 1994).

Productivity (as indicated by nest success, brood density, and brood size) on the delta during the 8 years that we have conducted aerial surveys is similar to or greater than values reported in other studies of swans on the Arctic Coastal Plain. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995–2001) recorded mean brood sizes of 2.0–2.8 young/brood and densities of 0.02–0.04 broods/km² (Anderson et al. 2002.). Platte and Brackney (1987) estimated 63–85% nest success, 0.04 broods/km², and 2.5 young/brood on

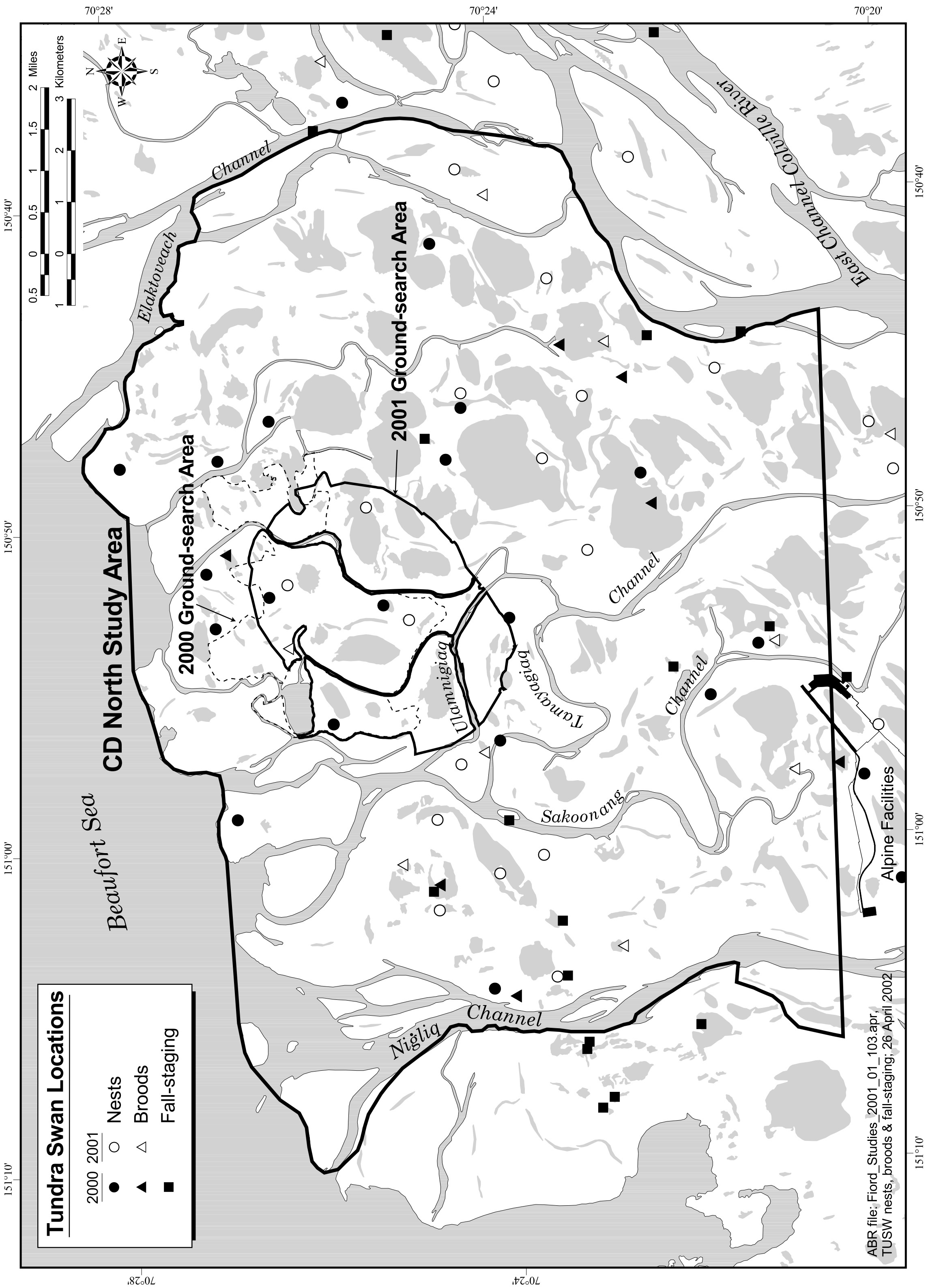


Figure 14. Distribution of Tundra Swan nests, broods, and fall-staging groups during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

Table 18. Numbers and densities (no./km²) of Tundra Swans and their nests during aerial surveys and estimated nesting success in the CD North study area, Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).

	Swans			Nests		
Year	No.	Density	% with Nests	No.	Density	% Estimated Nest Success[a]
1992[b]	63	0.30	21	9	0.04	89
1993	92	0.44	22	14	0.07	36
1995	74	0.36	51	21	0.10	57
1996	146	0.71	21	19	0.09	74
1997	264	1.28	9	15	0.07	80
1998	292	1.41	8	14	0.07	71
2000	96	0.46	27	16	0.08	38
2001	169	0.82	15	13	0.06	62
Mean	149	0.72	21	15	0.07	62

[a] nest success = (no. broods/ no. nests) × 100.
[b] data from a survey conducted by the Alaska Department of Fish and Game.

Table 19. Numbers of Tundra Swans and broods during brood-rearing and fall-staging aerial surveys in the CD North study area, Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).

	Brood-rearing								Fall Staging
Year	No. of broods	Brood density (no./km²)	Adults	% Adults with Broods	Young	Total Swans	% Young	Mean Brood Size	Total Swans
1992[a]	8	0.04	99	13	17	116	15	2.1	no data
1993	5	0.02	111	6	16	127	13	3.2	35
1995	12	0.06	87	19	41	128	32	3.4	40
1996	14	0.07	133	15	49	182	27	3.5	19
1997	12	0.06	164	12	32	196	16	2.7	10
1998	10	0.05	213	8	24	237	10	2.4	19
2000	6	0.03	202	6	11	213	5	1.8	21
2001	8	0.04	120	13	11	131	8	1.4	no data
Mean	9.3	0.5	141	11.5	25	166	15.8	2.7	

[a] data from surveys conducted by the Alaska Department of Fish and Game.

portions of the Arctic National Wildlife Refuge (ANWR) during 1982–1985.

Fall Staging

A fall-staging survey for swans was not flown in 2001. During swan staging surveys in past years, most swans generally have occurred in several large flocks that occupy river channels on the outer delta. Wetlands immediately east of the delta, lying between the Miluveach River and Kalubik Creek, have had the largest aggregations of Tundra Swans on the Arctic Coastal Plain of Alaska during fall staging (Seaman et al. 1981), and we have observed large numbers there as well (Appendix C8). In 1996, 355 swans were counted on the delta (Appendix D5) and 415 on several lakes just east of the delta. In 1997, 286 swans were recorded, and in 1998, 431 swans were recorded, primarily in the East Channel of the Colville Delta (e.g., near the mouth of the Miluveach River). The fall-staging survey area was expanded in 1998, with transects over the wetlands at the mouths of the Tingmeachsiovik River and Fish Creek, west of the mouth of the Nigliq Channel. We counted 229 swans in this area, most within a single group. This area had not been surveyed during previous years, so whether it is used regularly during fall staging is unknown. On 16 September 2000, the same area was flown but few swans (17) were found there.

Swans beginning fall migration appear to have varying departure times from the delta. On 19 September 1995, only 64 swans were counted (Appendix D5), most of which were in discrete family groups, distributed throughout the delta. Three days of subzero temperatures 2 weeks earlier had caused lakes to freeze (J. Helmericks, Golden Plover, Prudhoe Bay, AK, pers. comm.) and may have induced most swans to leave. Similarly, in 1992, subzero temperatures after 8 September caused an early freeze, and swans vacated the delta by the time of our fall-staging survey (17 September; Smith et al. 1993). In contrast, temperatures in 1993 remained above freezing until after a staging survey on 15 September when we saw 295 swans. In 1996, large numbers of swans (355) also were seen on the staging survey, but because the survey was conducted on 6 September before the first freezing temperatures of the month, there are no data for when the swans departed. These few observations suggest that the departure of most swans from the delta can be triggered before the middle of September by cold temperatures and freeze-up of waterbodies, but large numbers of swans can remain on the delta later when temperatures remain above freezing. Surveys in 4 of the 6 years considered here documented large numbers of swans staging on or near the Colville Delta prior to migration (Johnson et al. 1999a), an event also reported by Campbell et al. (1988).

HABITAT USE

Nesting

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. In the CD North study area in 2000 and 2001, 29 nests were found in 11 habitat types (Table 20). Eighteen nests were found in the 5 preferred habitats (based on the delta-wide multi-year analysis; Appendix D6): Salt-killed Tundra (7 nests), Wet Sedge–Willow Meadow (7 nests), Aquatic Sedge with Deep Polygons (3 nests), Moist Sedge–Shrub Meadow (1 nest), and Deep Open Water with Islands or Polygonized Margins (0 nests). The habitats used by swans nesting in the CD North study area were similar to those used on the entire delta over all years surveyed. During 8 years of surveys on the delta, 239 swan nests were located in 18 of 24 available habitats. Five habitat types were preferred, and 7 were avoided.

Tundra Swans breeding on the Canning and Kongakut river deltas in northeastern Alaska selected marsh habitats and nested near large lakes or coastal lagoons (Monda et al. 1994). Monda et al. (1994) found that nesting habitat preferences differed between their 2 study sites, which reflected differences in habitat availability. On the Kongakut delta, 42% of 36 nests were in areas classified as saline graminoid-shrub (probably equivalent to Salt Marsh). On the Canning delta, 52% of 54 nests were in graminoid-marsh (probably equivalent to Aquatic Grass and Aquatic Sedge marshes), 26% were in graminoid-shrub-water sedge (probably equivalent to Wet Sedge–Willow Meadow).

Brood-rearing

In 2000 and 2001 in the CD North study area, 8 of the 14 broods were observed in the 6 preferred

Table 20. Habitat use by nesting and brood-rearing Tundra Swans in the CD North study area, Colville River Delta, Alaska, 2000–2001.

Habitat Type	Nests		Broods	
	No.	Use (%)	No.	Use (%)
Brackish Water	0	0	1	7.1
Tapped Lake w/ Low-water Connection	0	0	2	14.2
Tapped Lake w/ High-water Connection	0	0	1	7.1
Salt Marsh	2	6.9	2	14.2
Tidal Flat	1	3.4	0	0
Salt-killed Tundra	7	24.1	1	7.1
Deep Open Water w/o Islands	0	0	2	14.3
Shallow Open Water w/ Islands or Polygonized Margins	1	3.4	0	0
River or Stream	0	0	0	0
Aquatic Sedge w/ Deep Polygons	3	10.3	0	0
Nonpatterned Wet Meadow	3	10.3	1	7.1
Wet Sedge–Willow Meadow	7	24.1	3	21.4
Moist Sedge–Shrub Meadow	1	3.4	0	0
Moist Tussock Tundra	1	3.4	0	0
Riverine or Upland Shrub	2	6.9	0	0
Barrens (riverine, eolian, lacustrine)	1	3.4	1	7.1
TOTAL	29	100	14	100

habitats (based on the delta-wide multi-year analysis; Appendix D6): Brackish Water (1 brood), Tapped Lake with Low-water Connection (2 broods), Tapped Lake with High-water Connection (1 brood), Salt Marsh (2 broods), Deep Open Water without Islands (2 broods), and Deep Open water with Islands or Polygonized Margins (0 broods) (Table 20; Appendix D6). Tundra Swans with broods (data pooled over 8 years) used 18 of 24 available habitats on the Colville Delta (Appendix D6). Six habitats were preferred and 4 were avoided. Wet Sedge–Willow Meadow was used by the highest percentage of broods in both the CD North study area and on the delta as a whole, but was used in proportion to its availability (Appendix D6). Habitat preferences differed between nesting and brood-rearing; only 1 habitat (Deep Open Water with Islands or Polygonized Margins) was preferred in both seasons.

Swan broods in northeast Alaska used different habitats as the brood-rearing season progressed (Monda et al. 1994). Early in the brood-rearing season on the Kongakut River delta, grazing in saline graminoid marsh and aquatic-marsh habitats predominated. Later in the season, surface and sub-surface foraging concentrated more in aquatic-marsh habitat. Changes in habitat and foraging methods may be related to nutritive quality of different plants or the increasing ability of older, larger cygnets to feed on submerged vegetation (e.g., pondweed [*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 on river deltas of the Kobuk-Selawik Lowlands. On the Colville Delta, swans are also reported to favor pondweed during the brood-rearing and molting periods (Johnson and Herter 1989). Wilk (1988) described spring-staging swans feeding on abundant pondweed in tidally influenced habitat in the Naknek River. Monda et al. (1994) also found that pondweed was an important component of the diet of swans of the Kongakut and Canning river deltas; pondweed, along with another important food, alkali grass (*Puccinellia phryganodes*), grows well in salt-affected environments. Although we did not collect data on the feeding habits of swans, the use of salt-affected and aquatic marsh habitats by broods and fall-staging flocks on the Colville Delta suggests that some of the same plants are being sought there.

LOONS

BACKGROUND

On the Arctic Coastal Plain of Alaska, Yellow-billed Loons nest primarily between the Colville and Meade rivers, with the highest densities found south of Smith Bay (Brackney and King 1992). The Colville Delta also is an important nesting area for Yellow-billed Loons (North and Ryan 1988). Yellow-billed Loons arrive on the delta just after the first spring meltwater accumulates on the river channels, usually during the last week of May (Rothe et al. 1983), and use openings in rivers, tapped lakes, and sea ice before nesting lakes are available in early June (North and Ryan 1988). 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).

DISTRIBUTION AND ABUNDANCE

Nesting

In 2001, 28 Yellow-billed Loons and 10 nests were counted in the CD North study area during the aerial survey (Table 21); an additional nest was found during ground-searches, yielding 11 nests total (Figure 15). The number of loons recorded during the aerial survey in 2001 was within the range of the number of loons (17 to 34 adults) seen during previous years (Table 21). The density of Yellow-billed loons ranged from 0.08 to 0.16 birds/km² during 7 years of aerial surveys (1993, 1995–1998, and 2000–2001—plot surveys in 1992 not included because they were not a representative sample of loon habitat). Densities similar to that found during 2001 in the CD North study area (0.14 birds/km²) 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; Derksen 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 North study area in 2001 was similar to that recorded on previous aerial surveys in 1993, 1995–1998, and 2000 (Smith et al. 1994; Johnson et al. 1999a), and during ground studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

In 1996–1998 and 2000–2001, lakes were resurveyed by helicopter where Yellow-billed Loon pairs had been seen but nests were not found during the initial aerial survey. During these second visits in 1996–1998, an additional 2 to 4 nests were found in the CD North study area that either had been missed or were initiated after the first survey. With the additional nests found in some years during revisit surveys, densities in the CD North study area ranged from 0.03–0.05 nests/km² in our 7 years of surveys. In 2000 and 2001, no additional nests were found during revisit surveys. The count of 10 nests in 2001 was within the range of nests (6–11) recorded on aerial surveys in the CD North study area during our 7 years of surveys (Table 21). During intensive ground surveys of the delta in 1983 and 1984, North (1986) found 11 and 13 nests, respectively, in the CD North study area. All 10 nests found on the aerial surveys in 2001 were on lakes where nesting by Yellow-billed Loons has been recorded in previous years (Appendix C9). Four of the nests were within the 2001 CD North ground-search area; nesting also occurred within this area in 1983–1984, 1989, 1992–1993, 1995–1998, and 2000 (North 1986, Johnson et al. 2000).

Nine nests of Pacific Loons were located opportunistically during Yellow-billed Loon surveys in 2001; no nests of Red-throated Loons were seen on the aerial survey (Table 21). Opportunistic counts of Pacific and Red-throated loons reflect their general distribution in the CD North 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 16, Appendix C10). Therefore, densities have not been calculated for these 2 species. Although counts are not adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon in the CD North study area during each year of study (Table 21). Summarizing ground surveys on the

Table 21. Numbers and densities (no./km²) of loons and their nests and broods counted on aerial surveys in the CD North study area, Colville River Delta, Alaska, 1993–2001. Pre-2000 data are from Johnson et al. (1999a).

	Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
	Number			Density		Number			Number		
Year	Adults	Nests/ Broods[b]	Young	Adults	Nests/ Broods[b]	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
NESTING											
1993	34	8		0.16	0.04	69	20		34	0	
1995	21	6		0.10	0.03	20	3		4	0	
1996	22	5 (7)		0.11	0.02 (0.03)	41	18		5	2	
1997	30	7 (10)		0.15	0.03 (0.05)	59	20		2	1	
1998	17	7 (11)		0.08	0.03 (0.05)	47	9		3	0	
2000	32	9 (9)		0.15	0.04 (0.04)	67	10		9	0	
2001	28	10 (10)		0.14	0.05 (0.05)	36	9		0	0	
Mean	26.3	7.4 (8.7)		0.13	0.04 (0.04)						
BROOD-REARING											
1993	20	5	5	0.10	0.02	25	1	1	0	0	0
1995	31	6	6	0.15	0.03	83	21	26	30	5	5
1996	42	5	5	0.20	0.02	61	12	13	11	0	0
1997	38	3	4	0.18	0.01	103	12	13	15	4	4
1998	39	7	8	0.19	0.03	85	13	15	5	3	3
2000	8	0	0	0.04	0	41	2	2	3	2	3
2001	16	2	2	0.08	0.01	23	4	4	6	0	0
Mean	27.7	4.0	4.3	0.13	0.02						

[a] Densities and averages 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.

delta, Rothe et al. (1983) reported similar findings and suggested that Pacific and Red-throated loon densities on the Colville Delta were comparable to other areas on the Arctic Coastal Plain. Density estimates from sample plots in 1981 were 1.5 birds/km² for Pacific Loons and 0.6 birds/km² for Red-throated Loon (Rothe et al. 1983).

Within the CD North ground-search area, 11 Pacific and 6 Red-throated loon nests were found in 2001 during ground searches (Figure 6, Table 5). We assumed from the number and locations of Red-throated Loon broods found during the brood search that 3 additional Red-throated Loon nests were in the area, but not found initially (Figure 9, Table 5). Densities of birds (based on the number of nesting birds) and nests in the ground-search area was 1.2 birds/km² and 0.6 nests/km² for Pacific Loons and 1.0 birds/km² and 0.5 nests/km² for Red-throated Loons during 2001.

Brood-rearing

Production of Yellow-billed Loons was poor in 2001. Sixteen adult Yellow-billed Loons and 2 broods were seen during the brood-rearing aerial survey in the CD North study area in 2001 (Table 21). Poor production also occurred in 2000, when no broods and only 8 adults were seen on the aerial survey. During surveys in 1993 and 1995–1998, ≥20 loons and ≥3 broods were counted in the same area (Table 21, Appendix C11). The density of Yellow-billed Loons during brood-rearing was 0.08 birds/km² in 2001 and 0.04 birds/km² in 2000.

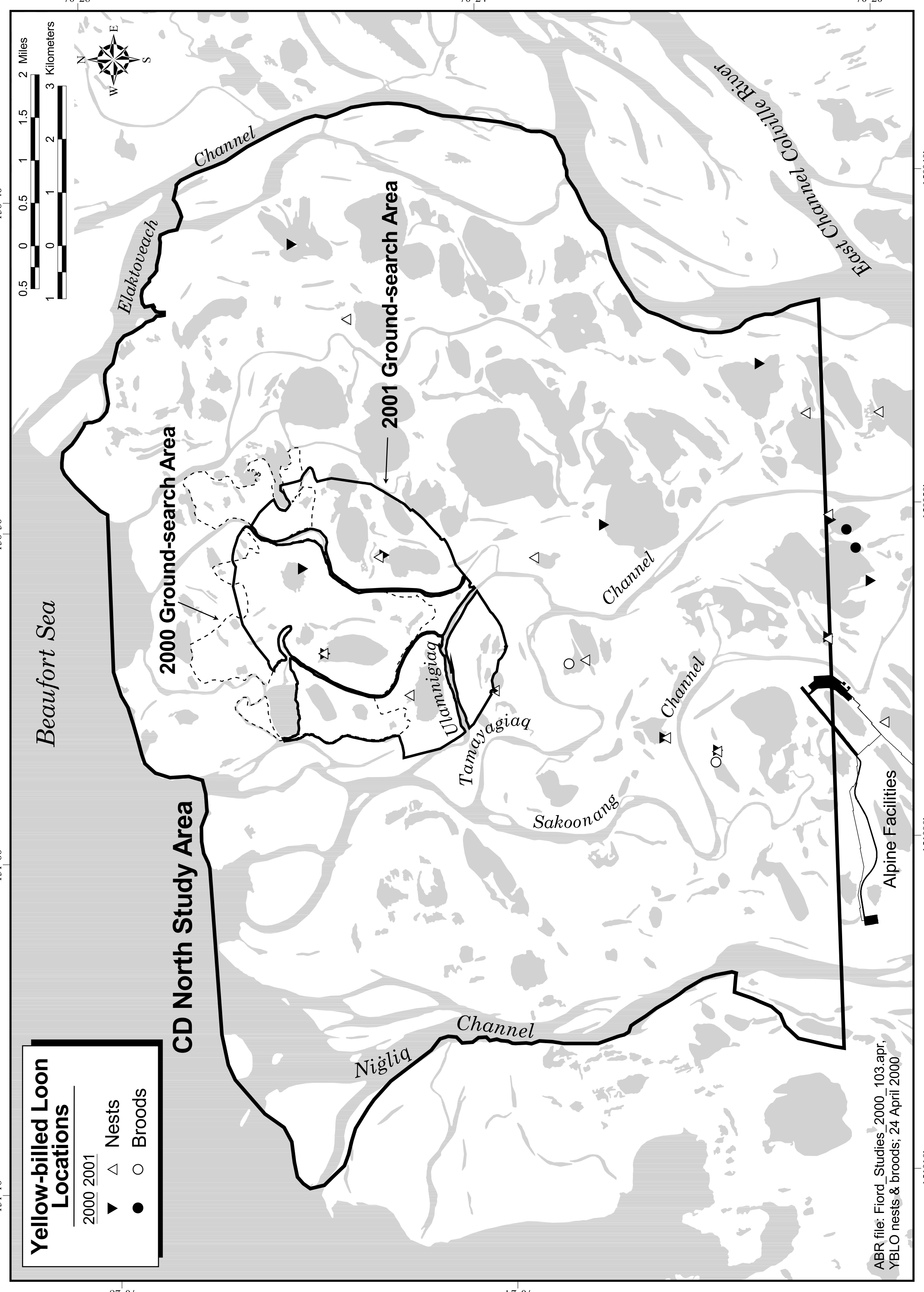


Figure 15. Distribution of Yellow-billed Loon nests and broods during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

In comparison, densities ranged from 0.10 to 0.20 birds/km² in 1993 and 1995–1998. North and Ryan (1988, 1989) found that adults with young remain on or near the nest lake during brood-rearing, while non-nesting and failed breeders maintain their territories throughout the summer. The aerial survey in 2001 was conducted at the same time as previous years, and the small number of loons seen may have resulted from pairs vacating their territories earlier than in previous years because of poor production. In 1993 and 1995–1998, between 3 and 7 Yellow-billed Loon broods were counted and densities ranged from 0.01 to 0.03 broods/km² (Table 21). The highest number of Yellow-billed Loon broods recorded in the CD North study area during 7 years of surveys was in 1998 when 7 broods and 8 young were counted.

Weather conditions may have caused Yellow-billed Loon production to be low in 2001 and to fail in 2000. Both years were characterized by a late thaw and cool spring temperatures (Figure 4), which may have delayed nest initiation and reduced nest success. In 2000 and 2001, fewer Pacific and Red-throated loons and their broods also were recorded in the CD North study area than during all previous years except 1993 (Table 21, Figure 16).

Within the CD North ground-search area, 7 Pacific and 5 Red-throated loon broods were seen in 2001 during the ground search (Figure 9). Brood density was 0.4 broods/km² for Pacific Loons and 0.3 broods/km² for Red-throated Loons. As mentioned above, these numbers underestimate the actual number of Pacific and Red-throated loons with broods. Both these loon species can rear their young on smaller waterbodies than Yellow-billed Loons; thus, because our aerial survey did not include all waterbodies, some broods were missed. Moreover, because our survey intensity for these smaller waterbodies varied among years and survey coverage was never complete, annual abundance cannot be compared or densities calculated for these 2 species (Appendix C12).

HABITAT USE

Nesting

In 2001, the habitat most frequently used for nesting (55% of all nests including 1 found during the ground search) by Yellow-billed Loons in the CD North study area was Wet Sedge–Willow Meadow (6 nests). The remaining 5 nests were found in both types of Deep Open Water (Table 22). Nests were built on peninsulas, shorelines, islands, or in emergent vegetation; the latter 2 types could be classified as part of a waterbody at the scale of our habitat map.

During 7 years of aerial surveys on the Colville Delta (1993, 1995–1998, and 2000–2001), 104 Yellow-billed Loon nests were found in 8 of 24 available habitats (Appendix D7). Sixty-three nests (61%) 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 D7). 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—that were unused and together occupied a large portion of the delta survey area (40%).

Because Yellow-billed Loons usually raise broods on the lakes where they nest, forage in lakes within their territories, and use lakes for escape habitat, waterbodies adjacent to nest sites are probably more important than the habitats on which the nests actually are built. Nests found in the CD North study area in 2000 and 2001 occurred most commonly near Deep Open Water without Islands (44 and 54% of all nests, respectively; Table 22). 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. Other ground-based studies of nesting Yellow-billed Loons on the Arctic Coastal Plain found nests occurring within 2 m of water (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989).

North (1986) found that similar waterbody types were used by nesting Yellow-billed Loons on

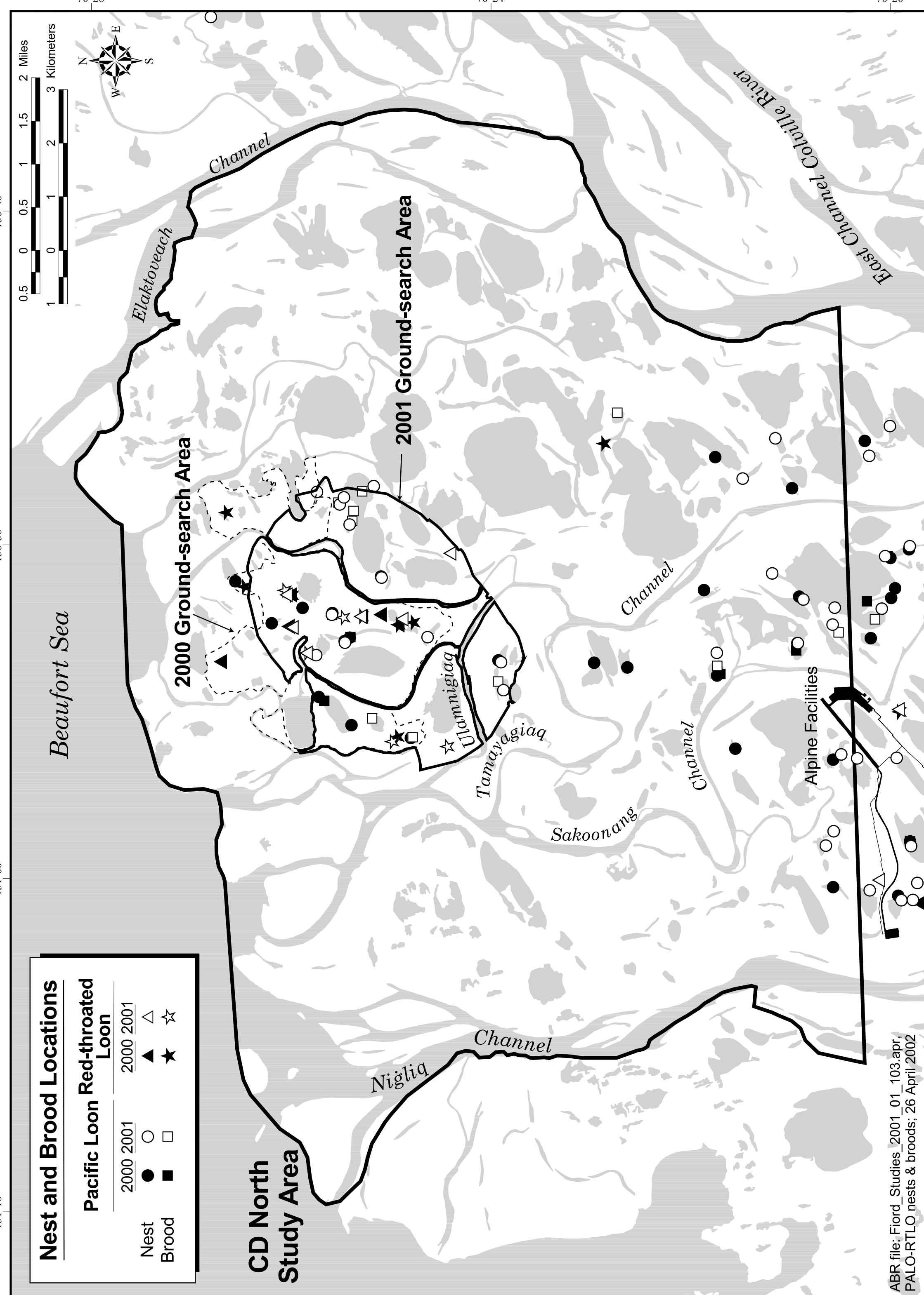


Figure 16. Distribution of Pacific and Red-throated loon nests and broods during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

Table 22. Habitat use by nesting Yellow-billed Loons in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

Habitat	2000 No. Nests	2000 Use (%)	2001 No. Nests	2001 Use (%)
HABITAT USED				
Tapped Lake w/ High-water Connection	1	11.1	0	0
Deep Open Water w/out Islands	2	22.2	2	18.2
Deep Open Water w/ Islands or Polygonized Margins	2	22.2	3	27.3
Nonpatterned Wet Meadow	1	11.1	0	0
Wet Sedge–Willow Meadow	3	33.3	6	54.5
TOTAL	9	100	11	100
NEAREST WATERBODY TYPE				
Tapped Lake w/ High-water Connection	2	22.2	0	0
Deep Open Water w/o Islands	4	44.4	6	54.5
Deep Open Water w/ Islands or Polygonized Margins	3	33.3	5	45.5
TOTAL	9	100	11	100

the Colville Delta in 1983 and 1984: 48% of 23 nests occurred on Deep-*Arctophila* lakes, 39% on Deep-Open lakes, and <1% on ponds <0.5 ha in size, ponds 0.5–1.0 ha, and shallow lakes >1.0 ha with emergent sedge or grass. Deep lakes, as described by North (1986), include the 2 Deep Open Water types and Tapped Lakes with High-water Connections that we have described. Although North and Ryan (1988) reported that Yellow-billed Loons did not nest on tapped lakes, they did not discriminate Tapped Lakes with High-water Connections, which may appear to be untapped because they commonly are connected to channels by low, vegetated areas that do not flood every year. The small waterbodies where North (1986) found nests probably correspond to our Aquatic Sedge with Deep Polygons, Shallow Open Water without Islands, and Aquatic Grass Marsh. Consistent with our observations, North (1986) found that nests on small waterbodies (<10 ha) always were near (<70 m) larger waterbodies.

Brood-rearing

In the CD North study area in 2001, 2 Yellow-billed Loon broods were found in 2 different habitats: Deep Open Water without Islands and Deep Open Water with Islands or Polygonized Margins. During aerial surveys in 1995–1998 and 2000, 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 (Appendix D7, Appendix C11). Deep Open Water without Islands was used by most broods (62% of total), 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. The concurrence of selection analyses for 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).

GLAUCOUS GULL

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 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 predaceous gulls have high nesting success, but the broods of these nests often are taken by gulls (Vermeer 1968, North and Ryan 1988b).

DISTRIBUTION AND ABUNDANCE

Eight Glaucous Gull nests were counted in the CD North study area during aerial surveys for Tundra Swans and Yellow-billed Loons in 2001 (Figure 17). An additional nest was found during ground surveys in the CD North ground-search area. Eight of the 9 nests were found in the northern part of the CD North study area and 3 of those nests were within the CD North ground-search area. The density of Glaucous Gull nests in the CD North study area in 2001 was 0.04 nests/km². Because Glaucous Gulls were being counted on aerial surveys designed to survey other species, some nests probably were missed.

In the CD North ground-search area, 10 Glaucous Gull nests were found in 2000 (0.8 nests/km²) and 3 nests were found in 2001 (0.2 nests/km²) (Table 5, Figures 7 and 17). Four of the 10 nests found in 2000 were in the same area that was searched in 2001 (Figure 7). Seventeen of the 19 Glaucous Gull nests found in both years were located on islands in Brackish Water, Deep Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons. No Glaucous Gull broods were seen during the aerial brood-rearing surveys; however, 1 brood of 2 young was seen in the ground-search area during a ground survey in late August 2001 (Figures 8, 9, and 17). In 2000, 6 broods were found in the ground-search area.

BRANT

BACKGROUND

The Colville Delta is an important staging area for migrating Brant in early spring (Simpson et al. 1982, Renken et al. 1983) and supports the largest concentration of nesting Brant on the Arctic Coastal Plain of Alaska (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983). Brant arrive on the delta during late May and early June, and nest initiation begins as soon as suitable nesting habitat is available (Kiera 1979, Rothe et al. 1983). Most Brant nests (>1,100; USFWS, unpubl. data) on the delta are located within a colony or group of colonies (hereafter, the Anachlik Colony-complex) consisting of 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). Brant began nesting at the Anachlik Colony-complex in the 1960s, nesting first on Anachlik Island, the site of the Helmericks' homestead, then expanding to Char, Brant, and Eskimo islands by the late 1970s–early 1980s (Martin and Nelson 1996). These 4 islands remain the core of the colony-complex, but Brant now nest in limited numbers on at least 5 other islands. Additional locations for small numbers of Brant nests are scattered across the delta, primarily in the northern half (Johnson et al. 1999a).

After eggs hatch in early July, most brood-rearing groups of Brant move from nesting areas to salt marshes along the coast. A large percentage (>50%; J. Helmericks, pers. comm.) of brood-rearing groups from the Anachlik Colony-complex moves northeast towards Oliktok and Milne points (Stickney et al. 1994, Anderson et al. 1997). Some remain on Anachlik Island, and others move to the area northwest of the East Channel (J. Helmericks, pers. comm.). Brant from the smaller colonies probably use salt marshes from the Elaktoveach Channel west to the Tingmeachsiovik River (Smith et al. 1994), outside of the CD North study area.

The fall migration of Brant along the arctic coast of Alaska usually begins in mid- to-late August (Johnson and Herter 1989), and major river deltas, such as the Colville Delta, provide important resting and feeding areas for Brant at that time (Johnson and Richardson 1981). These fall-staging Brant tend to use areas along the coast

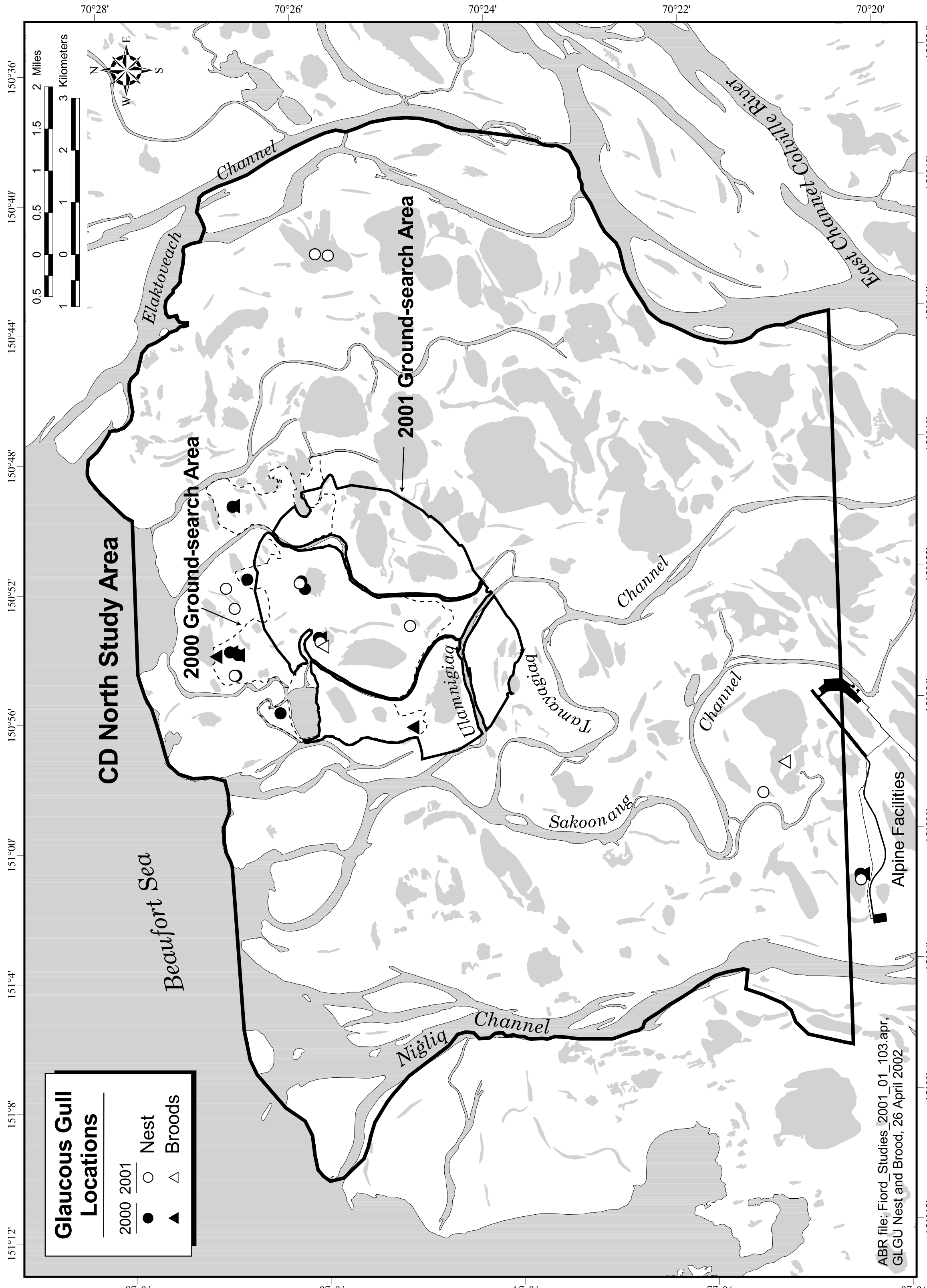


Figure 17. Distribution of Glaucous Gull nests and broods during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

that are similar, but not limited, to those used by brood-rearing groups (Smith et al. 1994).

DISTRIBUTION AND ABUNDANCE

Nesting

In 2001, 24 Brant nests were located in the CD North ground search area (17.9 km²), compared to 30 nests located in the 2000 CD North ground-search area (12.2 km²) (Figure 18, Table 5). Brant were the second most numerous species nesting in both years with densities of 1.3–2.5 nests/km². Nest success for Brant was low in both 2000 (10%) and 2001 (29%). In 1992, 1994, and 1997, ground searches were conducted for nesting eiders in portions of the CD North study area, but Brant nests were not recorded consistently.

Between 1992 and 1998, aerial surveys were conducted for nesting Brant that included the entire outer delta. During these surveys, ≥14 colonies (containing 2–18 nests) were recorded in the CD North study area that had 1–5 years of occupation, and 5 solitary nests with only 1 year of use also were found (Appendix C13). During the ground search for nests in 2001, 2 colonies with 4 and 16 nests each and 4 solitary nest locations were recorded. The largest colony in the ground-search area contained 20 nests in 2000 and up to ~10 nests during 1992–1998. The other colony found in 2001 (4 nests) contained a solitary nest in 2000 and a maximum of 2 nests during previous aerial surveys.

Brood-rearing

Data from both a multi-year banding study in the neighboring oilfields and our aerial surveys indicate that brood-rearing groups of Brant from the Colville Delta disperse as far east as the Kuparuk River delta (Anderson et al. 1996, Martin and Nelson 1996, Martin et al. 1997), and as far west as the Tingmeachsiovik River (Smith et al. 1994). The predominant pattern for most Brant is to rear their broods along the coast (Stickney and Ritchie 1996). In the CD North study area in 2001, 32 Brant were recorded in one group (20 adults and 12 goslings). The percentage of goslings was 38%, which was lower than that recorded in previous years (46–60% goslings).

The number of Brant observed in the CD North study area during brood-rearing in 2001 was well below average for the numbers recorded since surveys were started by USFWS in 1988 (mean = 285 birds, range = 35–934; Table 23) and the lowest ever recorded in this area. The distribution of Brant in this area was highly variable; in most years larger numbers of Brant were recorded between the East and Elaktoveach channels (Appendix C14). In both 2000 and 2001, a brood-rearing group was observed within the CD North ground-search areas.

Fall Staging

During fall-staging aerial surveys in 2001, 46 Brant were recorded in 2 locations in the CD North study area (Figure 19); group size ranged between 16 and 30 birds. The number of Brant recorded in 2001 was lower than in any previous year (1992–1993, 1995–1998, 2000), when 2–7 groups were observed with total numbers of Brant ranging from 64 to 314 (Appendix C15). Mean group size in previous years ranged between 21 and 70 birds.

HABITAT USE

Nesting

Detailed information was collected on the habitat occupied by 54 individual nests found on ground surveys in the CD North ground-search areas in 2000 and 2001 (Table 24). Over 90% of the nests were in aquatic habitats with 72% in Deep Open Water with Islands or Polygonized Margins. Nests were most often on islands (45 nests, 83%), polygon rims (6 nests, 11%), or along shorelines (3 nests, 6%). The largest colony (20 nests in 2000 and 16 in 2001) straddled a complex of different habitat types (Deep Open Water with Islands or Polygonized Margins and Aquatic Sedge with Deep Polygons). Brant nests averaged 13.9 m from permanent water with 45 nests located <1 m from permanent water, and the remaining 9 nests ranged from 5 to 265 m from permanent water.

A cumulative total of 23 Brant colonies (excluding the Anachlik colony-complex) and solitary locations have been compiled during nesting aerial surveys in 1992–1993 and 1995–1998 and during ground searches in both the Alpine (1995–2001) and CD North (2000–2001) study areas. Brant were found nesting in 9 of 21 available habitats, with Salt-killed Tundra and Aquatic Sedge with Deep Polygons being preferred in an analysis of habitat selection (Appendix D8).

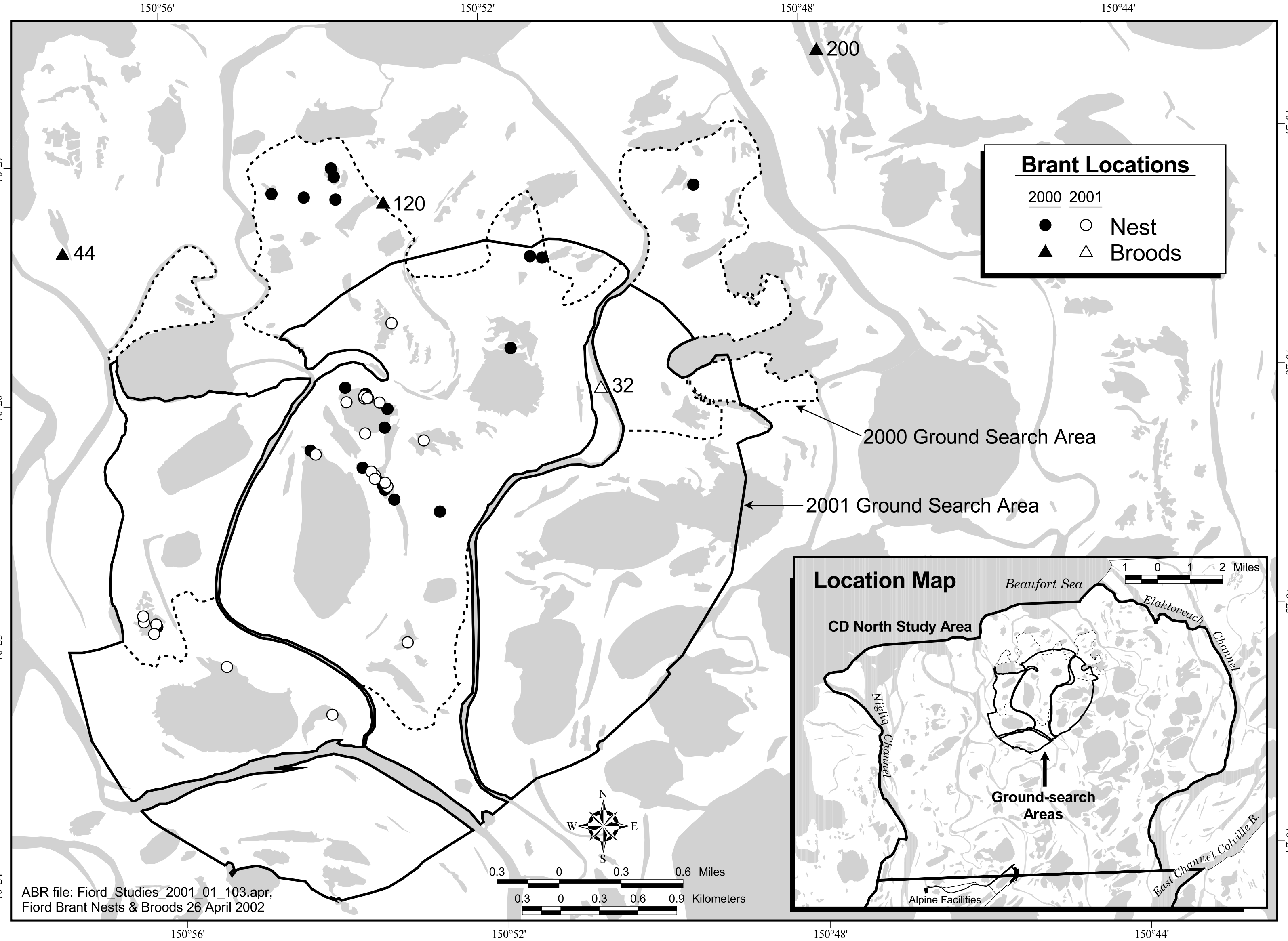


Figure 18. Distribution of Brant nests and brood-rearing groups during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000 and 2001. Total number of birds is listed for brood locations.

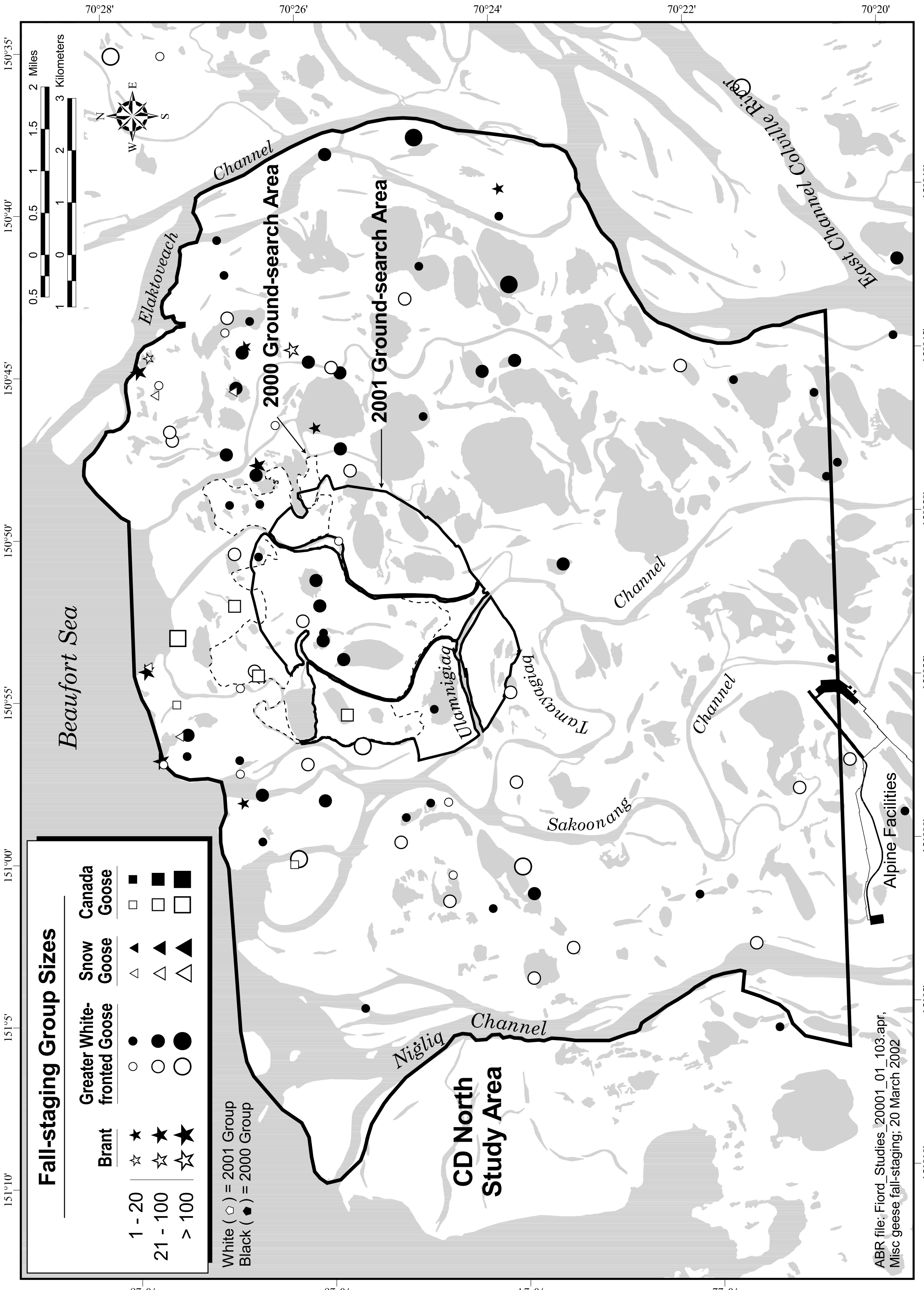


Figure 19. Distribution of fall-staging groups of Brant, Greater White-fronted, Snow, and Canada geese during aerial surveys in the CD North study area, Colville River Delta, Alaska, August 2000 and 2001.

Table 23. Abundance, distribution, and percentage of goslings in brood-rearing groups of Brant between the Elaktoveach and Nigliq channels on the Colville River Delta, Alaska, during late July–early August. Pre-1992 data are from Bayha et al. (1992); 1992–1998 data are from Johnson et al. (1999a).

Year	No. of Adults	No. of Groups	Goslings (%)
1988[a]	103	no data	no data
1990[a]	195	no data	no data
1991[a]	100	no data	no data
1992	35	1	0
1993	130	1	46
1995	305	2	46
1996	503	4	50
1997[b,c]	180	4	51
1998	934	8	60
2000[c]	364	3	59
2001[c]	32	1	38

[a] Counts were a mean of two surveys, except in 1991, when one survey was conducted between the Elaktoveach and Nigliq channels.
[b] Includes a group of 16 that was just outside the CD North study area in the Elaktoveach Channel.
[c] Data from the goose systematic brood-rearing survey, instead of the Brant coastal brood-rearing survey.

Table 24. Habitat use and nearest waterbody type of individual Brant nests in CD North ground-search areas, Colville River Delta, Alaska, 2000–2001.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Brackish Water	4	7.4
Salt-killed Tundra	1	1.9
Deep Open Water w/ Islands or Polygonized Margins	39	72.2
Shallow Open Water w/ Islands or Polygonized Margins	1	1.9
Aquatic Sedge w/ Deep Polygons	4	7.4
Aquatic Grass Marsh	1	1.9
Nonpatterned Wet Meadow	2	3.7
Wet Sedge–Willow Meadow	2	3.7
TOTAL	54	100
NEAREST WATERBODY TYPE[a]		
Brackish Water	6	11.1
Deep Open Water w/ Islands or Polygonized Margins	44	81.4
Shallow Open Water w/ Islands or Polygonized Margins	1	1.9
River or Stream	2	3.7
Aquatic Grass Marsh	1	1.9
TOTAL	54	100

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

The 2 habitats were occupied by 5 nests in the CD North ground search areas in 2000 and 2001 (Table 24) and contained, cumulatively, the most colonies and the most nests of all habitats in the CD North study area.

Brood-rearing

In the CD North study area during 2000 and 2001, 4 groups of brood-rearing Brant were seen in 4 different habitats: Salt Marsh, Salt-killed Tundra, River or Stream, and Barrens. All groups were within 0.05 km of water (Brackish Water and Shallow Open Water without Islands) and between 0.8 and 2.7 km from the coast. In previous years (1992, 1993, 1995, 1996, and 1998) during coastal brood-rearing surveys, 40 groups of Brant were seen in 10 different habitats, with salt-affected habitats receiving the greatest use (Appendix D8). During those years, Brackish Water was used by the most Brant brood groups (38%) and was the only preferred habitat on the delta. Brood-rearing groups frequently moved into nearby water when disturbed by our survey aircraft, so the high use of waterbodies probably was the result of some broods moving from adjacent foraging habitat (most likely Salt Marsh) as our aircraft approached. More than half of the brood-rearing groups were close to Brackish Water. The mean distance of brood-rearing groups to the nearest waterbody was 0.02 km.

OTHER GEESE

BACKGROUND

The Colville Delta is a regionally important nesting area for White-fronted Geese (Rothe et al. 1983). In the early 1980s, the USFWS recorded mean densities during June of 6.3 birds/km² and 1.8 nests/km² in scattered plots across the delta, and 6.6 nests/km² at one site on the western delta, which were among the highest densities recorded for these geese and their nests on the Arctic Coastal Plain of Alaska (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). More recently, we have recorded nest densities of 2.0–5.0 nests/km² on the delta in the Alpine project area (Johnson et. al. 2001).

In the early 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.). Today, 3 small colonies (26 to ≥400 nests) are known from the Sagavanirktok, Ikpikpuk, and Kukpowruk river deltas (Ritchie and Burgess 1993, Ritchie et al. 2002). In addition, small numbers of Snow Geese, and a few nests, have been recorded between the Kuparuk Oilfield and Kasegaluk Lagoon (King 1970; Ritchie and Burgess 1993; Ritchie and King 2002, ABR, unpubl. data). Currently in Alaska, large numbers of Snow Geese occur only during fall staging in the Arctic National Wildlife Refuge (Johnson and Herter 1989).

Several hundred Canada Geese nest along the banks and bluffs of the upper Colville River (Kessel and Cade 1958). Prior to 1996, Canada Geese were not reported nesting either on the Colville Delta or in NPRA, although local residents have observed Canada Geese nesting in the NPRA at least since the 1980s (J. Helmericks, pers. comm.). Canada Geese nest in scattered locations on the Arctic Coastal Plain east of the Colville River (Ritchie et al. 1991; ABR, unpubl. data) and commonly nest on islands in wetlands in the Prudhoe Bay area (Troy 1985, Murphy and Anderson 1993). A major molting area for these geese is located near Teshekpuk Lake, west of the Colville Delta (Derksen et al. 1979). Although the Colville Delta has not been identified as an important molting or brood-rearing area for Canada Geese, it is important during fall migration (Smith et al. 1994), when geese traveling along the Beaufort Sea coast stop and feed (Johnson and Richardson 1981, Garner and Reynolds 1986).

DISTRIBUTION AND ABUNDANCE

Nesting

During nest searches in 2000 and 2001, the nests of Greater White-fronted Geese accounted for almost half of the nests found in the ground search areas (120 and 177 nests, respectively; Figures 5 and 6, Table 5). The number of nests of these geese were several times greater than that of Brant, the second most numerous nesting species.

The densities of nests (9.9 nests/km² in 2001 and 9.8 nests/km² in 2000) were greater than densities found in the Alpine project area or the CD South ground-search areas (Table 8) and greater than any density previously reported for the delta (Simpson et al. 1982, Rothe et al. 1983, Johnson et al. 1999b, 2000). More than 60% of the nests found in the ground-search areas hatched each year.

No nests of Snow or Canada geese were found during our foot surveys in the CD North ground-search areas in either 2000 or 2001. However, in 1994, 2 Snow Goose nests were found during ground searches in this same area and additional nests were located on the outer delta either during ground surveys or aerial surveys in 1993, 1995, and 1997 (1 or 2 each year). All Snow Goose nests were <5 km from the coast. In 1997, a Canada Goose nest was found near the Nigliq Channel, which was the first record of Canada Geese nesting on the delta, and 2 nests were found just west of the delta in the NPRA during aerial surveys (Appendix C13) (Johnson et al. 1998). At one of these locations in the NPRA, 10 Canada Goose nests were counted in 1996 (Johnson et al. 1997). Since 1998, Canada Geese have been observed nesting in low numbers (1–2 nests) in the vicinity of the Alpine project area (Johnson et al. 2001).

Brood-rearing

In the CD North ground-search areas 11 groups of Greater White-fronted Geese with 25 adults and 41 young were counted in 2000 and 2 groups with 3 adults and 8 young were counted in 2001 (Figures 8 and 9, Table 9).

During the systematic aerial survey (50% coverage) of the CD North study area in 2001, 1,118 Greater White-fronted Geese were recorded in 23 groups (Figure 20, Table 25). Group sizes ranged from 6–170 birds (mean = 49) and goslings comprised 37% of the total number of geese (Table 25). The number of Greater White-fronted Geese seen in 2001 was lower than in 2000 (1,304 birds), 1998 (1,354 birds) and 1997 (1,224) and more than the number in 1996 (331) (Table 25, Appendix C16). In 1996–1998 and 2000, goslings comprised 35–58% of the birds seen during the systematic surveys. Prior to 1996, brood counts of Greater White-fronted Geese were collected opportunistically during aerial surveys conducted for Brant and eiders.

Small groups of Snow Geese have been seen in most years during brood-rearing surveys and most of these groups were located on the outer delta in the CD North study area. However, in 2001, no Snow Geese were observed during the brood-rearing survey. In previous years (1996–1998, and 2000), numbers of Snow Geese ranged between 6 and 72 birds during the systematic surveys (Appendix C16). Similar to 2001, no Snow Geese were recorded in the CD North study area during surveys in 1992 and 1993.

No Canada Geese were recorded during the brood-rearing aerial survey in 2001. There have only been 3 records of these geese on the delta during the brood-rearing/molting period. In 1998 and 2000, small brood-rearing groups were observed (24 and 22 birds, respectively) during the aerial survey (Appendix C16). The only other year when Canada Geese were seen on the delta was 1993, when 30 geese were seen during a ground-based survey in the CD North study area.

Fall Staging

During fall staging in 2001, large numbers of Greater White-fronted Geese, in groups that averaged 46 birds, were distributed throughout the CD North study area in a variety of aquatic and terrestrial habitats (Figure 19, Table 26). This also was the pattern of distribution in 1997, 1998 and 2000, but in 1996, the geese were concentrated around river channels and large lakes in fewer, but larger groups. On the systematic survey in 2001, 1,379 geese were counted, which was more than in 2000 (1,227 geese) and substantially greater than the counts in 1997–1998 (687–893 geese) (Table 26). In 1996, 765 Greater White-fronted Geese were recorded in the CD North study area, but the survey coverage was half that in subsequent years. Prior to 1996, we made observations opportunistically during surveys for focal species. Counts of fall-staging Greater White-fronted Geese seen on the delta during 1991, 1992, and 1995, were 213, 602, and 400 geese, respectively.

During the 2001 fall-staging survey, 4 groups of Snow Geese were recorded with a total of 50 birds (Figure 19). Small numbers (3 to 36 birds) of Snow Geese are recorded most years during the fall-staging season (Appendix C17), however, in

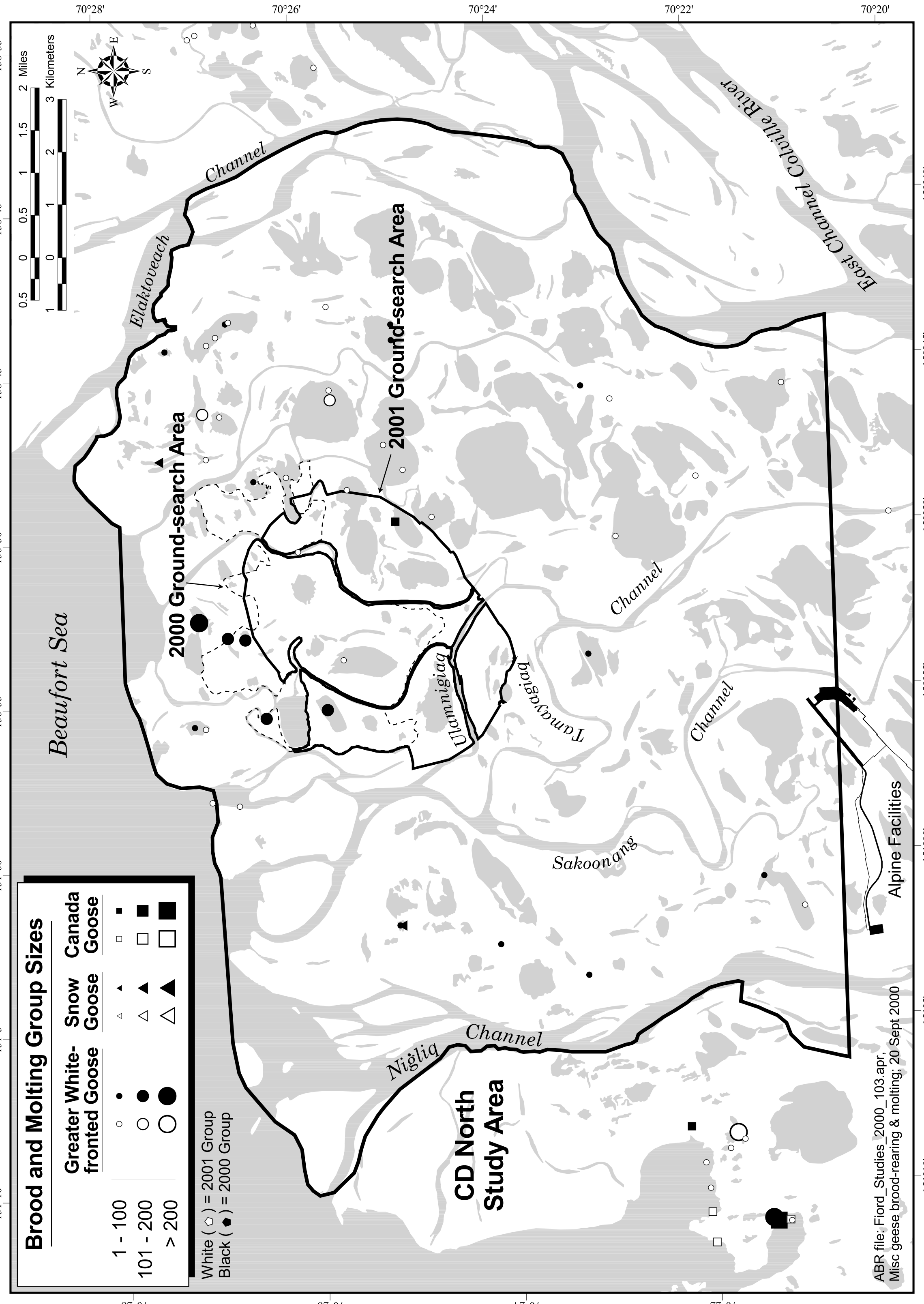


Figure 20. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese during aerial surveys in the CD North study area, Colville River Delta, Alaska, July 2000 and 2001.

Table 25. Numbers of Greater White-fronted Geese during brood-rearing aerial surveys in the CD North study area, Colville River Delta, Alaska, 1996–2001. Pre-2000 data are from Johnson et al. (1999a). In 1996, survey coverage was 25%; in all other years, coverage was 50%.

Year	No. of Birds	No. of Groups	Group size (Range)	No. of Goslings	% Groups w/ Goslings
1996	331	9	7–106	193	89
1997	1,224	22	9–225	424	77
1998	1,354	31	10–116	681	90
2000	1,304	17	14–360	664	88
2001	1,118	23	6–170	417	74

1998, no Snow Geese were seen. As during brood-rearing, all Snow Geese were seen on the outer delta during fall staging.

Canada Geese occurred in larger numbers during fall staging compared to brood-rearing and used coastal areas of the outer delta more than other areas on the delta (Figure 19). In 2001, 420 Canada Geese in 6 groups were observed in the CD North study area during the systematic survey for geese (Table 26). In 1996–1998, and 2000, 558–1,021 Canada Geese were counted, and the highest count was obtained in 1996 with half the survey coverage (25%) used in the other years. The greatest numbers of Canada Geese were recorded in 1992, when we counted ~4,600 Canada Geese in the CD North study area (Smith et al. 1993). During 1991, 1993, and 1995, the numbers counted incidental to other surveys were lower: 182–792 birds. Both brood-rearing and fall-staging counts of geese have been highly variable annually. Our data are insufficient to determine whether this annual variation in numbers is due to differences in survey timing and survey intensity, or is due to actual changes in abundance.

HABITAT USE

In 2000 and 2001, Greater White-fronted Geese in the CD North ground-search areas nested in almost all of the available habitats. Most nests were found in 2 habitats with polygonal surfaces: Wet Sedge–Willow Meadow (37% of all nests) and Aquatic Sedge with Deep Polygons (31%), which were the 2 preferred habitats (Table 27, Appendix D9). Nesting Greater White-fronted Geese significantly avoided 5 habitats in 2001, including Brackish Water, Tapped Lake with High-water Connection, both types of Deep Open Water, and Moist Sedge-Shrub Meadow, although all were used for nesting. Eighty-four percent of the Greater White-fronted Goose nests were on slightly elevated landforms—polygon rims, low ridges, or small hummocks—that were similar to the nesting sites reported for other areas of the delta (Simpson et al. 1982, Johnson et al. 2001). Nests ranged from <1 to 303 m (mean = 83.1 m, n = 298) from the nearest permanent waterbody.

Brood-rearing groups of White-fronted Geese recorded during the aerial surveys were generally distributed throughout the CD North study area in 2000 and 2001, and typically occurred in or near lakes: 70% of all groups were observed in Deep Open Water (both types), Brackish Water, and both types of Tapped Lakes (Table 28). All brood-rearing groups of Canada and Snow geese also were observed in lakes (Table 28).

During fall staging, Greater White-fronted Geese used habitats similar to those used during brood-rearing; 64% of all groups used water habitats (Table 28). Fall-staging Canada Geese used many of the same habitats, but were more likely (53% of all groups) to be found in terrestrial types (Table 28). Five groups of Snow Geese were seen, 3 were in water habitats (Open Nearshore Water, and Brackish Water); the remaining 2 groups were in Tide Flat and Moist Sedge–Shrub Meadow (Table 28).

FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes

Table 26. Numbers of Greater White-fronted Geese and Canada Geese during fall-staging aerial surveys in the CD North study area, Colville River Delta, Alaska, 1996–2001. Pre-2000 data are from Johnson et al. (1999a). In 1996, survey coverage was 25%; in all other years coverage was 50%.

	Greater White-fronted Goose				Canada Goose			
Year	No. of Birds	No. of Groups	Mean Group Size	Range	No. of Birds	No. of Groups	Mean Group Size	Range
1996	765	13	58.9	5–350	1021	8	127.6	10–500
1997	893	34	26.3	4–80	996	33	30.2	3–175
1998	687	22	31.2	6–150	678	20	33.9	6–75
2000	1,227	44	27.9	2–150	558	19	29.4	5–115
2001	1,379	30	46.0	2–150	420	6	70.0	20–150

are much more common on the coastal plain and 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 microtine rodents (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). Foxes are potent predators of nesting birds, and the growth of local populations from artificial food sources has led to concerns about the effects of foxes on avian populations (Day 1998, Burgess 2000).

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). The research of greatest relevance on the Colville Delta was that by Garrott (1980; also see Garrott et al. 1983a), who studied arctic foxes in the region in the late 1970s. We began recording information on fox dens on the Colville River Delta when baseline wildlife studies began there in 1992 (Smith et al. 1993). In 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 Delta and the western edge of the Kuparuk Oilfield (Appendix C18).

DISTRIBUTION AND ABUNDANCE

Number and Density of Dens

Twelve fox dens have been recorded in the CD North study area since 1992, including active and inactive sites of both species (Figure 21, Table 29). Ten (83%) of the dens were arctic fox sites in 2001. Two red fox dens were located near each other on an island in the Elaktoveach Channel (eastern portion of the study area; Figure 21), but their proximity indicates they are alternate sites

Table 27. Habitat selection (pooled among years) by Greater White-fronted Geese during nesting in the CD North ground-search areas, Colville River Delta, Alaska, 2000 and 2001.

Habitat	Total Area (km²)	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results
Open Nearshore Water (marine)	0	–	–	0	–
Brackish Water	1.26	1	0.3	4.2	avoid
Tapped Lake w/ Low-water Connection	0.30	0	0	1.0	ns
Tapped Lake w/ High-water Connection	0.87	1	0.3	2.9	ns
Salt Marsh	1.60	4	1.3	5.3	avoid
Tidal Flat	<0.01	0	0	<0.1	ns
Salt-killed Tundra	5.39	42	14.1	17.9	avoid
Deep Open Water w/o Islands	0.86	4	1.3	2.9	ns
Deep Open Water w/ Islands or Polygonized Margins	3.00	4	1.3	9.9	avoid
Shallow Open Water w/o Islands	0.06	0	0	0.2	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.22	4	1.3	0.7	ns
River or Stream	<0.01	0	0	<0.1	ns
Aquatic Sedge Marsh	0	–	–	0	–
Aquatic Sedge w/ Deep Polygons	3.93	93	31.3	13.0	prefer
Aquatic Grass Marsh	0.04	0	0	0.1	ns
Young Basin Wetland Complex	0	–	–	0	–
Old Basin Wetland Complex	0	–	–	0	–
Nonpatterned Wet Meadow	3.79	31	10.4	12.6	ns
Wet Sedge–Willow Meadow	6.62	111	37.4	22.0	prefer
Moist Sedge–Shrub Meadow	0.87	1	0.3	2.9	avoid
Moist Tussock Tundra	0	–	–	0	–
Riverine or Upland Shrub	0.22	1	0.3	0.7	ns
Barrens (riverine, eolian, lacustrine)	1.07	0	0	3.6	ns
Artificial (water, fill, peat road)	0	–	–	0	–
TOTAL	30.11	297	100	100	

used by a single denning pair (e.g., in 2000). The density of arctic fox dens active annually (3–8 dens; Table 30) ranged from 1 den/26 km² to 1 den/69 km², with a modal density (4 dens) of 1 den/52 km². The highest density of active dens occurred in 1996, a year of high microtine rodent populations when a large proportion of dens were occupied across the entire delta and adjacent coastal plain (Johnson et al. 1997). The annual density of active red fox dens cannot be calculated due to the absence of occupied sites in the CD North study area before 2000.

Despite intensive search effort, we have been unable to locate 4 dens on the northern Colville Delta reported to us by other researchers (M. North, unpubl. data; S. Earnst, pers. comm.); 2 of those sites were reportedly in the CD North study area. Therefore, those sites are not included in our density calculations. We suspect that additional dens may be present in the outermost portions of the delta that have not yet been searched thoroughly, primarily because of the abundance of arctic ground squirrel burrows in dune habitats there, which makes it difficult to distinguish fox dens.

In 9 years of surveys (1992, 1993, 1995–2001) and contacts with other observers, 75 fox dens have been located between the western

Table 28. Habitat use by brood-rearing/molting and fall-staging Greater White-fronted, Canada, and Snow geese in the CD North study area, Colville River Delta, Alaska, 2000 and 2001.

	Greater White-fronted Goose		Canada Goose		Snow Goose	
SEASON Habitat	No.	Use (%)	No.	Use (%)	No.	Use (%)
BROOD-REARING						
Brackish Water	7	17.5	0	0	1	50.0
Tapped Lake w/ Low-water Connection	7	17.5	1	100	0	0
Tapped Lake w/ High-water Connection	2	5.0	0	0	0	0
Salt Marsh	2	5.0	0	0	0	0
Salt-killed Tundra	2	5.0	0	0	0	0
Deep Open Water w/o Islands	6	15.0	0	0	1	50.0
Deep Open Water w/ Islands or Polygonized Margins	6	15.0	0	0	0	0
River or Stream	2	5.0	0	0	0	0
Aquatic Sedge with Deep Polygons	2	5.0	0	0	0	0
Nonpatterned Wet Meadow	1	2.5	0	0	0	0
Wet Sedge–Willow Meadow	1	2.5	0	0	0	0
Moist Tussock Tundra	1	2.5	0	0	0	0
Riparian or Upland Shrub	1	2.5	0	0	0	0
TOTAL	40	100	1	100	2	100
FALL STAGING						
Open Nearshore Water	0	0	2	11.8	1	20.0
Brackish Water	5	7.9	4	23.5	2	40.0
Tapped Lake w/ Low-water Connection	8	12.7	2	11.8	0	0
Tapped Lake w/ High-water Connection	3	4.8	0	0	0	0
Salt Marsh	4	6.3	1	5.9	0	0
Tide Flat	1	1.6	1	5.9	1	20.0
Salt-killed Tundra	6	9.5	1	5.9	0	0
Deep Open Water w/o Islands	6	9.5	0	0	0	0
Deep Open Water w/ Islands or Polygonized Margins	9	14.3	0	0	0	0
River or Stream	6	9.5	0	0	0	0
Aquatic Sedge with Deep Polygons	3	4.8	0	0	0	0
Nonpatterned Wet Meadow	3	4.8	1	5.9	0	0
Wet Sedge–Willow Meadow	3	4.8	1	5.9	0	0
Moist Sedge–Shrub Meadow	0	0	0	0	1	20.0
Barrens (riverine, eolian, lacustrine)	6	9.5	4	23.5	0	0
TOTAL	63	100	17	100	5	100

edge of the Colville Delta and the western edge of the Kuparuk Oilfield (most are depicted in 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.

The total density (active and inactive) of fox dens in the CD North study area (207 km²) was 1 den/17 km². Arctic fox den density was

Table 29. Annual status of arctic and red fox dens in the CD North study area during the 1993–2001 denning seasons, Colville River Delta, Alaska. Pre-2000 data are from Johnson et al. (2000b). Numbers in parentheses indicate the number of pups observed at active dens; zeroes indicate that dens were observed but no pups were seen; dashes indicate no data[a].

SPECIES Landform	1993 Status	1995 Status	1996 Status	1997 Status	1998 Status	1999 Status	2000 Status	2001 Status
ARCTIC FOX								
Old dune	Natal (5)	Inactive	Natal (6)	Inactive (0)	Natal (3)	Natal (8)	Inactive?	Inactive
Dune / lake bank	Natal (3)	Inactive	Natal (3)	Inactive? (0)	Inactive (0)	Inactive	Inactive	Inactive
Lake bank	Inactive	Inactive	Natal (4)	Natal? (0)	Natal? (0)	Inactive	Natal (3)	Natal (2)
Dune / lake bank	Inactive	Natal (–)	Natal (6)	Inactive (0)	Inactive	Inactive	Inactive?	Natal (3)
Dune / lake bank	Adults only	Secondary? (–)	Natal (5)	Natal (3)	Active (0)	Active (0)	Natal? (0)	Inactive
Dune ridge	–	Natal (3)	Natal (7)	Inactive? (0)	Natal (2)	Natal (0)	Natal (5)	Inactive
Dune / river bank	–	Secondary (3)	Natal (5)	Natal (4)	Natal (1)	Inactive	Inactive	Active (0)
Dune / lake bank	–	Inactive	Inactive	Not checked	Not checked	Inactive	Inactive	Inactive
Low dune ridge	–	–	Secondary (6)	Natal (5)	Inactive	Natal (2)	Natal (5)	Active (1?)
Large polygon rim	–	–	–	–	–	–	–	Inactive
RED FOX								
Sand dune[b]	–	–	–	–	Inactive	Inactive	Secondary (2)	Active (0)
Sand dune	–	–	–	–	–	–	Natal (0)	Inactive

[a] Natal dens are those at which young were whelped, with abundant adult and pup sign early in the current season; secondary dens are not used for whelping, but are used by litters moved from natal dens later in the season; active dens show evidence of consistent use, and are suspected to be natal or secondary dens, but pups were not seen; inactive dens either have no indication of use in the current season, or show limited use for resting or loafing by adults only.

[b] Arctic fox den until 2000.

Table 30. Occupancy status of arctic and red fox dens in the CD North study area, Colville River Delta, Alaska, 1993–2001. Pre-2000 data are from Johnson et al. (2000b).

SPECIES	1993		1995		1996		1997		1998		1999		2000		2001	
Status[a]	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ARCTIC FOX																
Natal	2	40	2	25	7	78	3	38	3	33	3	30	3	33	2	20
Secondary	0		1	13	1	11	0		0		0		0		0	
Active	1	20	1	13	0		1	13	2	22	1	10	1	11	2	20
Inactive	2	40	4	50	1	11	4	50	4	44	6	60	5	56	6	60
TOTAL	5		8		9		8		9		10		9		10	
RED FOX																
Natal	0		0		0		0		0		0		1	50	0	
Secondary	0		0		0		0		0		0		1	50	0	
Active	0		0		0		0		0		0		0		1	50
Inactive	0		0		0		0		0		0		0		1	50
TOTAL	0		0		0		0		0		0		2		2	

[a] natal dens are those at which young were whelped, with abundant adult and pup sign early in the current season; secondary dens are not used for whelping, but are used by litters moved from natal dens later in the season; active dens show evidence of consistent use, and are suspected to be natal or secondary dens, but pups were not seen; inactive dens either have no indication of use in the current season, or show limited use for resting or loafing by adults only

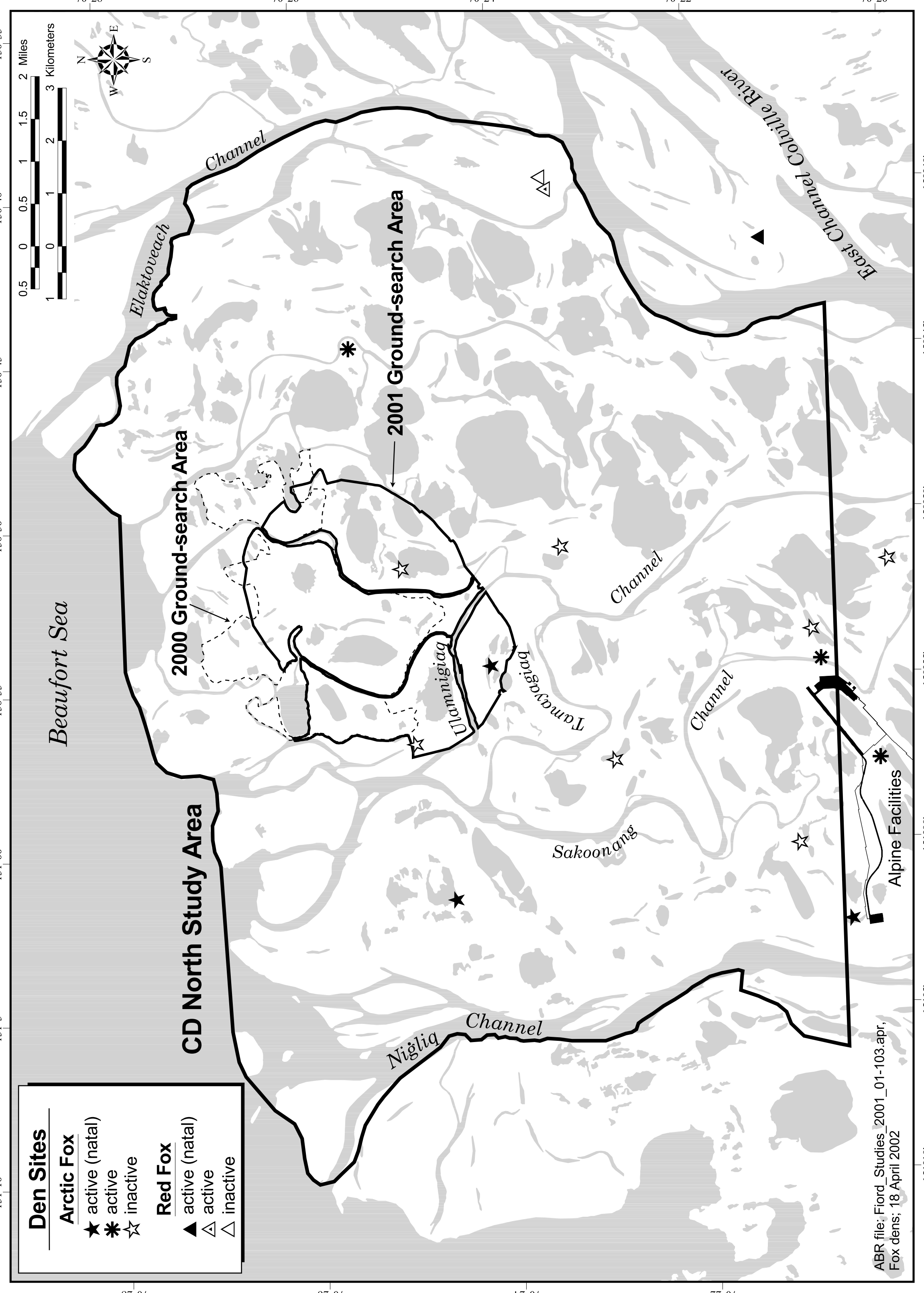


Figure 21. Distribution of arctic and red fox dens in the CD North study area, Colville River Delta, Alaska, 2001.

1 den/21 km² and red fox den density was 1 den/103 km², but because both red fox sites are used by the same pair, the effective density was 1 den/207 km². The density of red fox dens on the entire delta was 1 den/69 km²; comparative data are unavailable for this species from other arctic tundra areas. The density of arctic fox dens in the CD North study area is slightly higher than the density for the combined Colville Delta (551 km²) and Transportation Corridor (343 km²) survey areas, which was 1 den/26 km² (Johnson et al. 2002). The overall density also was higher than the 1 den/34 km² reported by Eberhardt et al. (1983) for their 1,700-km² Colville study area (which extended farther east–west than ours, but not as far inland). However, the overall density of arctic fox dens was lower than those reported for the 805-km² developed area of the Prudhoe Bay Oilfield (1 den/12–15 km²; Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues et al. 1994), but was near the range reported for undeveloped areas nearby the Prudhoe field (1 den/28–72 km²; Burgess et al. 1993, Rodrigues et al. 1994).

Den Occupancy and Production of Young

Based on brief visits at 9 of the 10 arctic fox dens in the study area and longer observations at 4 of those dens, we concluded that pups were present at a minimum of 2 dens (both natal sites) and suspected that pups may have been present at 2 other active dens (Table 29). Five arctic fox pups were counted at the 2 confirmed natal dens, for a mean litter size of 2.5 pups. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to reliably obtain complete counts.

An adult but no pups was observed at one of the red fox dens in the CD North study area; the status of either den as a natal site was unresolved. 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.

The estimated 40% den occupancy rate by arctic fox litters (natal and active categories combined) in the CD North study area in 2001 was at the low end of the range observed since 1993 (40–89% occupied; Table 30). Previously, the lowest occupancy rate observed for this species in the study area was 40% in 1999. In contrast, the 89% den occupancy rate in 1996 (when microtine rodent populations peaked) was the highest on record for the Colville area. Eberhardt et al. (1983) reported that in their Colville study area 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 the Prudhoe Bay Oilfield produced litters in 1992. 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). On Herschel Island in the northern Yukon, 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).

Pup production by arctic foxes in the CD North study area was low in 2001. The total count of 5 pups was below the annual mean total of 12.8 pups in the study area during 1993 and 1995–2001; the highest production observed was 42 pups in 1996. The mean litter size of 2.5 pups for arctic foxes in 2001 was at the low end of the range observed since 1993 (2.0–5.3 pups/litter). Den occupancy rate and litter sizes increase substantially in years when microtine rodents are abundant (Garrott 1980, Johnson et al. 1997, 1999a). In 1978, when small mammals were abundant on the Colville Delta, Garrott (1980) observed 7 litters (from a total of 23 active dens), which averaged 6.1 pups (range 2–8 pups/litter). In contrast, he observed only one litter the year before (from 2 active dens), when small mammals were scarce, and was unable to obtain a complete litter count. The number of pups produced and the mean litter size we recorded in 2001 suggested that prey populations were low to moderate in the study area.

HABITAT USE

In the CD North study area, the habitat type used most often for denning was Riverine or Upland Shrub (7 of 12 dens, or 58%); 4 other habitat types were used to a lesser extent—Barrens (1 den), Moist Sedge–Shrub Meadow (1 den), Wet Sedge–Willow Meadow (1 den), and Nonpatterned Wet Meadow (2 dens). In the CD North area, foxes tend to den in old dunes stabilized by vegetation, often those cut by lakes or river channels (Table 29). 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 delta (Appendix D10), updating the analysis by Johnson et al. (1999a). Sixteen dens (70% of the total) were located in Riverine or Upland Shrub, the only denning habitat that was preferred delta-wide. Dens in the 4 other habitats used actually were located in small patches of higher microrelief that were smaller than the minimal mapping size of habitat areas. Statistical analysis of habitat selection showed that the 3 most abundant terrestrial habitats on the delta—Tidal Flat, Barrens, and Wet Sedge–Willow Meadow—all were avoided by denning foxes (Appendix D10).

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have relatively deep seasonal thaw layers. Foxes locate dens on raised landforms with well-drained soil; typical locations on the Arctic Coastal Plain include ridges, dunes, lake and stream shorelines, pingos, and low mounds (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993). In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville Delta, the latter species dens almost exclusively in sand dunes. On the Colville Delta and adjacent coastal plain to the east, foxes den in sand dunes (mostly those stabilized by vegetation), banks of streams and lakes (including banks of drained-lake basins), ridges, and pingos (Table 29; 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 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.

LITERATURE CITED

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

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

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

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

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and A. M. Wildman. 2001. Avian studies in the Kuparuk Oilfield, 2000. Final report prepared for PHILLIPS Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks, AK. 88 pp.

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and A. M. Wildman. 2002. Avian studies in the Kuparuk Oilfield, 2001. Final report prepared for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks, AK. 77 pp.

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

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

Bellrose, F. C. 1976. Ducks, geese, and swans of North America. Second Edition. Stackpole Books, Harrisburg, PA. 540 pp.

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

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

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

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

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

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, A. A. Stickney, and J. R. Rose. 2000. Wildlife studies in the CD South study area, 2000. Final report prepared for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks. 84 pp.

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

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

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

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

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

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

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

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

Day, R. H., R. J. Ritchie, and D. A. Flint. 1995. Spectacled and Steller's eider surveys at remote Air Force sites in Alaska, 1994. Unpubl. report prepared for EA Engineering, Science, and Technology, Redmond, WA, and the U.S. Air Force, Elmendorf Air Force base, AK, by ABR, Inc., Fairbanks, AK. 66 pp.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. Neville, J. P. Parrett, A. K. Pritchard, J. R. Rose, A. A. Stickney, and A. M Wildman. 2002. Alpine Avian Monitoring Program, 2001. Fourth annual and synthesis reports prepared for ConocoPhillips Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2000a. Wildlife studies in the CD North study area, 2000. Final report prepared for PHILLIPS Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 96 pp.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Larned, W., R. Stehn, J. Fischer, and R. Platte. 2001. Eider breeding population survey, Arctic Coastal Plain, Alaska, 2001. Unpub. rep., by U. S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK. 21 pp. + figures.

Larson. S. 1960. On the influence of the Arctic Fox *Alopex lagopus* on the distribution of Arctic birds. Oikos 11:276-305.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

North, M. R. and M. R. Ryan. 1988b. Yellow-billed Loons, *Gavia adamsii*, nest successfully near Glaucous Gull, *Larus hyperboreus*, nests. Can. Field-Nat. 102(1):69-70.

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

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

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

Pennycuick, C. J., and D. Western. 1972. An investigation of some sources of bias in aerial transect sampling of large mammal populations. East African Wildlife Journal 10: 175–191.

Petersen, M. R., J. B. Grand, and C. P. Dau. 2000. Spectacled eider (*Somateria fischeri*). *In* A. Poole and F. Gill, eds. The Birds of North America, No. 547. The Birds of North America, Inc., Philadelphia, PA.

PHILLIPS Alaska, Inc. and Anadarko Petroleum Corp. 2002. Colville River Unit satellite development environmental evaluation document. Unpublished report prepared for U.S. Army Corps of Engineers, Anchorage, Alaska by PHILLIPS Alaska, Inc. and Anadarko Petroleum Corporation.

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

Quackenbush, L., R. Suydam, K. M. Fluetsch, and C. L. Donaldson. 1995. Breeding biology of Steller's Eiders nesting near Barrow, Alaska, 1991–1996. Unpubl. draft report prepared by USFWS, Fairbanks, AK. 53 pp.

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

Richardson, W. J. and S. R. Johnson. 1981. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea: 1. Timing, routes, and numbers in spring. Arctic 34:108-121.

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

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

Ritchie, R. J., P. Lovely, M. J. Knoche. 2002. Aerial surveys for nesting and brood-reading Brant and Snow Geese, Barrow to Fish Creek Delta and Snow Goose banding near the Ikpikpuk River Delta, Alaska, 2001. Final Report. ABR, Inc., Fairbanks, Alaska North Slope Borough, Department of Wildlife Management, Barrow, AK. 31 pp.

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

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

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

Sage, B. L. 1974. Ecological distribution of birds in the Atigun and Sagavanirktok River valleys, arctic Alaska. Can. Field-Nat. 88:281-291.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

USFWS. 1996. Spectacled Eider recovery plan. Anchorage, AK. 157 pp.

USFWS. 1998. Steller's Eider Recovery Plan. Draft report. Ecological Services, Fairbanks, AK.

Vermeer, K. 1968. Some aspects of ducks nesting in high densities among larids. Wilson Bull. 80:78-83.

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

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

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

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

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

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

Appendix A. Common and scientific names of birds and mammals seen during wildlife surveys on the Colville River Delta, 1992–2001 (Johnson et al. 2000 and this study).

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*	Ruff	*Philomachus pugnax*
Greater Scaup	*Aythya marila*	Long-billed Dowitcher	*Limnodromus scolopaceus*
Lesser Scaup	*Aythya affinis*	Common Snipe	*Gallinago gallinago*
Steller's Eider	*Polysticta stelleri*	Red-necked Phalarope	*Phalaropus lobatus*
Spectacled Eider	*Somateria fischeri*	Red Phalarope	*Phalaropus fulicarius*
King Eider	*Somateria spectabilis*	Pomarine Jaeger	*Stercorarius pomarinus*
Common Eider	*Somateria mollissima*	Parasitic Jaeger	*Stercorarius parasiticus*
Surf Scoter	*Melanitta perspicillata*	Long-tailed Jaeger	*Stercorarius longicaudus*
White-winged Scoter	*Melanitta fusca*	Ring-billed Gull	*Larus delawarensis*
Black Scoter	*Melanitta nigra*	Glaucous Gull	*Larus hyperboreus*
Long-tailed Duck	*Clangula hyemalis*	Sabine's Gull	*Xema sabini*
Red-breasted Merganser	*Mergus serrator*	Arctic Tern	*Sterna paradisaea*
Bald Eagle	*Haliaeetus leucocephalus*	Snowy Owl	*Nyctea scandiaca*
Northern Harrier	*Circus cyaneus*	Short-eared Owl	*Asio flammeus*
Rough-legged Hawk	*Buteo lagopus*	Common Raven	*Corvus corax*
Golden Eagle	*Aquila chrysaetos*	Horned Lark	*Eremophila alpestris*
Merlin	*Falco columbarius*	American Robin	*Turdus migratorius*
Gyrfalcon	*Falco rusticolus*	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*	Polar Bear	*Ursus maritimus*
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	*Ovibus moschatus*
Grizzly Bear	*Ursus arctos*		

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 brackis 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.

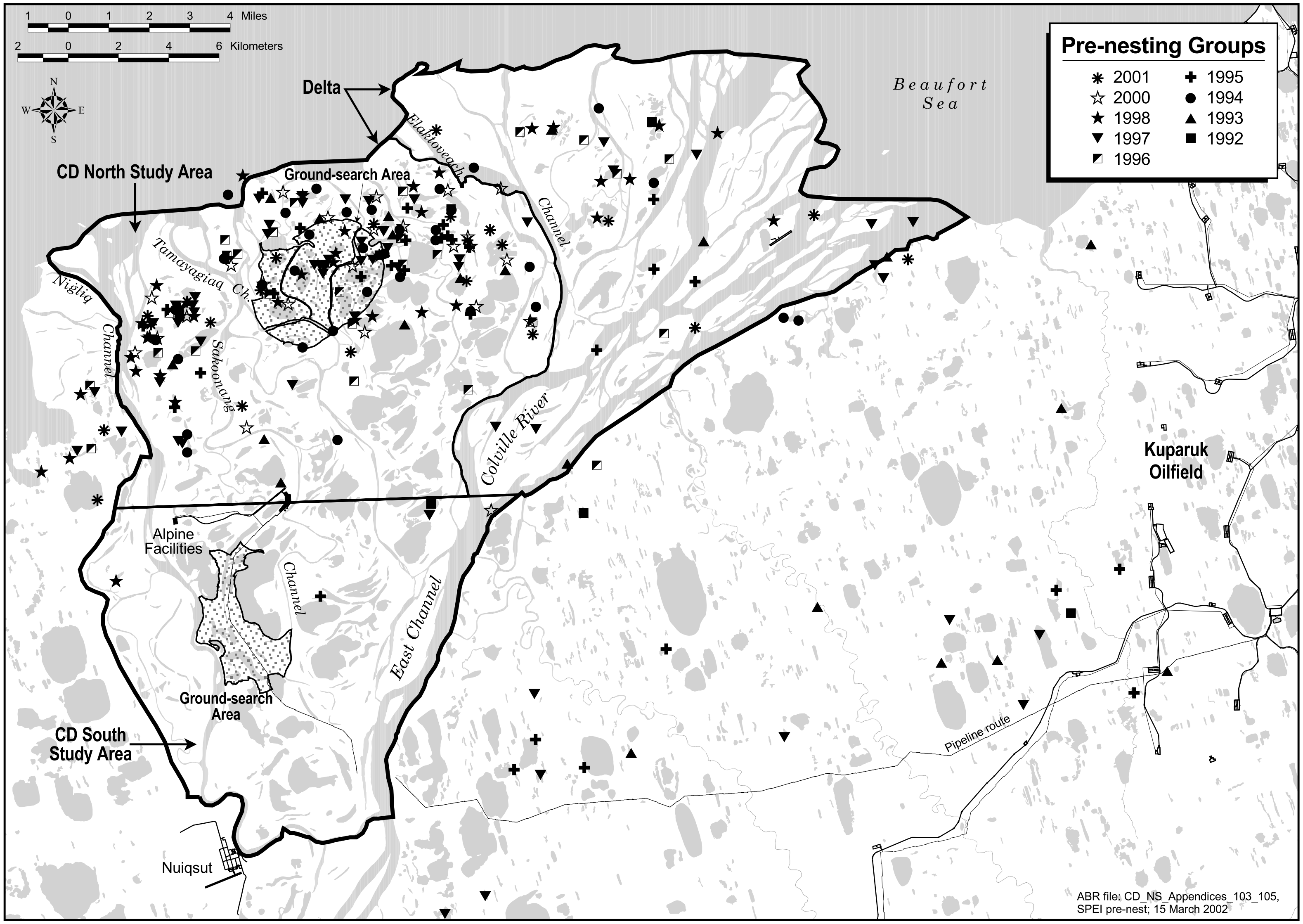
Appendix B1. (Continued)

Habitat	Description
Old Basin Wetland Complex (ice-rich)	Similar to preceding type, but characterized by well-developed low- and high-center polygons resulting from ice-wedge development and aggradation of segregated ice. The waterbodies in old complexes have smoother, more rectangular shorelines and are not as interconnected as in young complexes. The vegetation types generally include Wet Sedge Willow Meadow, Moist Sedge–Shrub Meadow, and Moist Tussock Tundra. Aquatic Sedge and Grass Marshes are absent. Soils generally have a moderately thick (0.2–0.5 m) organic layer overlying fine-grained silt or sandy silt.
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strangmoor cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. The uninterrupted movement of water and dissolved nutrients in nonpatterned ground results in more robust growth of sedges than in polygonized habitats. *Carex aquatilis* and *Eriophorum angustifolium* usually dominate, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata, S. arctica,* and *S. planifolia*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying fine-grained silt.
Wet Sedge–Willow Meadow	Occurs in lowland areas within drained lake basins, level floodplains, and swales on gentle slopes and terraces, associated with low-centered polygons and strangmoor (undulating raised sod ridges). Water depth varies through the season (<0.3 m maximum). Polygon rims and strangmoor interrupt surface and groundwater flow, so only interconnected polygon troughs receive downslope flow and dissolved nutrients; in contrast, the input of water to polygon centers is limited to precipitation. As a result, vegetation growth typically is more robust in polygon troughs than in centers. Vegetation is dominated by the sedges, *Carex aquatilis* and *Eriophorum angustifolium,* although other sedges may be present, including *C. rotundata, C. saxatilis, C. membranacea, C. chordorriza,* and *E. russeolum*. Willows (S*alix lanata*, *S. arctica,* and *S. planifolia)* usually are abundant.
Moist Sedge–Shrub Meadow (low- or high-relief polygons)	Occurs on better-drained uplands between thaw basins, riverbanks, old stabilized dunes, lower slopes of pingos, and foothill slopes, generally associated with nonpatterned ground, frost scars, and high-centered polygons with low relief. Vegetation is dominated by *C. aquatilis, C. bigelowii, E. angustifolium, S. planifolia,* and *Dryas integrifolia*. The ground is covered with a nearly continuous carpet of mosses. Soils generally have a thin layer (20–30 cm) of organic matter over silt loam.
Moist Tussock Tundra	Similar to preceding type, except that the vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum*. This type tends to occur on the upper portions of slopes and in better drained conditions than Moist Sedge–Shrub Tundra.
Riverine or Upland Shrub	Both open and closed stands of low (≤1.5 m high) and tall (>1.5 m high) willows along riverbanks and *Dryas* tundra on upland ridges and stabilized sand dunes. Tall willows occur mainly along larger streams and rivers, where the vegetation is dominated by *Salix alaxensis*. Low willow stands are widespread and typically have a canopy of *S. lanata* and *S. glauca*. Understory plants include the shrubs *Arctostaphylos rubra, S. reticulata,* and *D. integrifolia,* and the forbs *Astragalus* spp., *Lupinus arcticus*, and *Equisetum* spp. *Dryas* tundra is dominated by *D. integrifolia* but may include abundant dwarf willows such as *S. phlebophylla*. Common forbs include *Silene acaulis, Pedicularis lanata,* and *Astragalus umbellatus,* and *C. bigelowii* frequently is present. In Riverine Shrub, an organic horizon generally is absent or buried due to frequent sediment deposition. In Upland Shrub, soils generally have a thin (<5 cm) organic horizon.

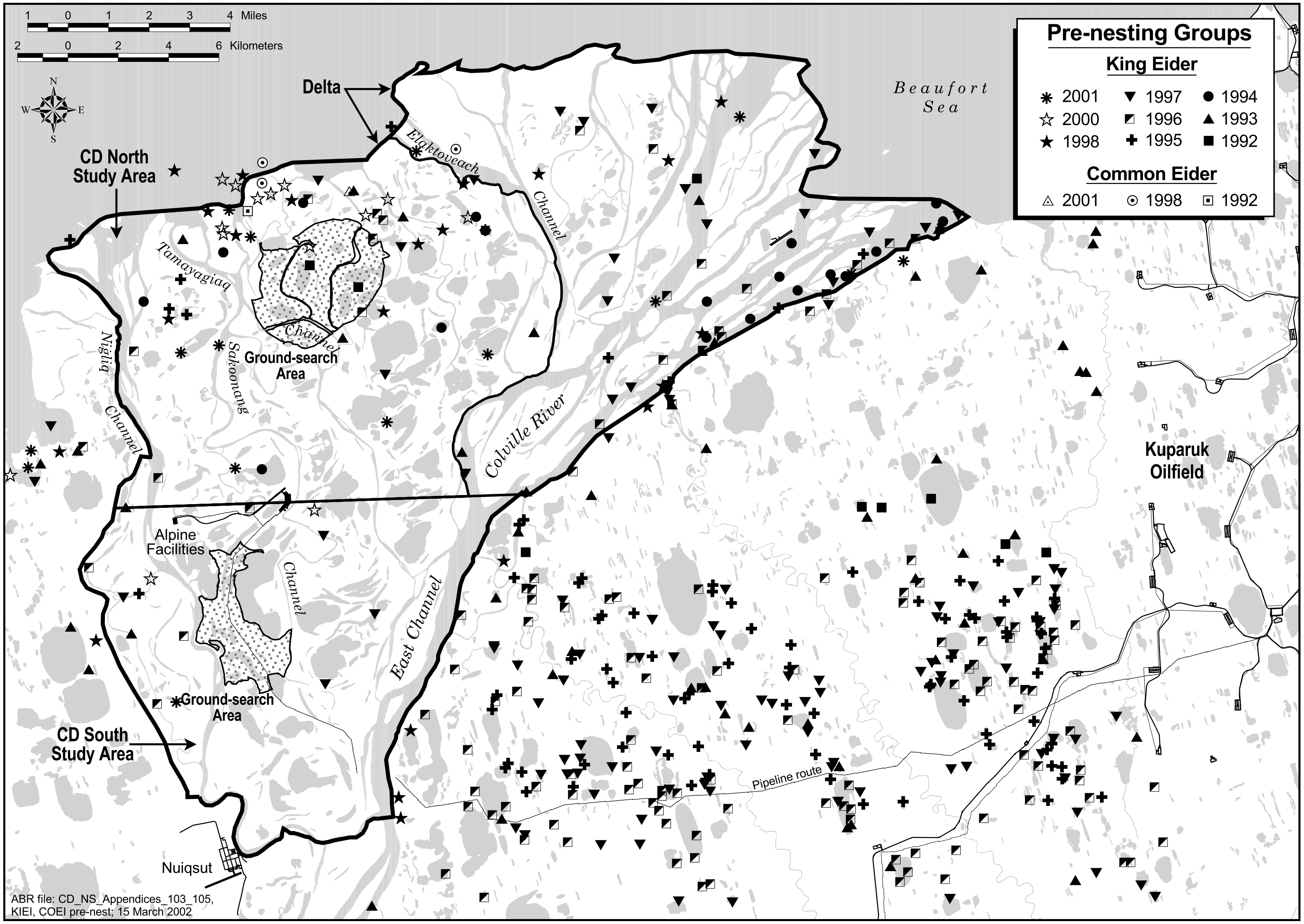
Appendix B1. (Continued)

Habitat	Description
Barrens (riverine, eolian, or lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas resulting from riverine, eolian, or thaw-lake processes. Riverine Barrens on river flats and bars are flooded seasonally and can have either silty or gravelly sediments. The margins frequently are colonized by *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum,* and *Equisetum arvense*. Eolian Barrens generally are located adjacent to river deltas and include active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical pioneer plants include *Salix alaxensis, Elymus arenarius,* and *Deschamspia caespitosa.* Lacustrine Barrens occur along margins of drained lakes and ponds. These areas may be flooded seasonally or can be well drained. On the delta, sediments usually are clay-rich, slightly saline, and are being colonized by salt-marsh plant species. Barrens may receive intensive use seasonally by caribou as insect-relief habitat.
Artificial (water, fill, peat road)	A variety of small disturbed areas, including impoundments, gravel fill, and a sewage lagoon at Nuiqsut. Gravel fill is present at Nuiqsut, and at the Helmericks residence near the mouth of the Colville River. A peat road runs roughly north-south within the Transportation Corridor. Two Kuparuk drill sites (2M and 2K) are included, as are several old exploratory drilling pads.

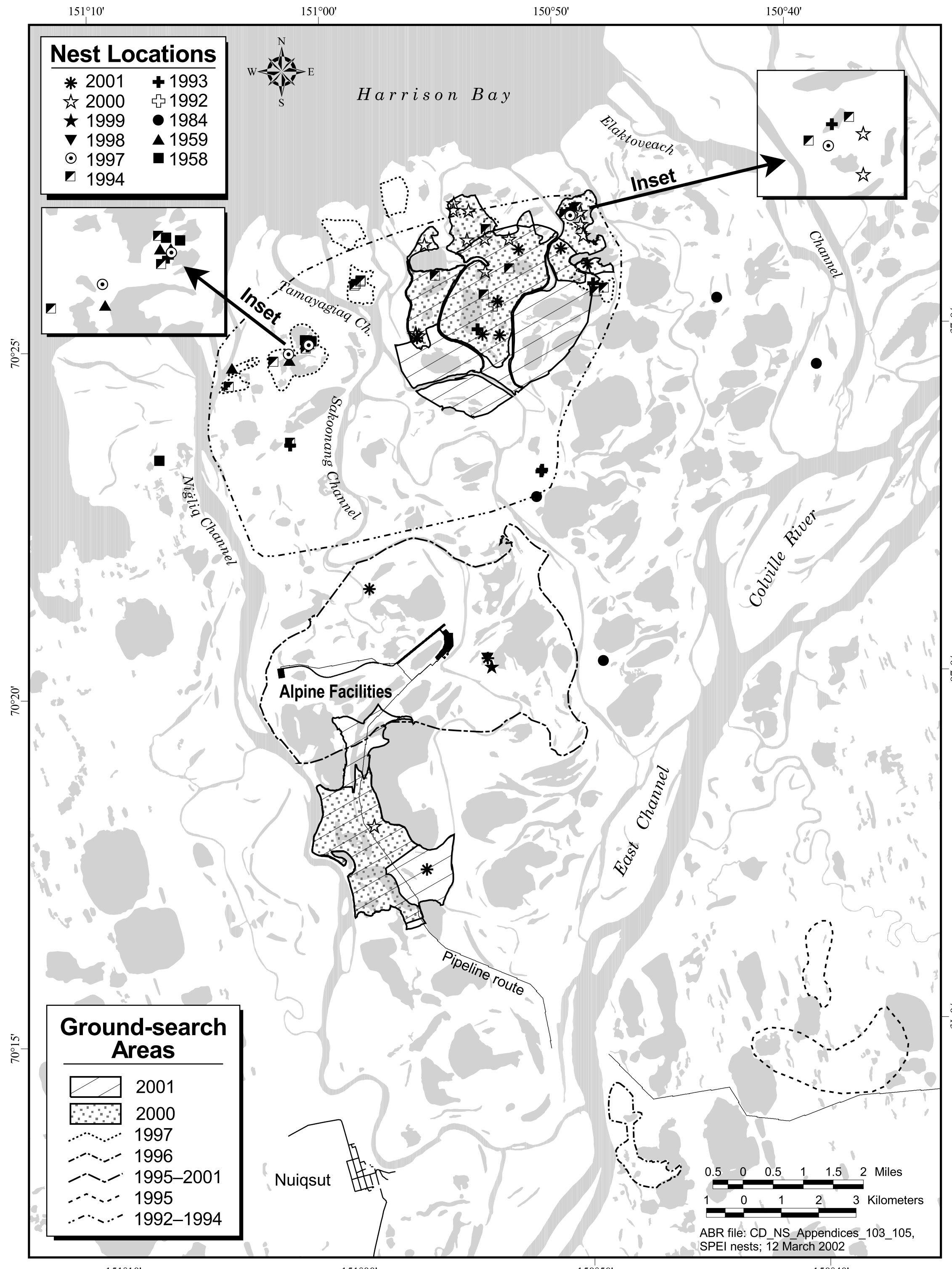
This page intentionally left blank



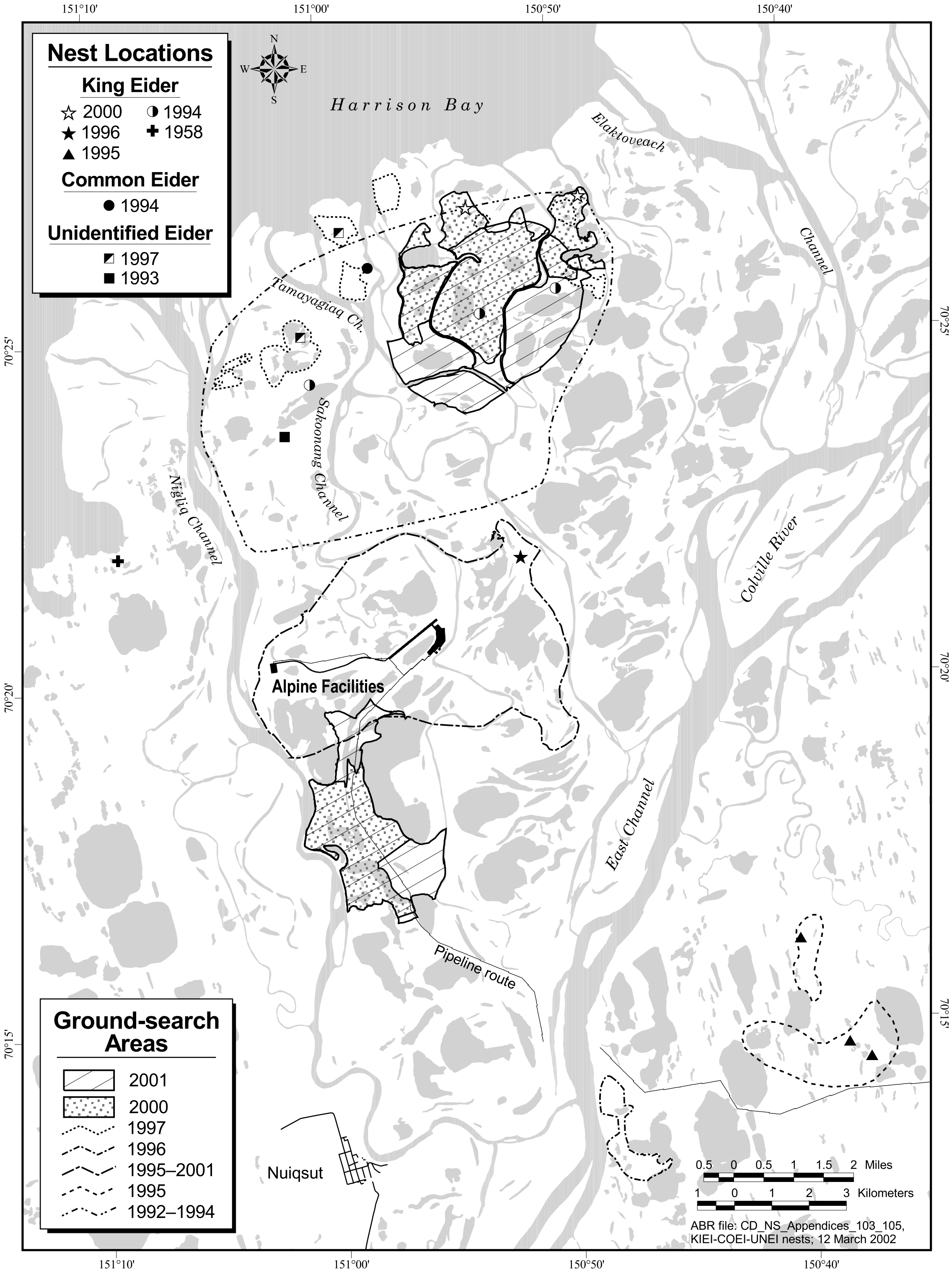
Appendix C1. Distribution of Spectacled Eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).



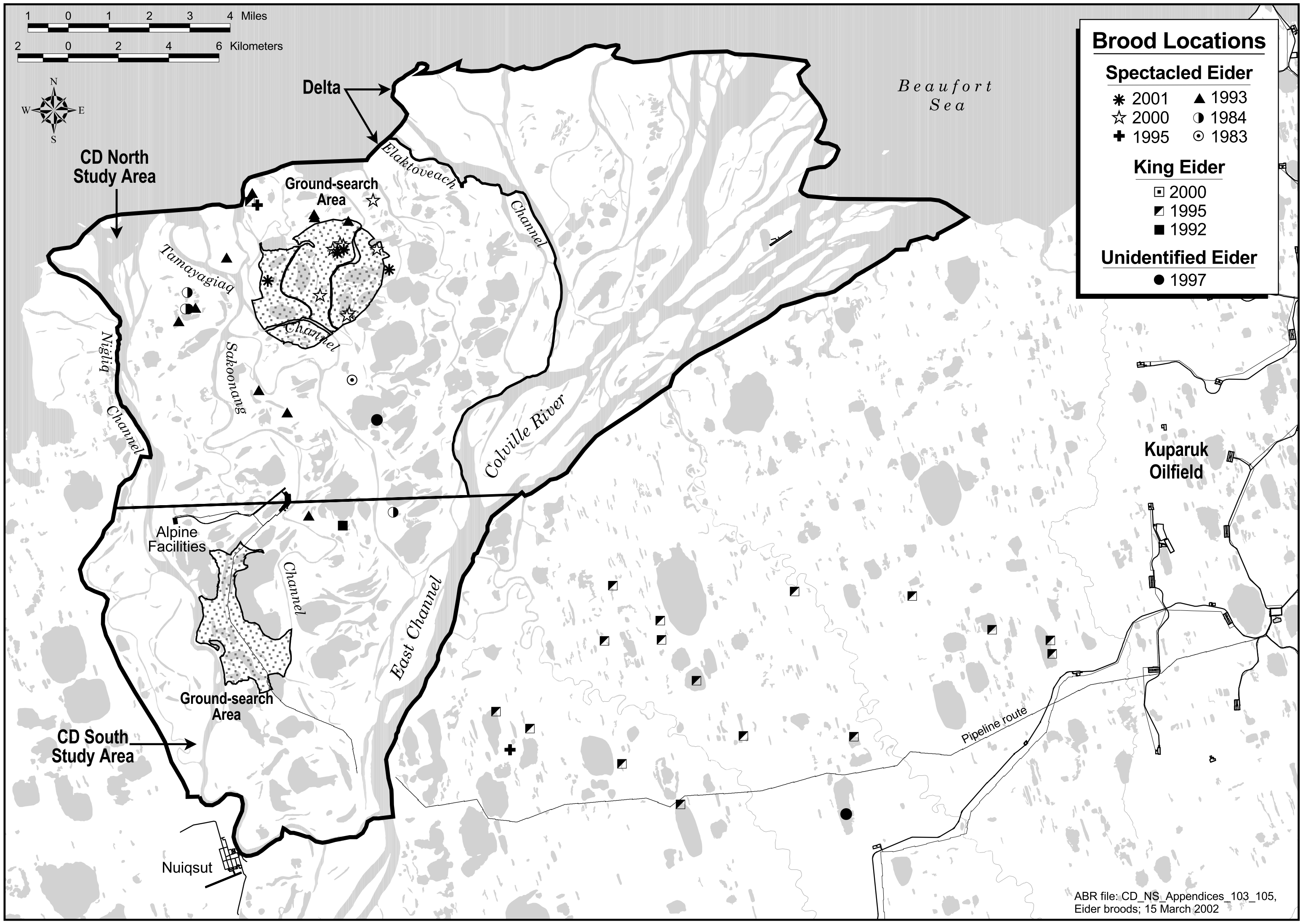
Appendix C2. Distribution of King and Common eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).



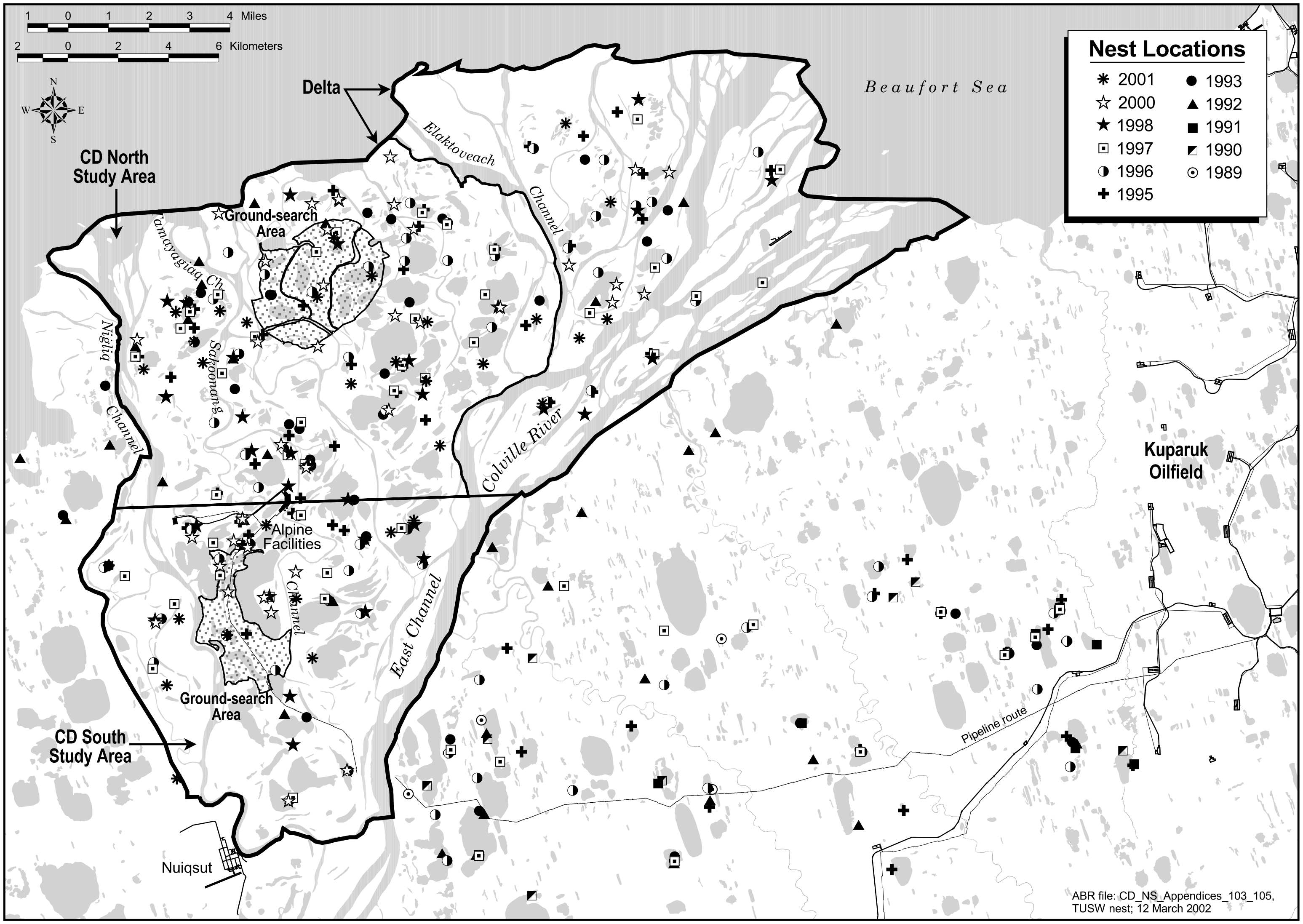
Appendix C3. Distribution of Spectacled Eider nests in ground search areas on the Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–2001. Pre-2000 data are from T. Myres (1958, 1959, unpubl. data), M. North (1984, unpubl. data), and Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



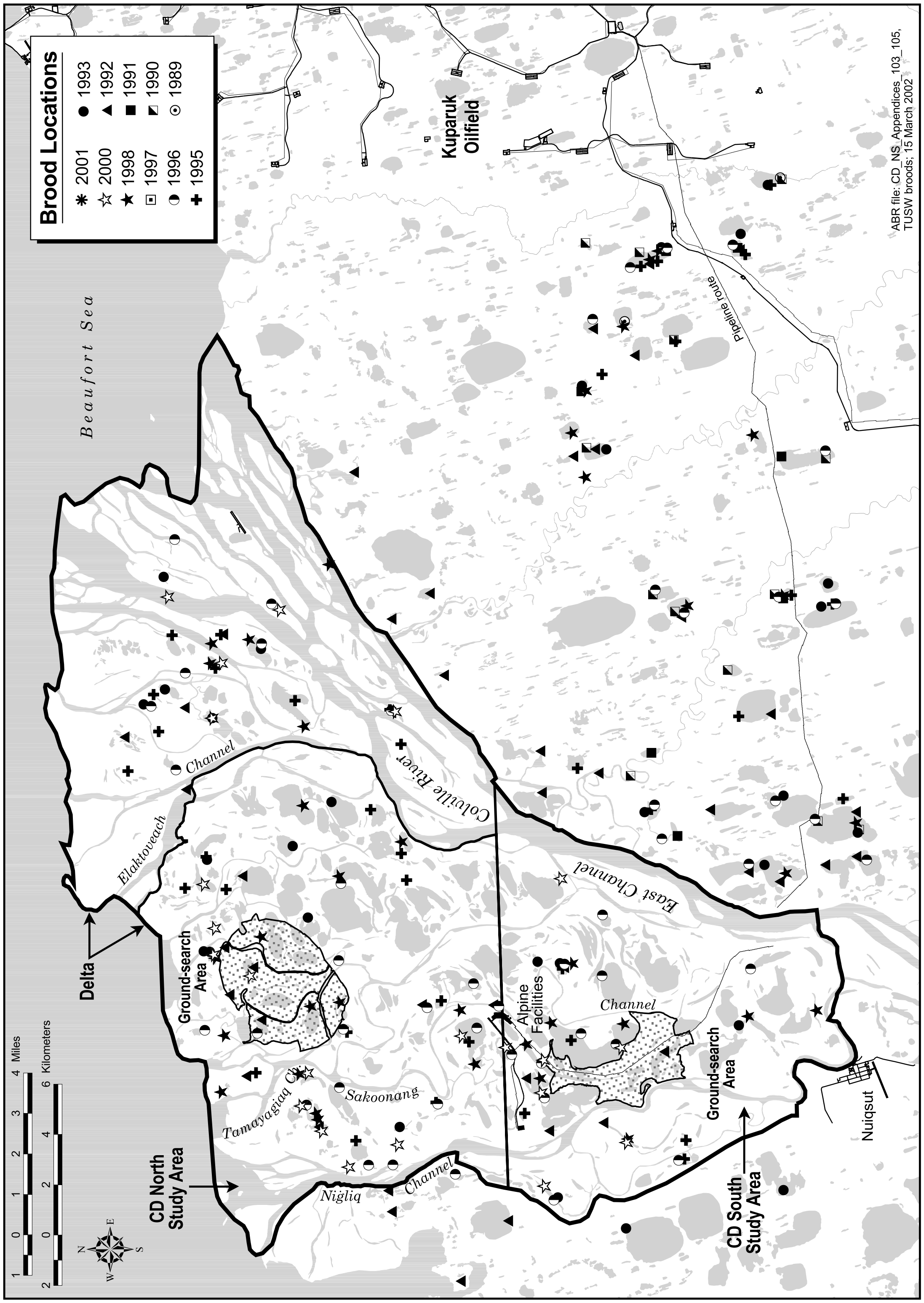
Appendix C4. Distribution of King, Common, and unidentified eider nests in ground search areas on the Colville River Delta, Alaska, 1958, and 1992–2001. Pre-2000 data are from T. Myres (1958, unpubl. data), Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



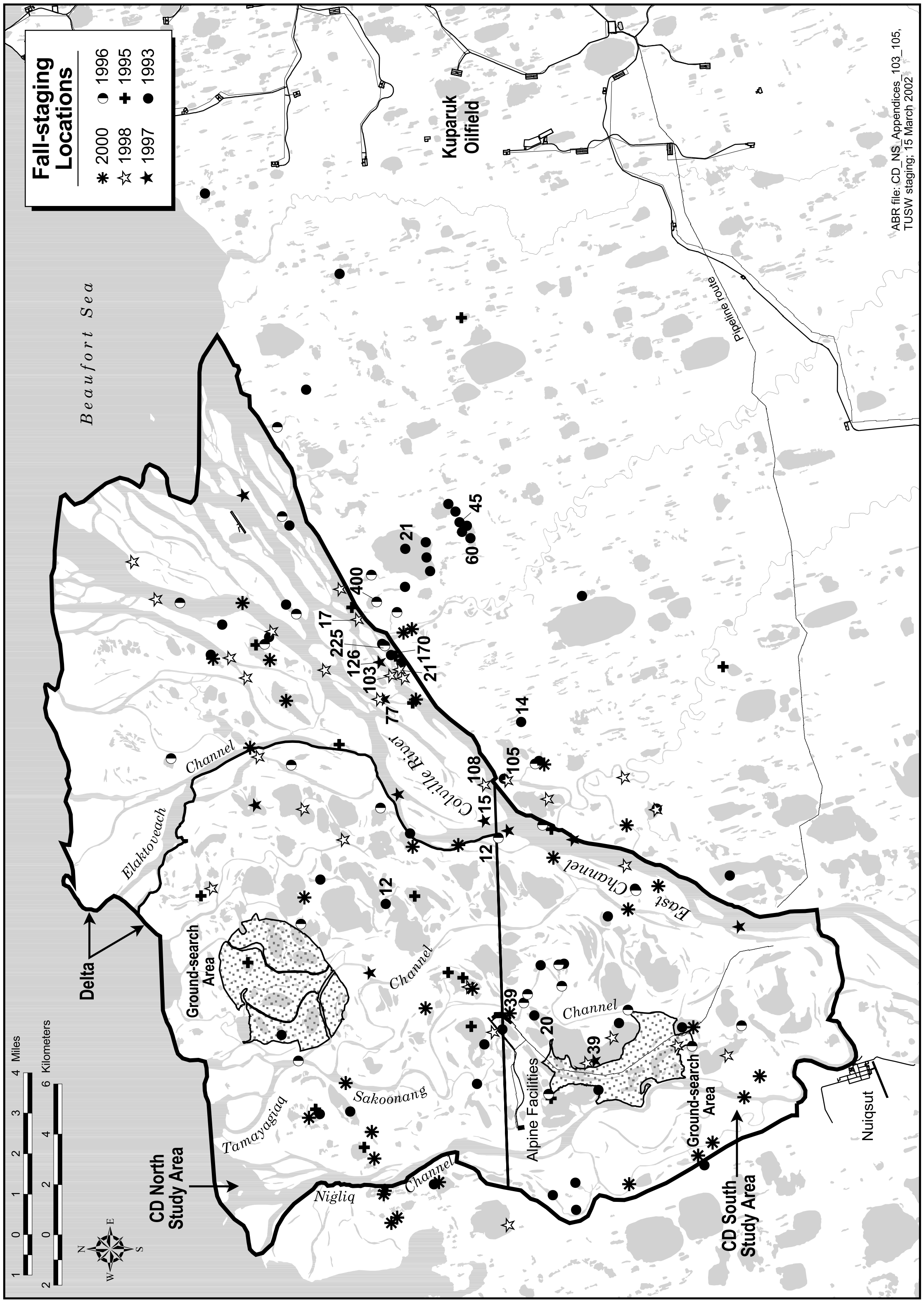
Appendix C5. Distribution of Spectacled, King, and unidentified eider broods during aerial and ground surveys in the Fiord and Nanuk study areas, Colville River Delta, Alaska, 1983, 1984, 1992–2001. Pre-2000 data are from M. North (1983, 1984, unpubl. data), and Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



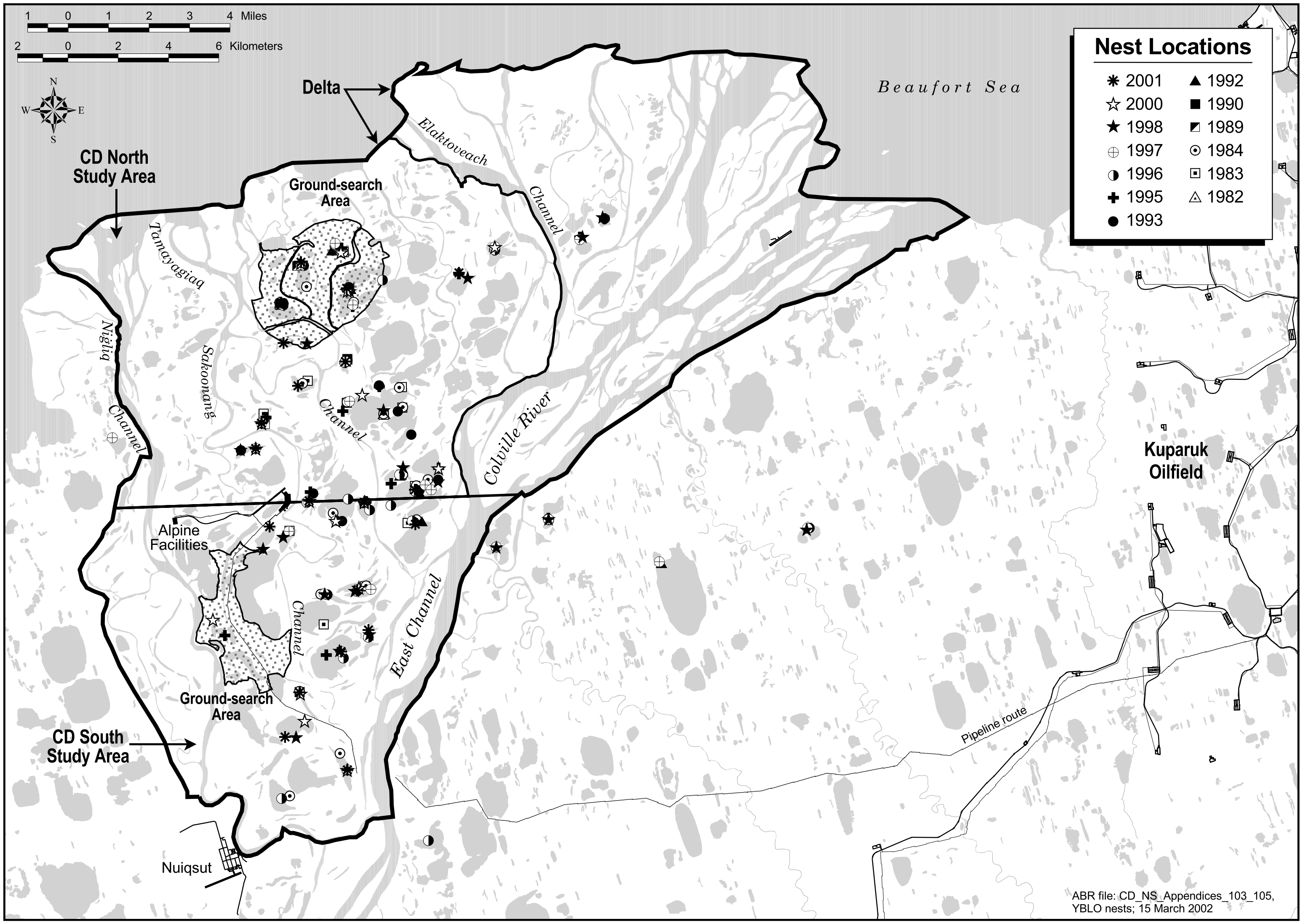
Appendix C6. Distribution of Tundra Swan nests during aerial and ground surveys on the Colville River Delta, Alaska, 1989–2001. Pre-2000 data are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), and Johnson et al. (1999a).



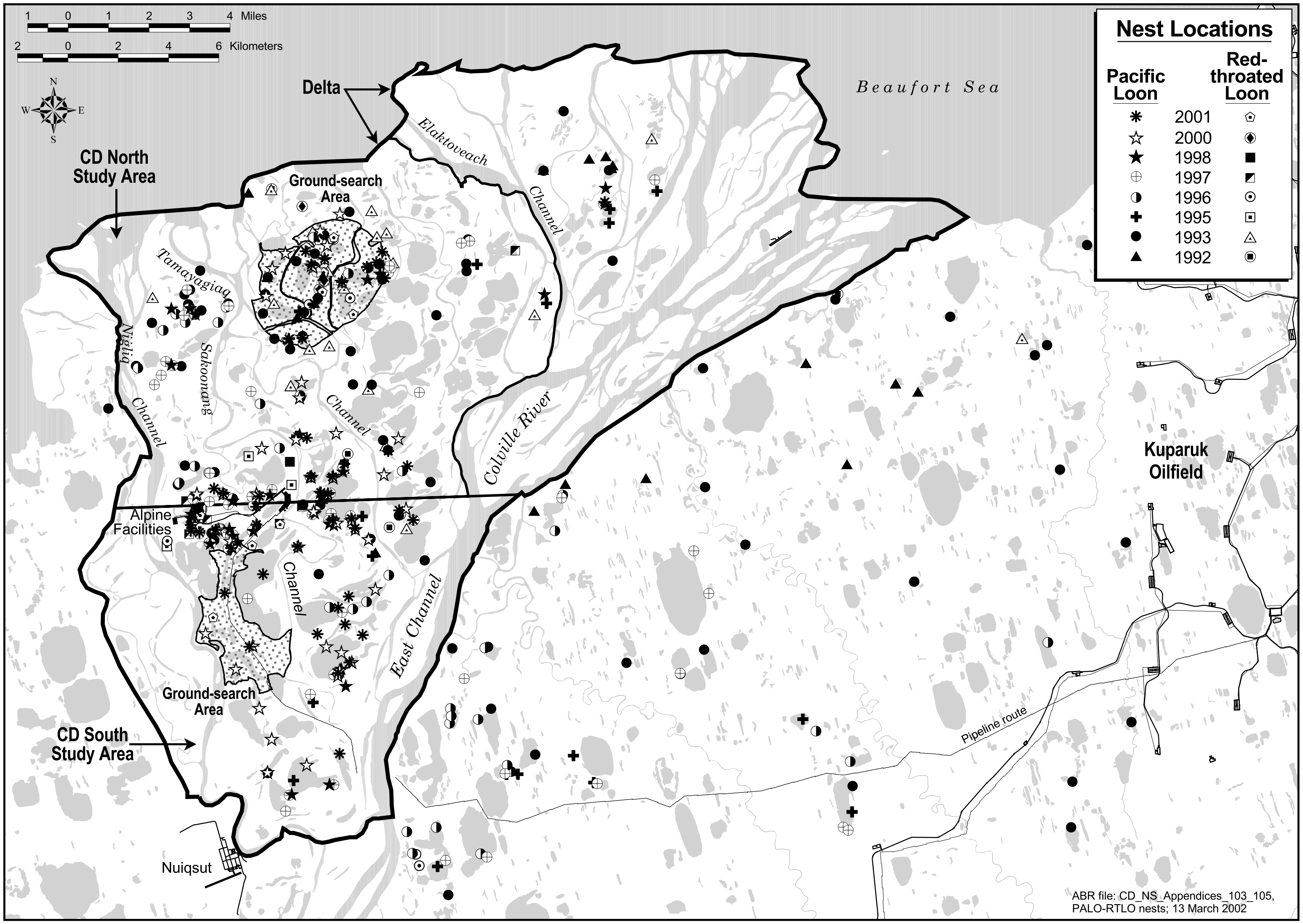
Appendix C7. Distribution of Tundra Swan broods during aerial and ground surveys on the Colville River Delta, Alaska, 1989–2001. Pre-2000 data are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), and Johnson et al. (1999a).



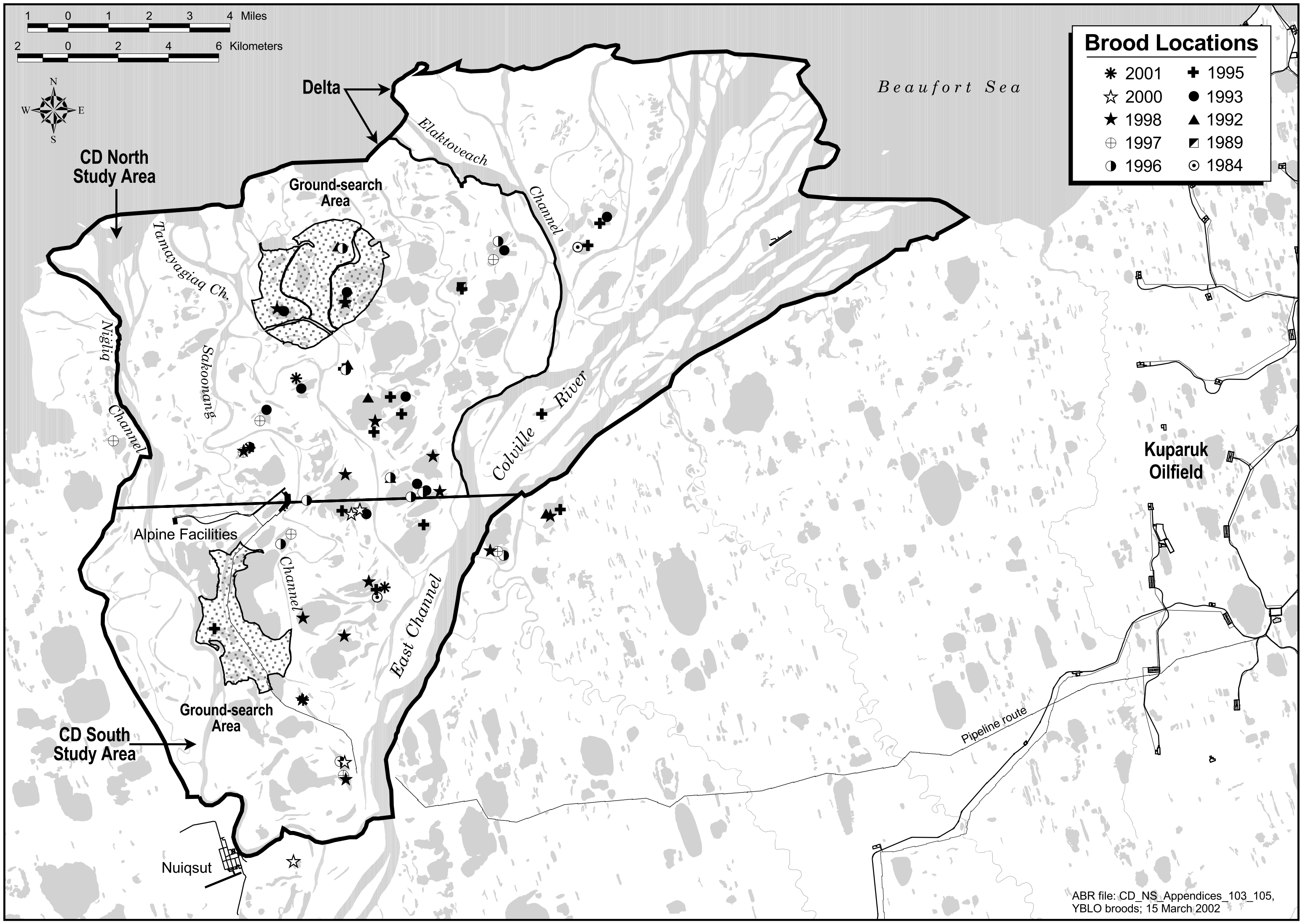
Appendix C8. Distribution of Tundra Swan fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1993–2001. Numbers indicate size of groups >10. Pre-2000 data are from Johnson et al. (1999a).



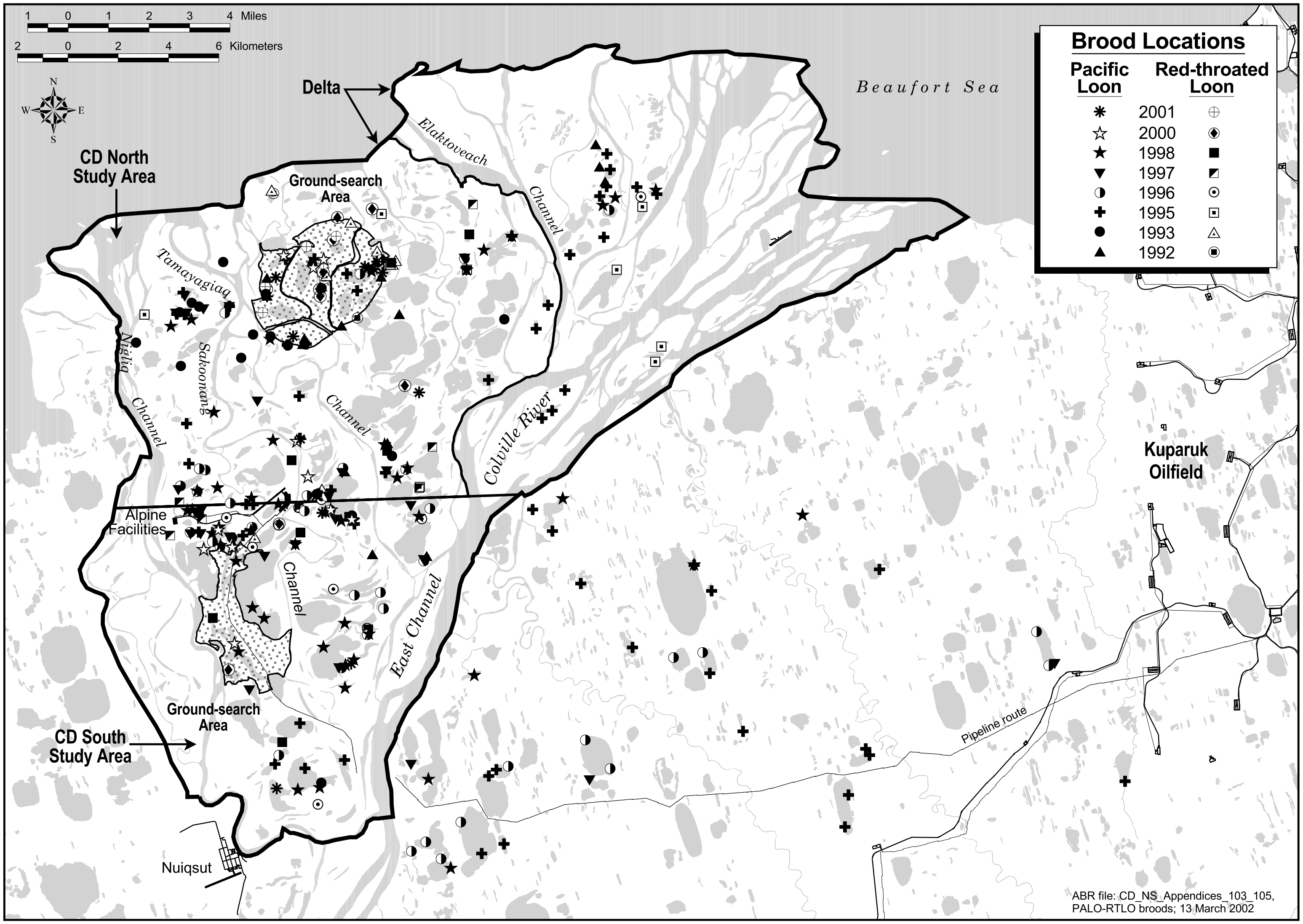
Appendix C9. Distribution of Yellow-billed Loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1982–2001. Pre-2000 data are from M. North (1982–1984, 1989, 1990, unpubl. data), S. Earnst (1995–1997, unpubl. data), and Johnson et al. (1999a).



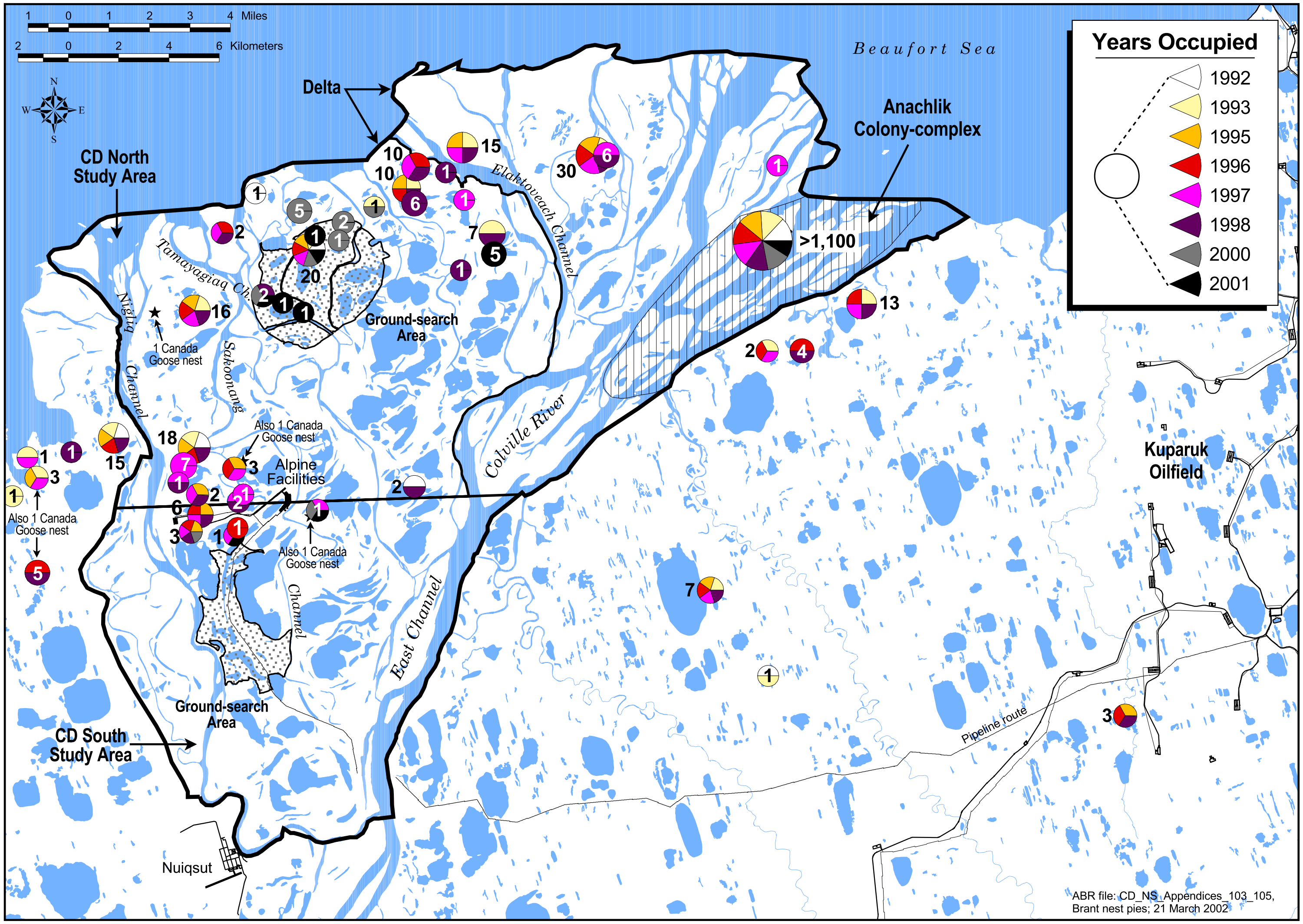
Appendix C10. Distribution of Pacific and Red-throated loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



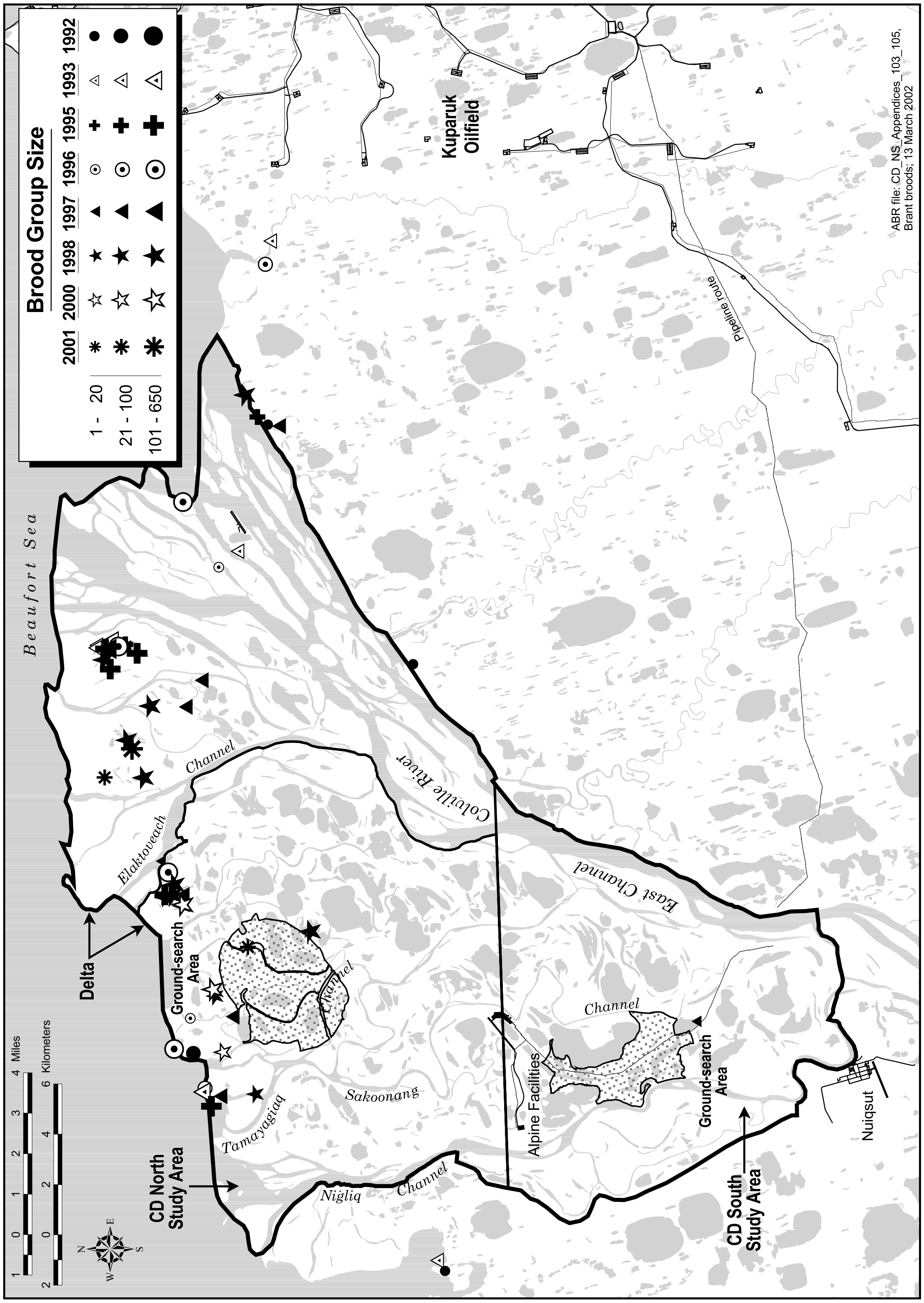
Appendix C11. Distribution of Yellow-billed Loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1984-2001. Pre-2000 data are from M. North (1984, 1989, unpubl. data), S. Earnst (1996, unpubl. data), and Johnson et al. (1999a).



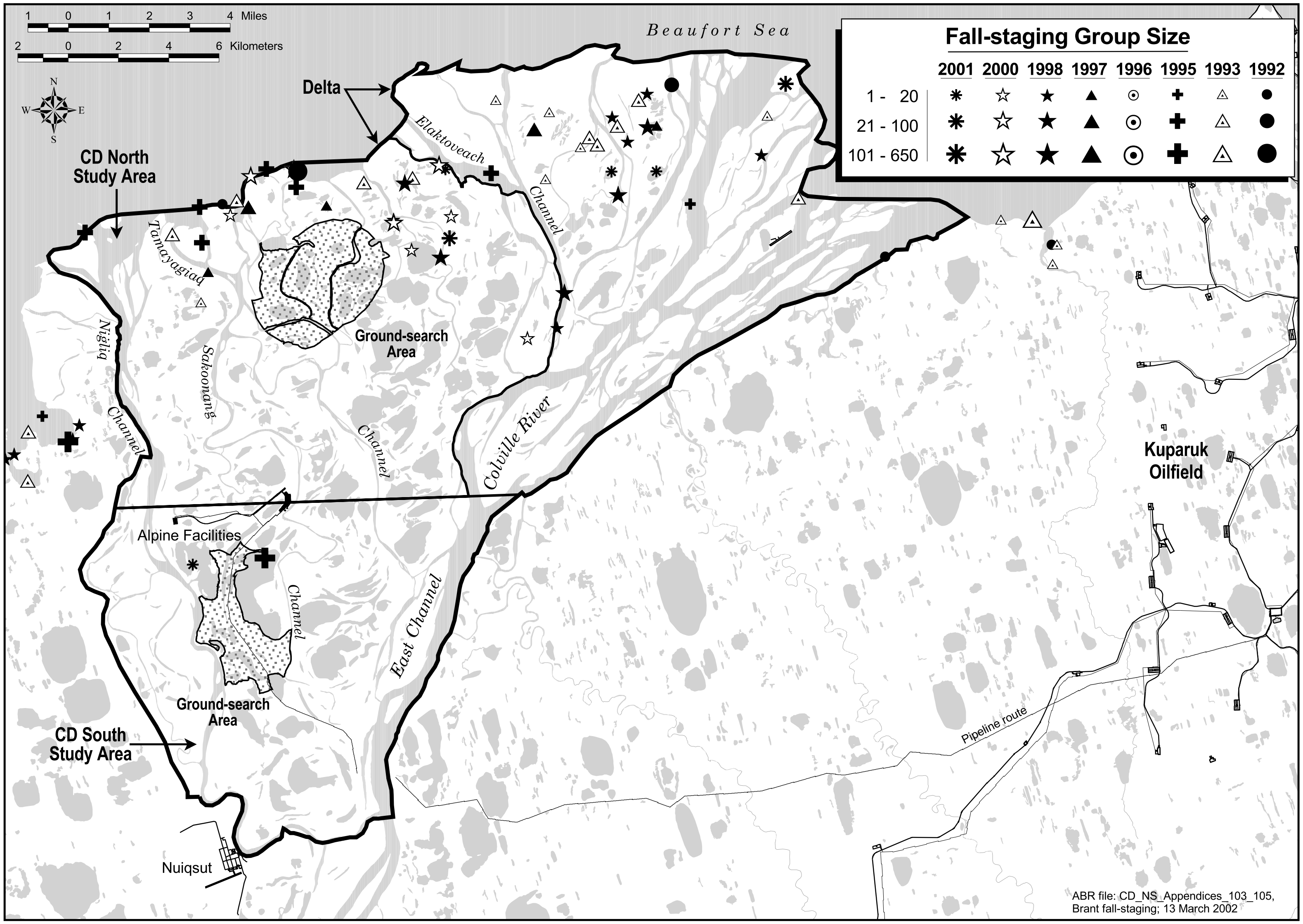
Appendix C12. Distribution of Pacific and Red-throated loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



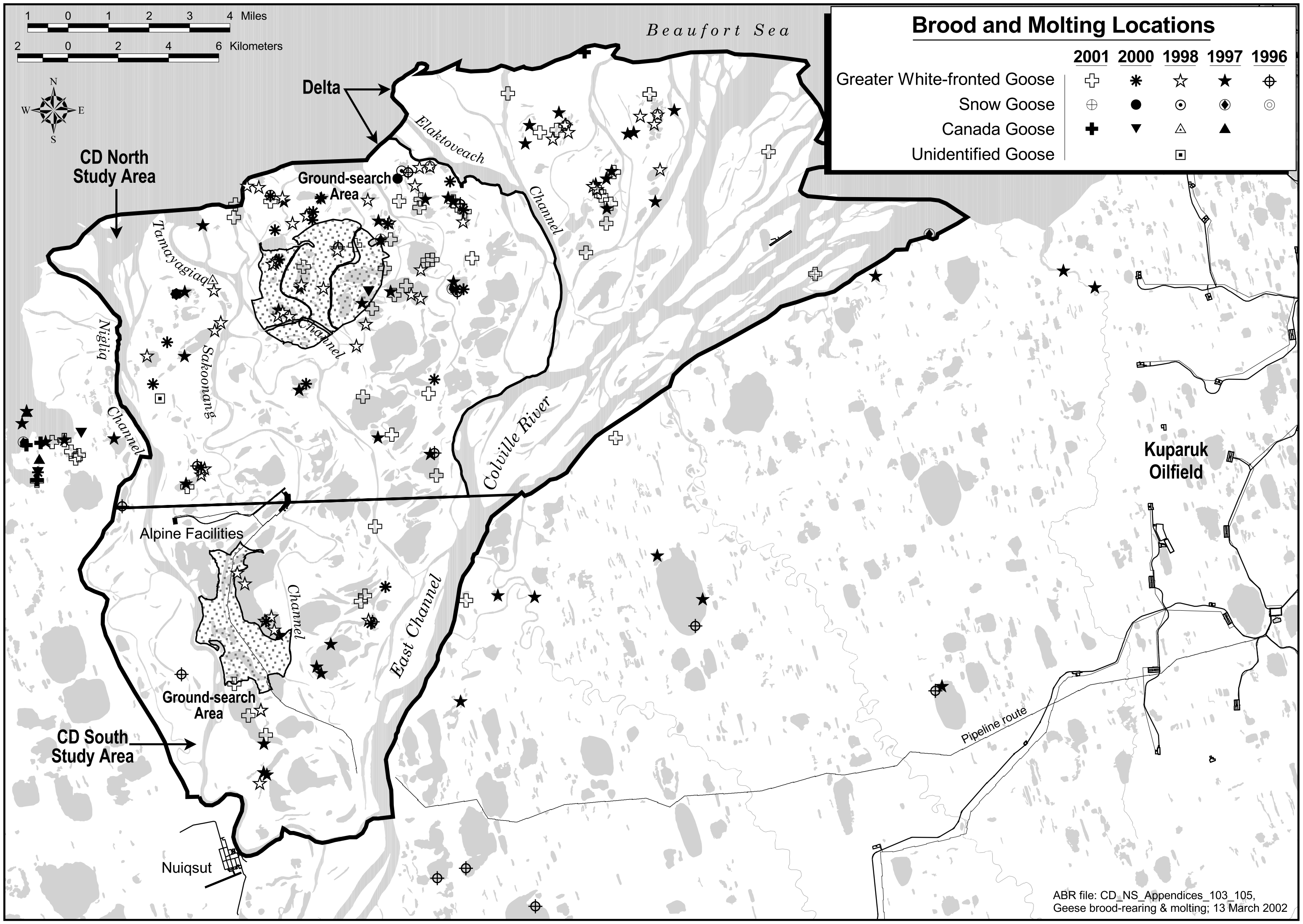
Appendix C13. Distribution and size of Brant colonies and locations of 5 Canada Goose nests during aerial (1992–1993, 1995–1998) and ground surveys (1995–2001) on the Colville River Delta, Alaska. Pre-2000 data are from Johnson et al. (1999a). Numbers represent the maximal number of nests counted during surveys. Delta-wide surveys were not conducted after 1998. Survey coverage was not uniform over the area portrayed.



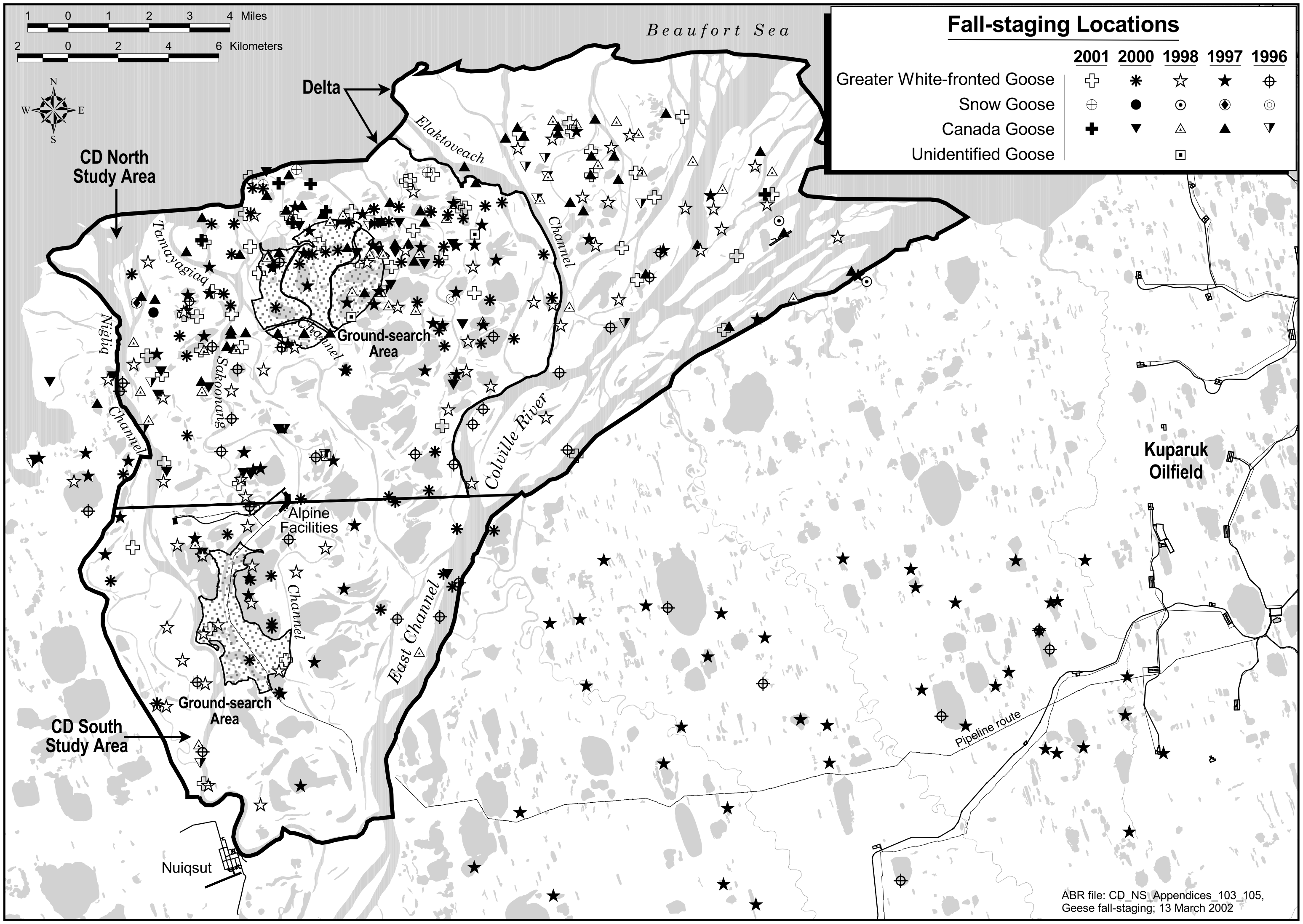
Appendix C14. Distribution and size of Brant brood-rearing groups during aerial surveys on the Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).



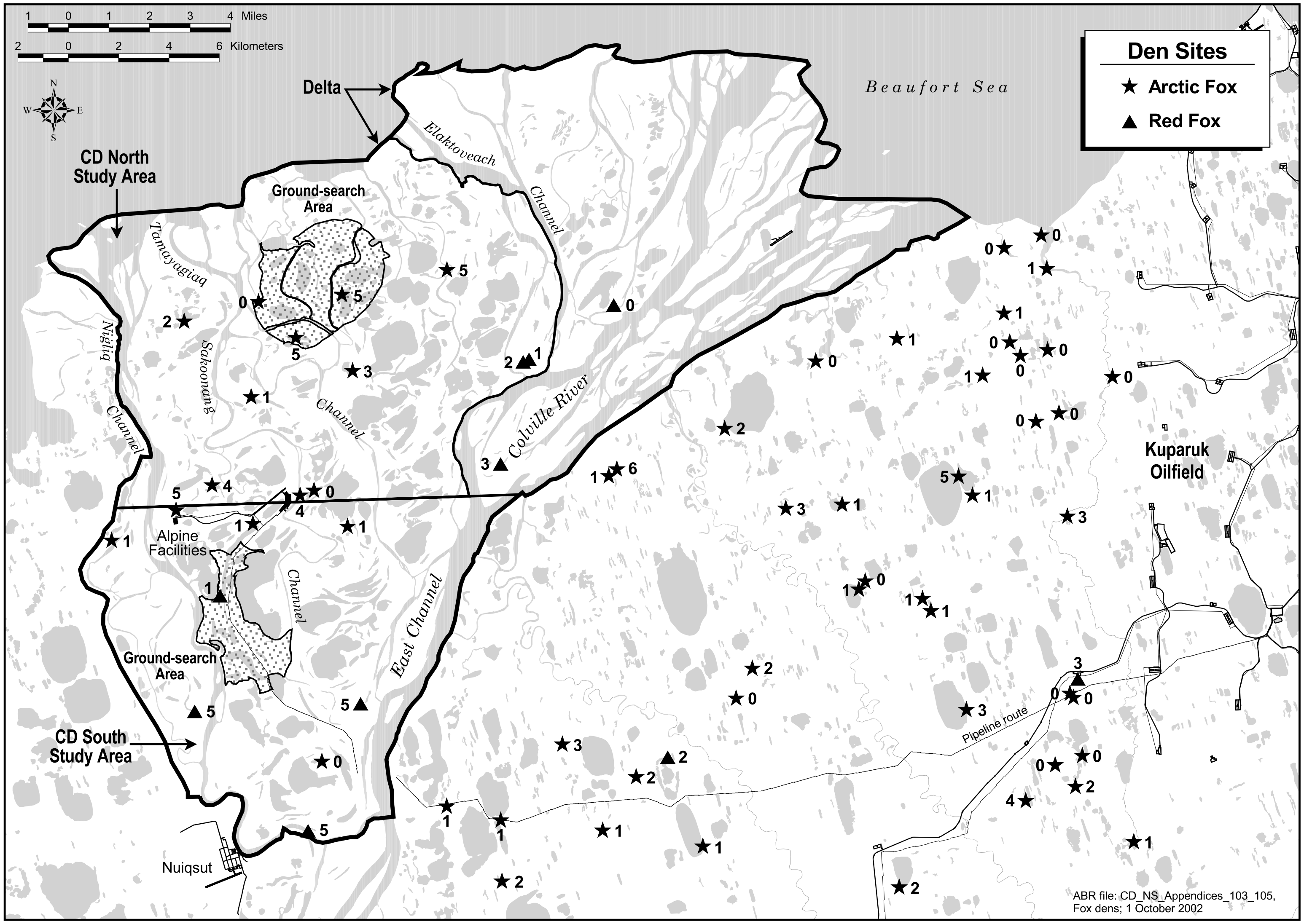
Appendix C15. Distribution and size of Brant fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).



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, July 1996–2001. Pre-2000 data are 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, August 1996–2001. Pre-2000 data are 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 on Colville River Delta, Alaska, 1992–2001. Survey coverage was not uniform over the area portrayed. Numbers represent years active. Pre-2000 data are from Johnson et al. (2000b).

Appendix D1. Habitat selection (pooled among years) by Spectacled Eiders and King Eiders during pre-nesting on the Colville River Delta, Alaska, 1993–1998, 2000, and 2001. Pre-2000 data are from Johnson et al. (1999a).

SPECIES Habitat Type	No. Adults	No. Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
SPECTACLED EIDERS					
Open Nearshore Water	0	0	0	1.5	ns
Brackish Water	50	21	13.1	1.3	prefer
Tapped Lake w/ Low-water Connection	27	11	6.9	4.4	ns
Tapped Lake w/ High-water Connection	10	6	3.8	4.0	ns
Salt Marsh	25	12	7.5	3.2	prefer
Tidal Flat	0	0	0	6.9	avoid
Salt-killed Tundra	29	16	10.0	5.0	prefer
Deep Open Water w/o Islands	9	6	3.8	4.0	ns
Deep Open Water w/ Islands or Polygonized Margins	13	8	5.0	1.6	prefer
Shallow Open Water w/o Islands	4	2	1.3	0.4	ns
Shallow Open Water w/ 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	<0.1	ns
Aquatic Sedge w/ 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	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	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	2.5	avoid
Moist Tussock Tundra	0	0	0	0.5	ns
Riverine or Upland Shrub	0	0	0	5.1	avoid
Barrens	4	2	1.3	14.9	avoid
Artificial	0	0	0	<0.1	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 w/ Low-water Connection	13	6	7.3	4.4	ns
Tapped Lake w/ 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 w/o Islands	4	1	1.2	4.0	ns
Deep Open Water w/ Islands or Polygonized Margins	5	2	2.4	1.6	ns
Shallow Open Water w/o Islands	0	0	0	0.4	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0	0.1	ns
River or Stream	132	41	50.0	14.0	prefer
Aquatic Sedge Marsh	0	0	0	<0.1	ns
Aquatic Sedge w/ Deep Polygons	6	3	3.7	2.6	ns
Aquatic Grass Marsh	0	0	0	0.3	ns
Young Basin Wetland Complex	0	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	ns
Nonpatterned Wet Meadow	1	1	1.2	8.1	avoid
Wet Sedge–Willow Meadow	12	7	8.5	19.6	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.5	ns
Moist Tussock Tundra	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	<0.1	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 D2. Habitat use by Spectacled Eiders during nesting on the Colville River Delta, Alaska, 1992–1994 and 1997–2001. Nests were found during ground searches of selected portions of the study area. Pre-2000 data are from Johnson et al. (1999a).

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 TYPE [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 D3. 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 are from M. North (1983, 1984, unpubl. data) and Johnson et al. (1999a). Broods were located during both aerial and ground surveys.

SPECIES Habitat Type	Number of 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] 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 D4. Numbers and densities (no/km²) of Tundra Swan nests and broods during aerial surveys of the Colville River delta, Alaska, 1992–2001. Pre-2000 data are from Johnson et al. (1999a).

	Nests		Broods			
Year	No.	No./km²	No.	No./km²	Mean Brood Size	Estimated Nest Success[a]
1992	14	0.03	16	0.03	2.4	114
1993	20	0.04	14	0.03	2.6	70
1995	38	0.07	25	0.05	3.7	66
1996	45	0.08	32	0.06	3.4	71
1997	32	0.06	24	0.04	2.5	75
1998	31	0.06	22	0.04	2.4	71
2000	32	0.06	20	0.04	1.9	63
2001	27	0.05	22	0.04	1.7	81

[a] Percent nest success = nests/broods x 100

Appendix D5. Numbers and densities (no/km²) of Tundra Swan adults and young during fall-staging surveys of the Colville River Delta, Alaska, 1992–1993, 1995–1996, and 2000. Pre-2000 data are from Johnson et al (1999a).

	Adults		Young		
Year	Total	Density	Total	Density	Number of Groups
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 D6. Habitat selection (pooled among years) by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995–1998, 2000, and 2001. Pre-2000 data are from Johnson et al. (1999a).

SEASON Habitat	Area (km²)	No. of Nests or Broods	Use (%)	Availability (%)	MonteCarlo Results
NESTING					
Open Nearshore Water (marine)	10.28	0	0	1.9	avoid
Brackish Water	6.50	0	0	1.2	ns
Tapped Lake w/Low-water Connection	21.40	2	0.84	3.9	avoid
Tapped Lake w/High-water Connection	20.40	4	1.67	3.7	ns
Salt Marsh	16.36	14	5.86	3.0	ns
Tidal Flat	55.99	4	1.67	10.2	avoid
Salt-killed Tundra	25.62	27	11.30	4.6	prefer
Deep Open Water w/o Islands	23.32	4	1.67	4.2	avoid
Deep Open Water w/Islands or Polygonized Margins	5.15	10	4.18	0.9	prefer
Shallow Open Water w/o Islands	2.30	1	0.42	0.4	ns
Shallow Open Water w/Islands or Polygonized Margins	0.54	1	0.42	0.1	ns
River or Stream	81.88	0	0	14.8	avoid
Aquatic Sedge Marsh	0	1	0.42	<0.1	ns
Aquatic Sedge w/Deep Polygons	13.59	17	7.11	2.5	prefer
Aquatic Grass Marsh	1.37	2	0.84	0.2	ns
Young Basin Wetland Complex	<0.01	0	0	<0.1	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.92	27	11.30	7.6	ns
Wet Sedge–Willow Meadow	102.37	92	38.49	18.6	prefer
Moist Sedge–Shrub Meadow	13.40	18	7.53	2.4	prefer
Moist Tussock Tundra	2.53	3	1.26	0.5	ns
Riverine or Upland Shrub	27.42	5	2.09	5.0	avoid
Barrens (riverine, eolian, lacustrine)	79.03	7	2.93	14.3	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	ns
TOTAL	551.42	239	100	100	
BROOD-REARING					
Open Nearshore Water (marine)	10.28	0	0	1.9	ns
Brackish Water	6.50	10	5.71	1.2	prefer
Tapped Lake w/Low-water Connection	21.40	23	13.14	3.9	prefer
Tapped Lake w/High-water Connection	20.40	13	7.43	3.7	prefer
Salt Marsh	16.36	15	8.57	3.0	prefer
Tidal Flat	55.99	2	1.14	10.2	avoid
Salt-killed Tundra	25.62	12	6.86	4.6	ns
Deep Open Water w/o Islands	23.32	18	10.29	4.2	prefer
Deep Open Water w/Islands or Polygonized Margins	5.15	9	5.14	0.9	prefer
Shallow Open Water w/o Islands	2.30	1	0.57	0.4	ns
Shallow Open Water w/Islands or Polygonized Margins	0.54	1	0.57	0.1	ns
River or Stream	81.88	6	3.43	14.8	avoid
Aquatic Sedge Marsh	0.13	0	0	<0.1	ns
Aquatic Sedge w/Deep Polygons	13.59	6	3.43	2.5	ns
Aquatic Grass Marsh	1.37	2	1.14	0.2	ns
Young Basin Wetland Complex	<0.01	0	0	<0.1	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.92	10	5.71	7.6	ns
Wet Sedge–Willow Meadow	102.37	31	17.71	18.6	ns
Moist Sedge–Shrub Meadow	13.40	3	1.71	2.4	ns
Moist Tussock Tundra	2.53	0	0	0.5	ns
Riverine or Upland Shrub	27.42	3	1.71	5.0	avoid
Barrens (riverine, eolian, lacustrine)	79.03	10	5.71	14.3	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	ns
TOTAL	551.42	175	100	100	

Appendix D7. Habitat selection (pooled among years) by Yellow-billed Loons during nesting and brood-rearing on the Colville River Delta, Alaska, 1993, 1995–1998, 2000, and 2001. Pre-2000 data are 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 w/ Low-water Connection	0	0	5.3	avoid
Tapped Lake w/ 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 w/o Islands	8	7.7	5.5	ns
Deep Open Water w/ Islands or Polygonized Margins	22	21.1	1.8	prefer
Shallow Open Water w/o Islands	0	0	0.4	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	1	1.0	<0.1	ns
Aquatic Sedge w/ 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 w/ Low-water Connection	0	0	5.3	ns
Tapped Lake w/ 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 w/o Islands	23	61.5	5.5	prefer
Deep Open Water w/ Islands or Polygonized Margins	6	15.8	1.8	prefer
Shallow Open Water w/o Islands	0	0	0.4	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	ns
Aquatic Sedge Marsh	0	0	<0.1	ns
Aquatic Sedge w/ Deep Polygons	0	0	2.9	ns
Aquatic Grass Marsh	0	0	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	0	0	8.7	ns
Wet Sedge–Willow Meadow	0	0	24.7	avoid
Moist Sedge–Shrub Meadow	0	0	3.5	ns
Moist Tussock Tundra	0	0	0.7	ns
Riverine or Upland Shrub	0	0	6.5	ns
Barrens	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 D8. Habitat selection (pooled among years) by nesting (1992–1993, 1995–1998, and 2000–2001) and brood-rearing (1993, 1995–1996, and 1998) Brant in the Outer Delta survey area, Colville River Delta, Alaska. Pre-2000 data are from Johnson et al. (1999a). Nesting was based on the cumulative locations of colonies, including ground locations in 2000 and 2001.

SEASON Habitat	Area (km²)	Max. Estimate of Nests	No. of Colonies/ Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING						
Open Nearshore Water (marine)	10.02	0	0	0	4.0	ns
Brackish Water	6.45	7	1	4.3	2.6	ns
Tapped Lake w/ Low-water Connection	5.50	0	0	0	2.2	ns
Tapped Lake w/ High-water Connection	2.22	5	1	4.3	0.9	ns
Salt Marsh	13.17	21	3	13.0	5.3	ns
Tidal Flat	56.01	0	0	0.0	22.5	avoid
Salt-killed Tundra	23.18	54	9	39.1	9.3	prefer
Deep Open Water w/out Islands	1.40	0	0	0	0.6	ns
Deep Open Water w/ Islands or Polygonized Margins	3.37	2	2	8.7	1.4	ns
Shallow Open Water w/out Islands	0.67	0	0	0	0.3	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.26	0	0	0	0.1	ns
River or Stream	48.67	0	0	0	19.5	avoid
Aquatic Sedge Marsh	0	-	-	-	-	-
Aquatic Sedge w/ Deep Polygons	7.38	25	4	17.4	3.0	prefer
Aquatic Grass Marsh	0.39	1	1	4.3	0.2	ns
Young Basin Wetland Complex	0	-	-	-	-	-
Old Basin Wetland Complex	0	-	-	-	-	-
Nonpatterned Wet Meadow	15.19	16	1	4.3	6.1	ns
Wet Sedge–Willow Meadow	17.11	15	1	4.3	6.9	ns
Moist Sedge–Shrub Meadow	2.51	0	0	0	1.0	ns
Moist Tussock Tundra	1.69	0	0	0	0.7	ns
Riverine or Upland Shrub	1.22	0	0	0	0.5	ns
Barrens (riverine, eolian, lacustrine)	32.84	0	0	0	13.2	ns
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	ns
TOTAL	249.29	146	23	100	100	
BROOD-REARING						
Open Nearshore Water (marine)	10.02		1	2.5	4.6	ns
Brackish Water	6.33		15	37.5	2.9	prefer
Tapped Lake w/ Low-water Connection	5.11		0	0	2.3	ns
Tapped Lake w/ High-water Connection	2.07		0	0	0.9	ns
Salt Marsh	12.66		4	10	5.8	ns
Tidal Flat	56.01		4	10	25.7	avoid
Salt-killed Tundra	22.24		5	12.5	10.2	ns
Deep Open Water w/out Islands	0.60		0	0	0.3	ns
Deep Open Water w/ Islands or Polygonized Margins	1.86		0	0	0.9	ns
Shallow Open Water w/out Islands	0.49		1	2.5	0.2	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.22		0	0	0.1	ns
River or Stream	42.41		5	12.5	19.5	ns
Aquatic Sedge Marsh	0		-	-	-	-
Aquatic Sedge w/ Deep Polygons	6.17		1	2.5	2.8	ns
Aquatic Grass Marsh	0.19		0	0	0.1	ns
Young Basin Wetland Complex	0		-	-	-	-
Old Basin Wetland Complex	0		-	-	-	-
Nonpatterned Wet Meadow	9.69		0	0	4.4	ns
Wet Sedge–Willow Meadow	9.41		1	2.5	4.3	ns
Moist Sedge–Shrub Meadow	1.76		0	0	0.8	ns
Moist Tussock Tundra	1.69		0	0	0.8	ns
Riverine or Upland Shrub	0.81		0	0	0.4	ns
Barrens (riverine, eolian, lacustrine)	28.25		3	7.5	13.0	ns
Artificial (water, fill, peat road)	0.02		0	0	<0.1	ns
TOTAL	218.01		40	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 North ground-search areas, Colville River Delta, Alaska, 2000 and 2001.

Habitat	2000 No. of Nests	2000 Use (%)	2000 Availability (%)	2000 Monte Carlo Results	2001 No. of Nests	2001 Use (%)	2001 Availability (%)	2001 Monte Carlo Results
Open Nearshore Water (marine)	–	–	0	–	–	–	0	–
Brackish Water	1	0.8	6.2	avoid	0	0	2.8	avoid
Tapped Lake w/ Low-water Connection	0	0	0.1	ns	0	0	1.6	ns
Tapped Lake w/ High-water Connection	–	–	0	–	1	0.6	4.9	avoid
Salt Marsh	0	0	7.0	avoid	4	2.3	4.1	ns
Tidal Flat	–	–	<0.1	–	–	–	0	–
Salt-killed Tundra	20	16.7	28.8	avoid	22	12.4	10.5	ns
Deep Open Water w/o Islands	2	1.7	0.9	ns	2	1.1	4.2	avoid
Deep Open Water w/ Islands or Polygonized Margins	1	0.8	9.7	avoid	3	1.7	10.1	avoid
Shallow Open Water w/o Islands	0	0	0.1	ns	0	0	0.3	ns
Shallow Open Water w/ Islands or Polygonized Margins	1	0.8	0.5	ns	3	1.7	0.8	ns
River or Stream	0	0	<0.1	–	–	–	0	–
Aquatic Sedge Marsh	–	–	0	–	–	–	0	–
Aquatic Sedge w/ Deep Polygons	39	32.5	15.0	prefer	54	30.5	11.7	prefer
Aquatic Grass Marsh	–	–	0	–	0	0	0.2	ns
Young Basin Wetland Complex	–	–	0	–	–	–	0	–
Old Basin Wetland Complex	–	–	0	–	–	–	0	–
Nonpatterned Wet Meadow	9	7.5	8.9	ns	22	12.4	15.1	ns
Wet Sedge-Willow Meadow	47	39.2	17.1	prefer	64	36.2	25.4	prefer
Moist Sedge-Shrub Meadow	0	0	3.5	avoid	1	0.6	2.4	avoid
Moist Tussock Tundra	–	–	0	–	–	–	0	–
Riverine or Upland Shrub	–	–	0	–	1	0.6	1.3	ns
Barrens (riverine, eolian, lacustrine)	0	0	2.0	ns	0	0	4.6	ns
Artificial (water, fill, peat road)	–	–	0	–	–	–	0	–
TOTAL	120	100	100		177	100	100	

Appendix D10. Habitat selection by foxes, as indicated by den site locations on the Colville River Delta, Alaska. The sample analyzed includes all active and inactive dens of arctic foxes and red foxes confirmed during 1992–2001, because both species may use the same dens in different years. Pre-2000 data are from Johnson et al. (2000b).

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability[a] (%)	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-
Brackish Water	0	-	-	0	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-
Tapped Lake w/ High-water Connection	0	-	-	0	-
Salt Marsh	16.55	0	0	4.4	ns
Tidal Flat	56.01	0	0	14.8	avoid
Salt-killed Tundra	25.64	0	0	6.8	ns
Deep Open Water w/out Islands	0	-	-	0	-
Deep Open Water w/ Islands or Polygonized Margins	0	-	-	0	-
Shallow Open Water w/out Islands	0	-	-	0	-
Shallow Open Water w/ Islands or Polygonized Margins	0	-	-	0	-
River or Stream	0	-	-	0	-
Aquatic Sedge Marsh	0	-	-	0	-
Aquatic Sedge w/ Deep Polygons	13.22	0	0	3.5	ns
Aquatic Grass Marsh	0	-	-	0	-
Young Basin Wetland Complex	<0.01	0	0	<0.1	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.54	2	8.7	11.0	ns
Wet Sedge–Willow Meadow	102.63	3	13.0	27.2	avoid
Moist Sedge–Shrub Meadow	13.20	1	4.4	3.5	ns
Moist Tussock Tundra	2.55	0	0	0.7	ns
Riverine or Upland Shrub	27.58	16	69.6	7.3	prefer
Barrens (riverine, eolian, lacustrine)	78.67	1	4.4	20.8	avoid
Artificial (water, fill, peat road)	0.39	0	0	0.1	ns
TOTAL	377.99	23	100	100	

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