WILDLIFE STUDIES IN THE CD NORTH STUDY AREA, 2002

THIRD ANNUAL REPORT

Prepared for

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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. In this third annual report on the 2002 field season, the results are presented from the third year of study of the wildlife resources in the CD North study area and the eleventh year of studies on the Colville Delta.

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 Eider, Tundra Swan, Brant, Yellow-billed Loon, arctic fox, 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. 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 (18.9 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 18 occur in the ground-search area. Lakes are more abundant (21% of the area) in the CD North study area than they are on the entire delta (15% of the area). The most abundant single habitat is Patterned Wet Meadow, which covers 20% of the CD North study area.

CONDITIONS IN THE STUDY AREA

The 2002 breeding season differed from recent years in that May temperatures were warm and snowmelt and river breakup were early. June temperatures returned to levels near long-term means. Snowfall in late June and early July may have caused some nest or brood losses and affected overall productivity for some species.

NESTS IN THE GROUND-SEARCH AREA

In 2002, 346 nests of 19 species were recorded in the CD North ground-search area and the overall nest success was 64%. Nest density was almost twice that of other areas on the delta that were similarly searched. In 2000–2002, habitats with polygonal surface forms contained the highest numbers of nests. More than half of the nests in each year belonged to geese, with Greater White-fronted Geese the most abundant (120–213 nests), followed by Brant (23–30 nests). Duck nests were abundant in both years and primarily consisted of Long-tailed Duck (18–23 nests) and Spectacled Eider (7–14 nests). Three to 9 Tundra Swan and 2–5 Yellow-billed Loon nests were found each year in the ground-search areas.

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 all pre-nesting sightings since 1993 was 4.0 km. Twenty-six Spectacled Eiders were counted on pre-nesting aerial surveys in 2002, for the lowest

density on record since delta-wide surveys began in 1993. Survey timing may have been late relative to the departure of male eiders in 2002. The mean density of Spectacled Eiders in the CD North area is similar to the mean 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 Spectacled Eiders used Brackish Water, Salt-killed Tundra, Salt Marsh, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons significantly more than the availability of those habitats. On an intensive nest survey of the CD North ground-search area during 2002, 7 Spectacled Eider nests were found and 2 (28%) of those nests hatched successfully. In overlapping search areas in 2000 and 2001, 14 and 7 Spectacled Eider nests were found, respectively. Most Spectacled Eider 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 2002 in the CD North study area was the highest density recorded since 1993. Only 9 King Eider nests and 3 broods have been found on surveys of the delta since 1992.

TUNDRA SWANS

In 2002, 31 Tundra Swan nests were counted during aerial surveys in the CD North study area, more than half the number counted on the entire delta. Preferred nesting habitats included Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, Nonpatterned Wet Meadow, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow. Nine swan broods were counted in the CD North study area in 2002. Nest success, estimated by dividing numbers of broods by the number of nests, was 29%, the lowest value recorded in the study area. Mean brood size for the CD North study area was 3.4 young/brood, which was one of the highest recorded in the study area. Delta-wide, 7 habitats were preferred during brood-rearing: Brackish Water, Salt Marsh, both types of Tapped Lake, both types of Deep Open Water, and Aquatic Grass Marsh.

YELLOW-BILLED LOONS

In 2002, 11 nests were counted during combined aerial and ground surveys in the CD North study area, which was one of the highest counts recorded during 8 years of surveys. Densities similar to that found in the CD North study area in 2002 (0.13 birds/km^2) have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska. All nests found during aerial surveys in 2002 were on lakes where nesting by Yellow-billed Loons has been recorded in previous years. Five of the nests were within the CD North ground-search area. Two habitats were preferred during nesting (Deep Open Water with Islands or Polygonized Margins and Patterned Wet Meadow), whereas 3 habitats were preferred during brood-rearing (Tapped Lake with High-water Connection and both types of Deep Open Water). Six broods were seen in the CD North study area in 2002, one of the highest counts ever.

PACIFIC AND RED-THROATED LOONS

In 2002 18 Pacific and 10 Red-throated loon nests were found in the CD North ground-search area. That same year within the ground-search area, 5 Pacific and 4 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.

Twenty-three nests were found in the ground-search area in 2002. During the nest search in 2002, 4 colonies with 2 and 15 nests each were recorded. Over 90% of the nests in 2000–2002 were in aquatic habitats with 77% in Deep Open Water with Islands or Polygonized Margins. In 2002, 12 adults and 22 gosling Brant were recorded in the CD North study area. Brackish Water was used by the most Brant brood-rearing groups (38%) and was the only preferred habitat. During fall staging in 2002, 101 Brant were seen in the CD North study area, which was low compared with other years.

GREATER WHITE-FRONTED GEESE

The nests of Greater White-fronted Geese accounted for more than half of the nests found in the ground search area in 2002. The density of Greater White-fronted Goose nests (11.3 nests/km²) was greater than any density previously reported for the delta and 75% of the nests hatched. Greater White-fronted Geese in the CD North ground-search area preferred to nest in habitats with polygonal surface forms: Patterned Wet Meadow, Aquatic Sedge with Deep Polygons, and Shallow Water with Islands or Polygonized Margins. During the brood-rearing aerial survey (50% coverage) of the CD North study area in 2002, 803 Greater White-fronted Geese were recorded and goslings comprised 37% of the total number of geese.

CANADA GEESE

Two Canada Goose nests were found during the 2002 nest searches in the CD North ground-search area, the first nests of that species found in the area. In 1997, a Canada Goose nest was found near the Niġliq 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. During the brood-rearing/molting period, Canada Geese have only been recorded in small numbers in 4 years on the delta, and 2002 was one of those years. 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 2002, 331 Canada Geese, the lowest count on record, were observed in the CD North study area during fall staging.

FOXES

Twelve fox dens have been located in the CD North study area since 1992; 10 of the dens were arctic fox sites in 2002 (1 den/21 km²), and 2 were red fox dens. The highest density of active dens occurred in 1996, a year of high microtine rodent populations. The density of arctic fox dens in the CD North study area is within the range of densities reported for other areas. Pups were observed at 3 natal dens and suspected at one other active den in 2002. An estimated 40% of the dens in the CD North study area were occupied by arctic fox litters in 2002, which was at the lower end of the range observed since 1993 (40–89%). Mean litter size in 2002 was 3.7 pups, which was about the midrange of values since 1993. The habitat type used most often for denning on the delta was Riverine or Upland Shrub, and it was 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: Seth Adams, Summer Andersen, Julie Betsch, Douglas Blockcolsky, Jennifer Boisvert, Jessie Bopp, Cathy Egan, Luke Frey, J. J. Frost, Jim King, Mike Knoche, Pat Lovely, Todd Mabee, Alden Miller, Randy Mullen, Julie Neville, Rebecca Peterson, Bob Ritchie, Jay Schamel, Pam Seiser, John Shook, Diane Tracy, 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 Mel Campbell, Jim Dell, Mark Fleming, and Glen Giammalva of Maritime Helicopters safely transported us around the study area. Jessica Adema, Justin Harth, Dennis Lund, and Ray Swanson facilitated our field travel and logistics. Will Lentz, Matt Macander, Chad Ritchie, and Allison Zusi-Cobb digitized wildlife locations, summarized map data, and produced clear, concise figures. Jennifer Roof expertly supervised 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 and Kuparuk oilfields 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 (PHILLIPS and Anadarko 2002), which incorporated the results of the 2000–2001 field seasons, was prepared to provide information for development permit applications. The proposed CD North Development Project is located on the Colville River Delta (hereafter, Colville Delta), 10.1 km northeast 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 2002 field season presents the results from the third 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, 2003a).

Wildlife studies have been conducted by ARCO Alaska, Inc. (now ConocoPhillips Alaska, Inc. [CPAI]) in the Colville 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, CPAI agreed to focus on species selected using the following criteria: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, or 3) special concern of regulatory agencies. Accordingly, Yellow-billed 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). In subsequent years, 3 additional species were targeted for more focused attention: King Eider, 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. 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 Niġliq (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 (Smith et al. 1993). 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 two 10-ha plots. Of the plots surveyed in 1992, one 10-ha plot, one larger aerial survey plot, and a portion of another 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 Brant, which have a coastal distribution; Smith et al. 1994). In 1994, the entire delta was surveyed,

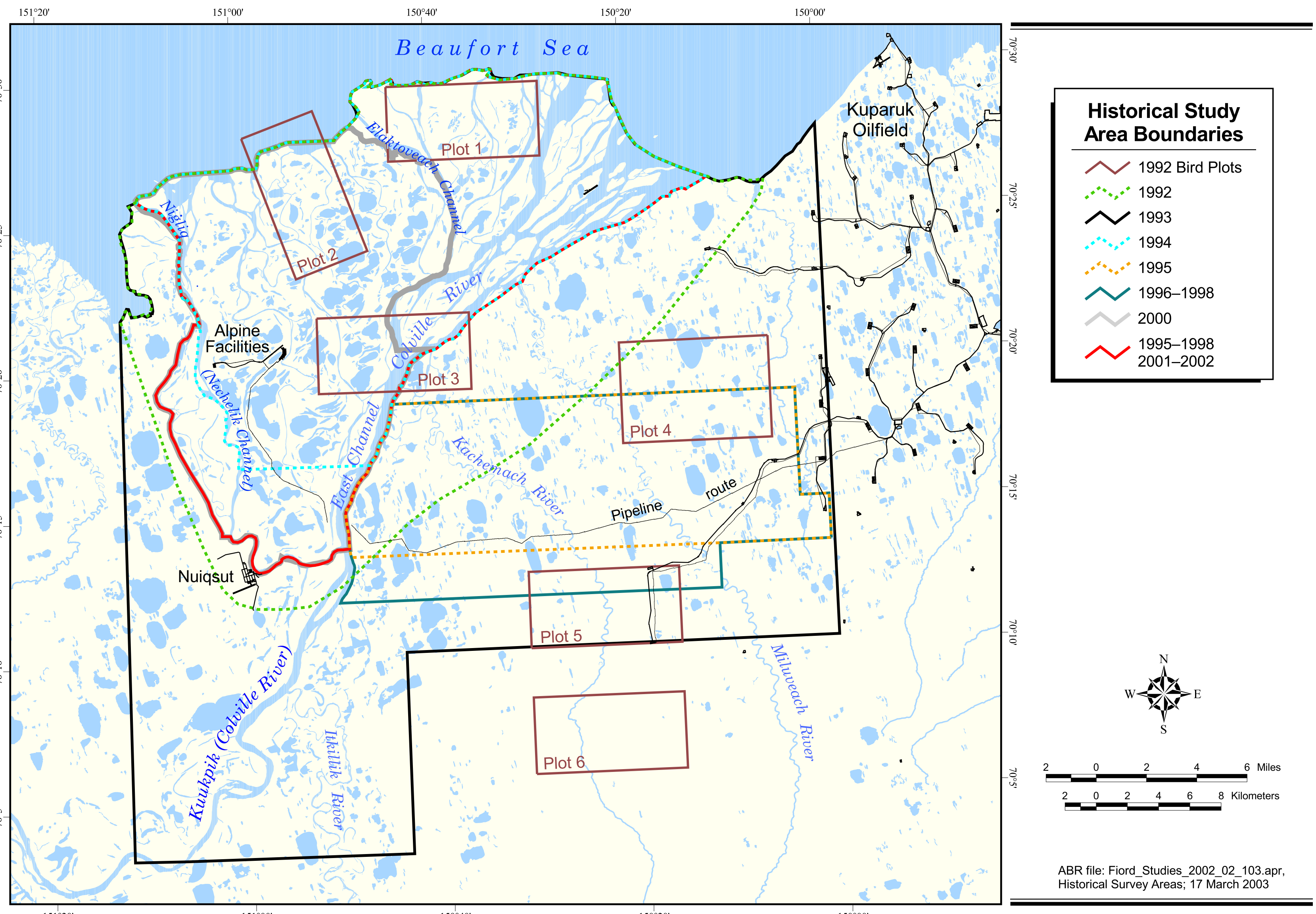

Figure 1. Map of historical wildlife study areas (1992–2002) on the Colville River Delta and adjacent areas, Alaska. Boundaries do not include caribou survey areas.

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 (Alpine 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, although the Alpine transportation corridor was not surveyed in 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, 2003). No delta-wide surveys for wildlife were conducted in 1999. Surveys were resumed in 2000–2002 (Johnson et al. 2000a, 2002, this study), 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, which occasionally uses the delta in large numbers during July–August, was the focus of a separate, more wide-ranging caribou study (Lawhead and Prichard 2001, 2002, 2003).

The overall goal of the study in 2002 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 August. 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 periods;
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 Colville River is known as the Kuukpik by local Iñupiat (Kuukpiŋmiut, or people of the Colville). A few Iñupiaq names are readily available for the study area from the Iñupiat–English Map of the North Slope Borough (North Slope Borough Planning Department, Barrow, Alaska, May 1997) (Figure 1). We have included the available Iñupiaq names with the names assigned on USGS maps in parentheses where first cited, and thereafter, we use the Iñupiaq names because they preceded the English names or Anglicized spelling of Iñupiaq names. We use the names from USGS maps if no Iñupiaq name is yet widely available, or if there could be confusion in usage. Therefore, we continue to use Colville Delta, which is widely known on maps and in the literature, but does not have a specific Iñupiaq name on the Iñupiat–English Map.

The CD North study area (207 km²) is located on the outer portion of the Colville Delta and is delimited by the Beaufort Sea on the north, the Alpine airstrip on the south, the Elaktoveach and East channels of the Kuukpik on the east and the Niġliq (Nechelik Channel) 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 Kuukpik 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 Kuukpik 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). 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

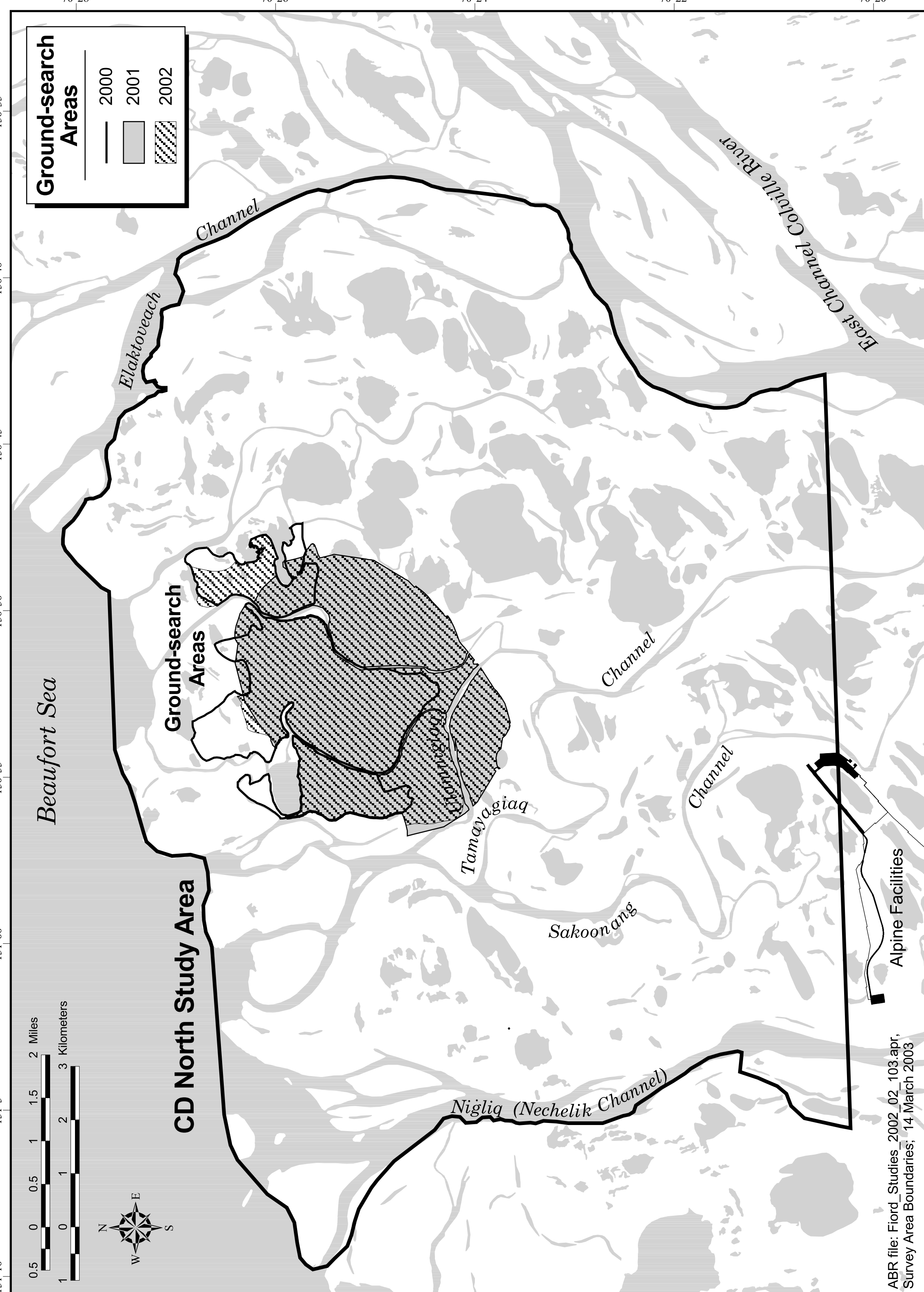

Figure 2. Survey area boundaries for wildlife studies in the CD North study area, Colville River Delta, Alaska, 2000–2002.

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 Kuukpik has 2 main distributaries: the Niġliq (Nechelik 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 Channel, including the Sakoonang, Tamayagiaq, Ulamnigiaq, 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 Niġliq 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 Kuukpik 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. 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 and loons 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 between mid-May and mid-June (PHILLIPS and Anadarko 2002). 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 2000–2002, aerial and ground-based 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 conducted to investigate what landforms and vegetation types were most important seasonally to wildlife on the Colville Delta. Specifically, statistical analyses of habitat selection were performed for a subset of wildlife species, and habitat use was summarized for the remaining species. Habitat classification and mapping (Figure 3) of the Colville Delta 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, 1992–1998) were included in our assessments of distribution, abundance, and habitat use, where such inclusion was appropriate.

WILDLIFE SURVEYS

Both fixed-wing aircraft and helicopters were used to fly aerial surveys over the Colville Delta for selected bird and mammal species (Table 1). Aerial surveys covered the CD North study area (207 km², Figure 2), which was the larger of 2 areas 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 CD North study area, intensive searches were conducted on foot for nests and broods in the area proposed for oil development (henceforth, the ground-search area; Figure 2). The ground-search area in 2002 overlapped the ground-search areas in 2000 and 2001 (Figure 2) and was centered on the location of 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 2000–2002. Habitat selection (i.e., tests of preference and avoidance) from aerial survey data was not analyzed specifically for the CD North study area. 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 (these multi-year habitat selection analyses for the Colville Delta are presented in Appendices C and D). Habitat selection analyses also were conducted on nest locations of Spectacled Eiders and White-fronted Geese in the ground-search areas. Analyses of habitat selection were based on the locations of bird groups, bird nests or broods, and fox dens observed during either aerial surveys or ground surveys (Spectacled Eider and Greater White-fronted Goose nests, only). For each species, seasonal habitat use was calculated for applicable combinations of season (e.g., pre-nesting, nesting, and brood-rearing) and years 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 for a subset of species.

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 individuals in groups are probably not using a location independently. 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 was used in the analyses. For all other species, the parameters were calculated for each year of survey and pooled for all years for an overall assessment of habitat use. 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 using Monte Carlo simulations (Haefner 1996, Manly 1997). Each simulation used random numbers (range 0–100) to choose a habitat from the cumulative frequency distribution of the percent availability of habitats.

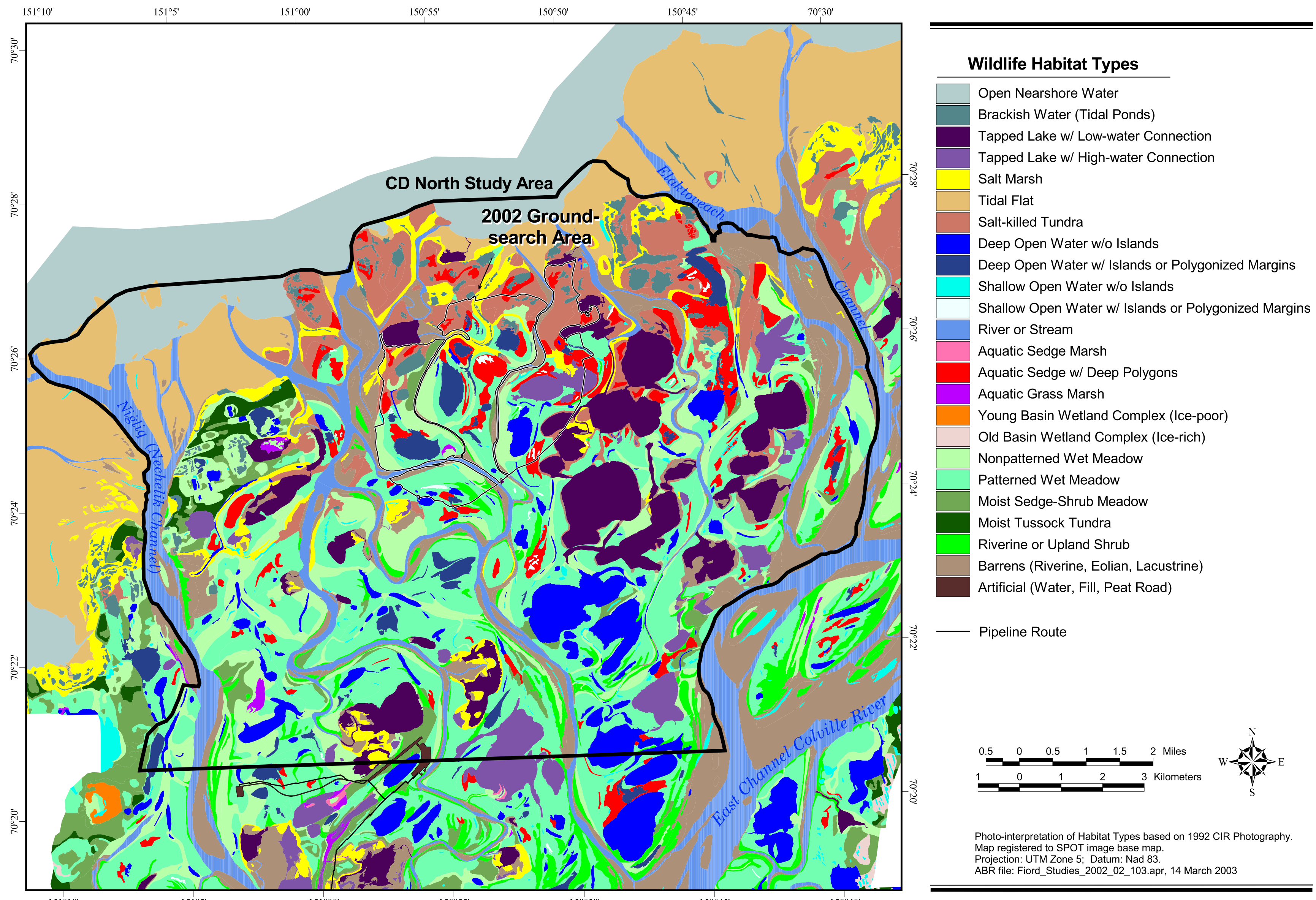

Figure 3. Habitat map of the CD North study area, Colville River Delta, Alaska.

Table 1. Descriptions of wildlife surveys conducted in the CD North study area, Colville River Delta, Alaska, 2002.

AREA SURVEYED Survey Type	Season	Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
CD NORTH GROUND-SEARCH AREA (18.9 km²)							
Large Waterbird Ground Searches[b]	Nesting	14–29 June	-	-	-	-	
	Brood-rearing[c]	16–18 July	-	-	-	-	Includes nest-fate check and loon nest search
	Brood-rearing	21–22 August	-	-	-	-	Primarily for loons
CD NORTH STUDY AREA (207 km²)							
Eider Survey	Pre-nesting	12–13 June	C185	0.4	0.4	30–35	
Tundra Swan Surveys	Nesting	22–24 June	C185	1.6	1.6	150	Includes survey for gull nests
	Brood-rearing	21–22 August	C185	1.6	1.6	150	
Yellow-billed Loon Surveys[d]	Nesting	25, 28 June	206L	n/a	n/a	60	Includes survey for gull nests
	Brood-rearing[e]	21 August	206L	n/a	n/a	60	
Goose Surveys	Brood-rearing	20 July	C206	0.8	1.6	90	
	Fall staging	24 August	C185	0.8	1.6	90	
Fox Den Surveys	Denning	29–30 June	206B	-	-	-	Status check at known den sites
	Denning	9–11 July	-	-	-	-	Pup observations at active den sites

[a] Dash indicates ground search, no aircraft used. C185 = Cessna 185 airplane; C206 = Cessna 206 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.

This procedure is analogous to distributing random points on the habitat map and tallying the habitats used. The number of "random choices" in a simulation was equal to the number of nests, dens, or groups of birds from which the observed 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 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 CD North study area in 2000 and 2001 (Johnson et al. 2000a, 2002), which were originally developed in the Colville wildlife studies in 1996–1998 and used in the Alpine project area in 1999–2001 (Johnson et al. 1997, 1998, 1999a, 1999b, 2000b, 2001, 2003). The 2002 CD North ground-search area comprised the area of potential disturbance (radius = 1,920 m) around a proposed airstrip and encompassed 18.9 km^2 (Figure 2); this area was similar to, but slightly larger than the 2001 ground-search area (17.9 km^2). The ground-search area in 2000 was smaller (12.2 km^2), covering preliminary descriptions of the proposed development area, as it was understood at that time (Johnson et al. 2000a). In all years, searching was conducted on foot within 10 m of the shorelines of all waterbodies, and with ~10-m spacing between adjacent observers walking zig-zag paths in all intervening habitat. Six to 16 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: species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. In 2002, the nest search was conducted between 14 and 29 June.

All nest locations were mapped on 1:18,000-scale color aerial photographs for later entry into a GIS database. In addition, the locations of most nests also were recorded using handheld global positioning systems (GPS). Down and feather samples were taken from some 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 included in species summaries (identified by footnotes in tables). All others were recorded as unidentified.

Nest sites of waterbirds in the ground-search area were revisited after hatch (between 16 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 21 and 22 August, all waterbodies ≥25 m long were searched primarily for loon broods, and all brood locations were recorded on aerial photographs.

Despite the intensive nature of the ground-search effort, nests of Tundra Swans and loons occasionally were found during aerial surveys that were not detected during the ground search. We have included all nests detected on aerial and ground surveys in summaries for the ground-search area. Because the same surveys were conducted each year, we assume that the results are comparable among years.

EIDERS

Aerial surveys were flown during the pre-nesting period (Table 1), 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 2002, the same methods were used as in previous years (1994–1998 and 2000–2001), although the survey areas differed in extent (Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 2000a, 2002). In 2002, the survey over the CD North and CD South study areas also 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; Figure 1) 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., doubling 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 >3 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.

Eider nests and broods were recorded during searches on foot in the CD North ground-search area as described above in the methods for Ground Searches for Nests and Broods. Unattended nests were identified to species by classification of color patterns on contour feathers (Anderson and Cooper 1994).

Habitat use was calculated for pre-nesting, nesting, and brood-rearing eiders. Pre-nesting habitat selection was analyzed for locations of groups (i.e., ≥1 individual bird) 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, and 2000–2002 were used. The pre-nesting survey in 1993 was flown at 50% coverage, and the survey in 2000 was flown at 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 availabilities of habitats for all years of a particular survey were summed and divided by the number of surveys to calculate the weighted habitat availability. Habitat selection for nesting Spectacled Eiders was calculated similarly, but only 2000–2002 nest search data were included, and habitat availability was calculated from the ground-search areas.

TUNDRA SWANS

In 2002, aerial surveys for nesting and brood-rearing Tundra Swans were flown during 22–24 June and 21–22 August, respectively (Table 1). 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. Two observers each visually searched 800-m-wide transects on opposite sides of the airplane while the pilot navigated and scanned for swans ahead of the airplane. 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. 2002). Beginning in 1995, each nest was photographed with a 35-mm camera for site verification. During nesting in 1992, the nesting survey differed from those of other years in that it was flown along east–west survey lines spaced 2.4 km apart (Smith et al. 1993). During brood-rearing in 1992, parallel lines oriented northeast–southwest were flown at ~2.4-km intervals.

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

Habitat use was calculated for Tundra Swan nests and broods found during 2000–2002 in the CD North study area, whereas habitat selection was calculated for nests and broods on the entire delta in 1992–1998 and 2000–2002. Each survey was flown at 100% coverage, so the entire Colville Delta was used for calculating available habitats. The 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. We have chosen to include all nest sites, while recognizing that all locations may not be annually independent.

LOONS

Aerial surveys for nesting and brood-rearing Yellow-billed Loons in the CD North study area in 2002 were conducted on 25 and 28 June and 21 August, respectively. Similar surveys have been conducted on the Colville Delta in 1993, 1995–1998, and 2000–2001 (Smith et al. 1994; Johnson et al. 1996, 1997, 1998, 1999a, 2000a, 2002). The area of the Colville Delta west of the Niġliq (see Figure 1) was included in the nesting aerial survey in 2002, but was not surveyed in previous years. 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 2000–2002, all surveys were conducted using a helicopter, whereas in previous years, surveys were conducted either by 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 2000–2002, lakes where Yellow-billed Loons were observed, but no nest was found on that initial survey, were resurveyed by helicopter. 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. 2000a). Observations of Pacific and Red-throated loons were recorded incidentally. Loon locations were recorded on 1:63,360-scale USGS maps.

The total adults, nests, broods, and young counted on aerial surveys were summarized by season for each species of loon 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 was calculated for Yellow-billed Loon nests and broods found in 2000–2002 in the CD North study area. Habitat selection was evaluated for Yellow-billed Loon nests and broods that were found on aerial surveys of the CD North and CD South study areas combined. Habitat selection was calculated for nest locations in 1993, 1995–1998, and 2000–2002 and for brood locations in 1995–1998 and 2000–2002.

GLAUCOUS GULLS

Glaucous Gull nests and broods were recorded during the nesting and brood-rearing aerial surveys for Tundra Swans and Yellow-billed Loons on the Colville Delta in 2001 and 2002 (see methods for Tundra Swans and Loons above). In 2000, Glaucous Gull nests and broods were recorded on the nesting and brood-rearing aerial surveys for Yellow-billed Loons. 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 in 2000 and 2001. Those surveys were conducted by a single observer in a helicopter. During foot searches in the CD North ground-search area, nest locations of Glaucous Gulls were recorded on aerial photographs and/or stored in GPS receivers.

GEESE

In 2002, systematic aerial surveys for geese were conducted during the brood-rearing (20 July) and fall-staging (24 August) periods. These surveys were developed originally in 1996 to count Greater White-fronted Geese (hereafter, 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. Two observers (including the pilot) searched 400-m-wide strips on opposite sides 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 surveys in 1997, 1998, 2000, and 2001 also was 50%, but in 1996 coverage was equivalent to 25% with 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 Delta in 2000–2002, 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 29–30 June 2002, and active dens were observed during 9–11 July 2002 to count pups (Table 1). Most survey effort was focused on checking dens found in previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a, 2001, 2002), 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.

RESULTS AND DISCUSSION

HABITAT AVAILABILITY

Twenty-four habitats were classified and mapped on the Colville Delta (Johnson et al. 1996), of which 21 occurred in the CD North study area (Figure 3, Table 2). 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 2002, Wet Sedge–Willow Meadow was renamed Patterned Wet Meadow, because the latter name better describes the surface form of this habitat.

In the CD North study area, the most abundant habitats were Patterned Wet Meadow (20% of the total area), Barrens (11%), Nonpatterned Wet Meadow (10%), and Tapped Lake with Low-water Connection (9%; Table 2). 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 a large proportion of lakes that are tapped or brackish from flooding. Because the CD North study area is on the outer delta, it contains larger proportions of coastal habitats—Open Nearshore Water, Brackish Water, Tapped Lake with Low-water Connection, Salt Marsh, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons—than does 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 2002 (henceforth, the ground-search area; Figure 3) contained 18 habitats, of which all but 5 occupied >1% of the search area (Table 3). Patterned Wet Meadow occurred over the most area (24% of total), followed by Salt-killed Tundra (15%), Nonpatterned Wet Meadow (14%), Aquatic Sedge with Deep Polygons (12%), and Deep Open Water with Islands or Polygonized Margins (10%).

CONDITIONS IN THE STUDY AREA IN 2002

The 2002 breeding season differed from the preceding 2 years in that snowmelt occurred much earlier and temperatures in May were much warmer. Snow was gone by 17 May at Colville Village (the Helmerick's home site, a coastal location with conditions similar to the CD North

Table 2. Availability of wildlife habitat types in the CD North study area, Colville River Delta, Alaska, 2002.

Habitat	CD North Study Area Area (km²)	CD North Study Area Availability (%)	Colville Delta Area (km²)	Colville Delta Availability (%)
Open Nearshore Water	7.12	3.4	10.02	1.8
Brackish Water	4.01	1.9	6.53	1.2
Tapped Lake with Low-water Connection	17.76	8.6	21.62	3.9
Tapped Lake with 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 without Islands	10.04	4.9	20.77	3.8
Deep Open Water with Islands or Polygonized Margins	4.21	2.0	7.76	1.4
Shallow Open Water without Islands	0.89	0.4	2.02	0.4
Shallow Open Water with 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
Patterned Wet 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	22.29	10.8	78.67	14.3
Artificial	0.15	0.1	0.39	<0.1
TOTAL	206.87	100	551.67	100

ground-search area) compared with 10 June in 2000 and 7 June in 2001. The mean temperature in May 2002 was –2.7° C, whereas the 6-yr mean (1997–2002) was –6.3° C (NOAA: http://lwf.ncdc.noaa.gov). The mean temperature in June 2002 was 3.2° C, similar to the 6-yr mean (1997–2002) of 3.4° C.

For the period of bird arrival (approximately 15–31 May) and nest initiation (1–15 June), 54 thawing-degree days accumulated in 2002, compared to 17 and 34 thawing-degree days in 2000 and 2001, respectively (Figure 4). (Cumulative thawing-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.) In the adjacent Kuparuk Oilfield, the total number of thawing-degree days in 2002 for the combined arrival and nest initiation periods was the third highest recorded since avian studies were initiated there in 1988 (Anderson et al. 2002, 2003). The warmer temperatures and lack of snow in 2002 suggests that birds encountered favorable conditions at the time they were initiating nests.

Temperatures in late June were cool, averaging <4° C. Snow fell on 20, 22, and 23 June and on 2–4 July. A storm with high winds moved through the coastal areas in early July. The same

Table 3. Availability of wildlife habitat types in the CD North ground-search areas, Colville River Delta, Alaska, 2000–2002.

Habitat	2000		2001		2002	
	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Brackish Water	0.76	6.2	0.50	2.8	0.59	3.1
Tapped Lake with Low-water Connection	0.01	0.1	0.29	1.6	0.28	1.5
Tapped Lake with High-water Connection	0	0	0.87	4.9	0.87	4.6
Salt Marsh	0.86	7.0	0.74	4.1	0.75	4.0
Tidal Flat	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1
Salt-killed Tundra	3.51	28.8	1.88	10.5	2.78	14.7
Deep Open Water without Islands	0.11	0.9	0.75	4.2	0.75	4.0
Deep Open Water with Islands or Polygonized Margins	1.19	9.7	1.81	10.1	1.81	9.6
Shallow Open Water without Islands	0.01	0.1	0.05	0.3	0.05	0.3
Shallow Open Water with Islands or Polygonized Margins	0.07	0.5	0.15	0.8	0.15	0.8
River or Stream	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1
Aquatic Sedge with Deep Polygons	1.83	15.0	2.10	11.7	2.23	11.8
Aquatic Grass Marsh	0	0	0.04	0.2	0.04	0.2
Nonpatterned Wet Meadow	1.09	8.9	2.70	15.1	2.70	14.3
Patterned Wet Meadow	2.08	17.1	4.54	25.4	4.54	24.0
Moist Sedge–Shrub Meadow	0.43	3.5	0.44	2.4	0.44	2.3
Riverine or Upland Shrub	0	0	0.22	1.3	0.22	1.2
Barrens	0.25	2.0	0.82	4.6	0.71	3.8
TOTAL	12.20	100	17.90	100	18.89	100

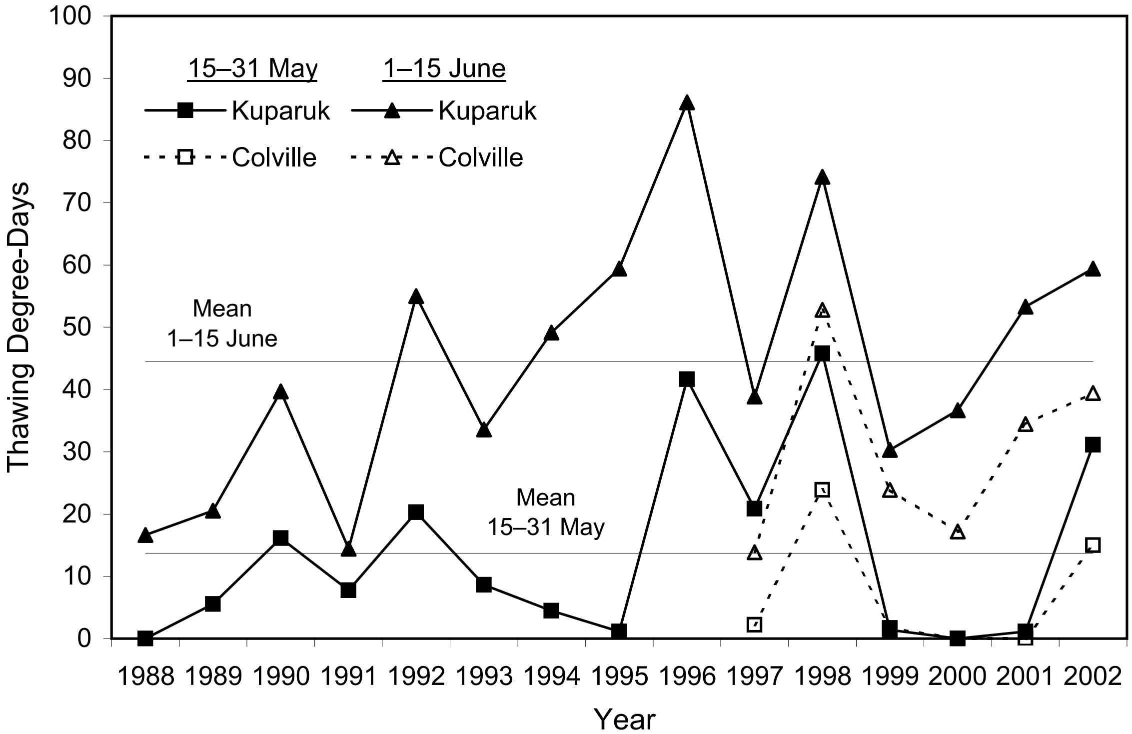

Figure 4. Cumulative number of thawing degree-days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield (1988–2002) and Colville River Delta (1997–2002), Alaska. Mean values computed from Kuparuk data (*n* = 15 years).

storm, moving eastward, was responsible for the loss by flooding of several Tundra Swan nests monitored on the Mackenzie River Delta (H. Swystun, Univ. Northern British Columbia, pers. comm.). We suspect that weather conditions at the time of hatch and early in the brood-rearing period adversely affected productivity of many species of birds on the Colville Delta in 2002.

NESTS AND BROODS IN THE GROUND-SEARCH AREA

NESTS

In 2002, 346 nests of 19 species were recorded in the CD North ground-search area and overall nesting success was 64% (Table 4). The number of nests found in 2002 was greater than in 2000 (245 nests) and 2001 (299 nests), although the 2000 search area was much smaller. Nesting success in 2002 also was higher than that in 2001 (52%), but similar to 2000 (62%). Habitats with polygonal surface forms contained the highest numbers of nests in all years combined: Patterned Wet Meadow contained 247 nests (28% of all nests), Aquatic Sedge with Deep Polygons contained 218 nests (25%), Deep Open Water with Islands and Polygonized Margins contained 136 nests (15%), and Salt-killed Tundra contained 105 nests (12%; Table 5). Eighty-five nests (10%) were found in Nonpatterned Wet Meadow.

Nest density in 2002 (18.3 nests/km²) was lower than in 2000 (20.1 nests/km²), but was greater than in 2001 (16.7 nests/km²; Table 6). The size and location of the 2001 and 2002 ground-search areas was virtually identical, but the 2000 area, while smaller, encompassed some productive lakes to the north of the 2000–2001 ground-search areas (Figure 2). Similar to previous years, more than half of the nests in 2002 belonged to geese, with most belonging to White-fronted Geese (213 nests), followed by Brant (23 nests) (Figure 5; Table 4). In 2002, for the first time, Canada Geese were found nesting in the ground-search area (2 nests). Snow Goose nests were found in 1994 (2 nests), 1997 (1 nest), and 2002 (1 nest). Duck nests were also common in 2002, and belonged primarily to Long-tailed Ducks (23 nests), and eiders: Spectacled (7 nests), King (3), and unidentified eiders (2 nests; Figure 5). The first Northern Shoveler nest was found in

Table 4. Number of nests and nesting success of birds in the CD North ground-search areas in 2000 (12.2 km²), 2001 (17.9 km²), and 2002 (18.9 km²), Colville River Delta, Alaska.

	Number of Nests						Nesting Success (%)[a]		
	2000	2001	2002						
Species	Total	Total	Total	Successful	Failed	Unknown Fate	2000	2001	2002
Red-throated Loon[b]	10	9	10	4	1	5	–	–	–
Pacific Loon	9	11	18[c]	7	1	10	–	–	–
Yellow-billed Loon	2	4[c]	5	1	0	4	–	–	–
Greater White-fronted Goose	120	177[d]	213	149	51	13	75	62	75
Snow Goose	0	0	1	1	0	0	–	–	100
Canada Goose	0	0	2	2	0	0	–	–	100
Brant	30	24	23[d]	13	8	2	10	29	62
Unidentified goose	0	0	1	0	0	1	–	–	–
Tundra Swan	3	3	9[c]	5	2	2	67	100	71
Northern Pintail	3[d]	2[d]	2	0	2	0	0	0	0
Northern Shoveler	0	0	1	0	1	0	–	–	0
Spectacled Eider	14[d]	7[d]	7[d]	2	5	0	43	14	29
King Eider	2	0	3[d]	0	3	0	100	–	0
Unidentified eider	0	0	2	0	2	0	–	–	0
Long-tailed Duck	18[d]	21[d]	23[d]	0	21	2	44	5	0
Unidentified duck	1	1	2	0	2	0	0	0	0
Willow Ptarmigan	8	8	2	1	0	1	–	–	–
Unidentified ptarmigan	0	1	0	0	0	0	–	–	–
Bar-tailed Godwit	0	0	1	0	0	1	–	–	–
Parasitic Jaeger	1	2	2	1	0	1	–	–	–
Glaucous Gull	10	3	5	1	2	2	89	33	33
Sabine's Gull	5	9	4	1	0	4	–	–	–
Arctic Tern	9	17	10	0	1	9	100	–	–
TOTAL	245	299	346	173[a]	99[a]	57	62	52	64

[a] Estimates are not provided for loons, ptarmigan, jaegers, Sabine's Gulls, or 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, 3 in 2001, and 1 in 2002 that were presumed present from the presence of broods observed during fate checks.
[c] Includes some nests observed during aerial surveys.
[d] Includes nests identified to species from down and feather characteristics.

the CD North ground-search area in 2002. Nine Tundra Swan nests were found in 2002 (2 from aerial surveys, the remainder during ground searches), ~3× the number found in previous years. The number of loon nests also was up slightly in 2002, with 5 Yellow-billed Loon and 18 Pacific Loon nests (2 from aerial surveys only) (Figure 6, Table 4). The number of Red-throated Loon nests (10) was similar to numbers in previous years. 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, farther south on the delta (Table 6).

Nests of Long-tailed Ducks were 3–6 times more abundant in the CD North ground-search area in all years than in the CD South and Alpine ground-search areas (Table 6). Nesting success was fair to poor in all years (44% in 2000, 5% in 2001, and 0% in 2002). In all years, Long-tailed

Table 5. Relative abundance (%) of nests by species in each habitat type in and near the CD North ground-search areas, Colville River Delta, Alaska, 2000–2002. Nests were found during ground and aerial surveys.

Habitat	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Canada Goose	Brant[a]	Tundra Swan	Northern Pintail	Spectacled Eider[a]	King Eider[a]	Unidentified Eider	Long-tailed Duck[a]	Willow Ptarmigan	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Total Nests
Brackish Water	11	16	0	<1	0	8	0	0	4	0	0	0	0	0	33	0	0	3	23
Tapped Lake with High Water Connection	0	18	0	<1	0	0	0	0	0	0	0	2	0	0	0	0	3	1	10
Salt Marsh	0	3	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	1	10
Salt-killed Tundra	11	3	0	13	0	1	39	29	39	40	0	5	22	0	0	33	0	12	105
Deep Open Water without Islands	0	11	8	1	0	0	6	0	0	0	0	11	0	0	0	0	0	2	18
Deep Open Water with Islands or Polygonized Margins	4	32	67	2	100	77	6	14	7	0	50	22	0	0	56	28	33	15	136
Shallow Open Water without Islands	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1
Shallow Open Water with Islands or Polygonized Margins	11	8	0	2	0	1	0	0	0	0	0	3	0	0	0	6	14	3	24
Aquatic Sedge with Deep Polygons	46	3	0	30	0	6	39	14	18	40	0	21	11	20	11	6	25	25	220
Aquatic Grass Marsh	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Nonpatterned Wet Meadow	7	3	0	11	0	3	0	14	11	0	50	10	22	60	0	17	6	10	85
Patterned Wet Meadow	11	5	25	38	0	3	11	0	21	20	0	19	44	20	0	11	17	28	246
Moist Sedge–Shrub Meadow	0	0	0	1	0	0	0	14	0	0	0	5	0	0	0	0	0	1	8
Riverine or Upland Shrub	0	0	0	<1	0	0	0	14	0	0	0	2	0	0	0	0	0	0	4
Barrens	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total %	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Total Nests	28	38	12	517	2	77	16	7	28	5	2	63	18	5	18	18	36		892

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

Table 6. Densities of nests (nests/km²) in the CD North ground-search areas (2000–2002), and mean nest density in the CD South ground-search area (2000–2002) and in the Alpine project area (1996–2001), Colville River Delta, Alaska. Alpine data are from Johnson et al. (2003) and CD South data are from Burgess et al.(2003a).

Species	CD North 2000	CD North 2001	CD North 2002	CD North 3-year Mean	CD South 3-year Mean	Alpine 6-year Mean
Red-throated Loon	0.8[a]	0.5[a]	0.5[a]	0.6[a]	0.2[a]	0.2
Pacific Loon	0.7	0.6	1.0[b]	0.8[b]	0.4	0.5
Yellow-billed Loon	0.2	0.2[b]	0.3	0.2[b]	0.1[b]	0.1
Red-necked Grebe	0	0	0	0	0.1	0.1
Greater White-fronted Goose	9.8	9.9[c]	11.3	10.3[c]	4.6	3.4[c]
Snow Goose	0	0	0.1	<0.1	0	0
Canada Goose	0	0	0.1	<0.1	0	0.1
Brant	2.5	1.3	1.2[c]	1.7[c]	0	0.2[c]
Unidentified goose	0	0	0.1	<0.1	0	0
Tundra Swan	0.2	0.2	0.4[b]	0.3	0.3	0.4
Mallard	0	0	0	0	<0.1	0
Northern Shoveler	0	0	0.1	<0.1	0.1[c]	0.1[c]
Northern Pintail	0.2[c]	0.1[c]	0.1	0.2	1.3[c]	0.5[c]
Green-winged Teal	0	0	0	0	<0.1	0.1[c]
Greater Scaup	0	0	0	0	<0.1	0.1
Lesser Scaup	0	0	0	0	0	<0.1
Unidentified scaup	0	0	0	0	0.1	0.1[c]
Spectacled Eider	1.1[c]	0.4[c]	0.4[c]	0.6	0.1	<0.1
King Eider	0.2	0	0.2[c]	0.1[c]	0	<0.1
Unidentified Eider	0	0	0.1	<0.1[c]	0	0
Long-tailed Duck	1.5[c]	1.2[c]	1.2[c]	1.3	0.2[c]	0.4[c]
Unidentified duck	0.1	0.1	0.1	0.1[c]	0.1	0.1
Northern Harrier	0	0	0	0	<0.1	0
Willow Ptarmigan	0.7	0.4	0.1	0.4	1.6	0.7
Rock Ptarmigan	0	0	0	0	0.1	<0.1
Unidentified ptarmigan	0	0.1	0	<0.1	0	0.1
Sandhill Crane	0	0	0	0	0	<0.1
Whimbrel	0	0	0	0	0.1	0
Bar-tailed Godwit	0	0	0.1	<0.1	0.1	0.1
Common Snipe	0	0	0	0	0	<0.1
Parasitic Jaeger	0.1	0.1	0.1	0.1	<0.1	0.1
Long-tailed Jaeger	0	0	0	0.3	0.2	0.1
Glaucous Gull	0.8	0.2	0.3	0.4	0.1	0.1
Sabine's Gull	0.4	0.5	0.2	0.7	0	<0.1
Arctic Tern	0.7	0.9	0.5	0.4	0.4	0.4
Short-eared Owl	0	0	0	0	0.1	<0.1
Area searched (km²)	12.2	17.9	18.9		5.8–10.0	11.4–17.2
Waterbird[d] nest density	19.4	16.2	18.2	17.9	8.6	7.3
Total nest density	20.1	16.7	18.3	18.4	10.2	7.9
Total number of nests	245	299	346		79–82	69–182
Number of species	15	14	19		14–17	16–20

[a] Includes nests that were presumed present from the presence of broods during the nest fate or aerial brood surveys.
[b] Includes 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.

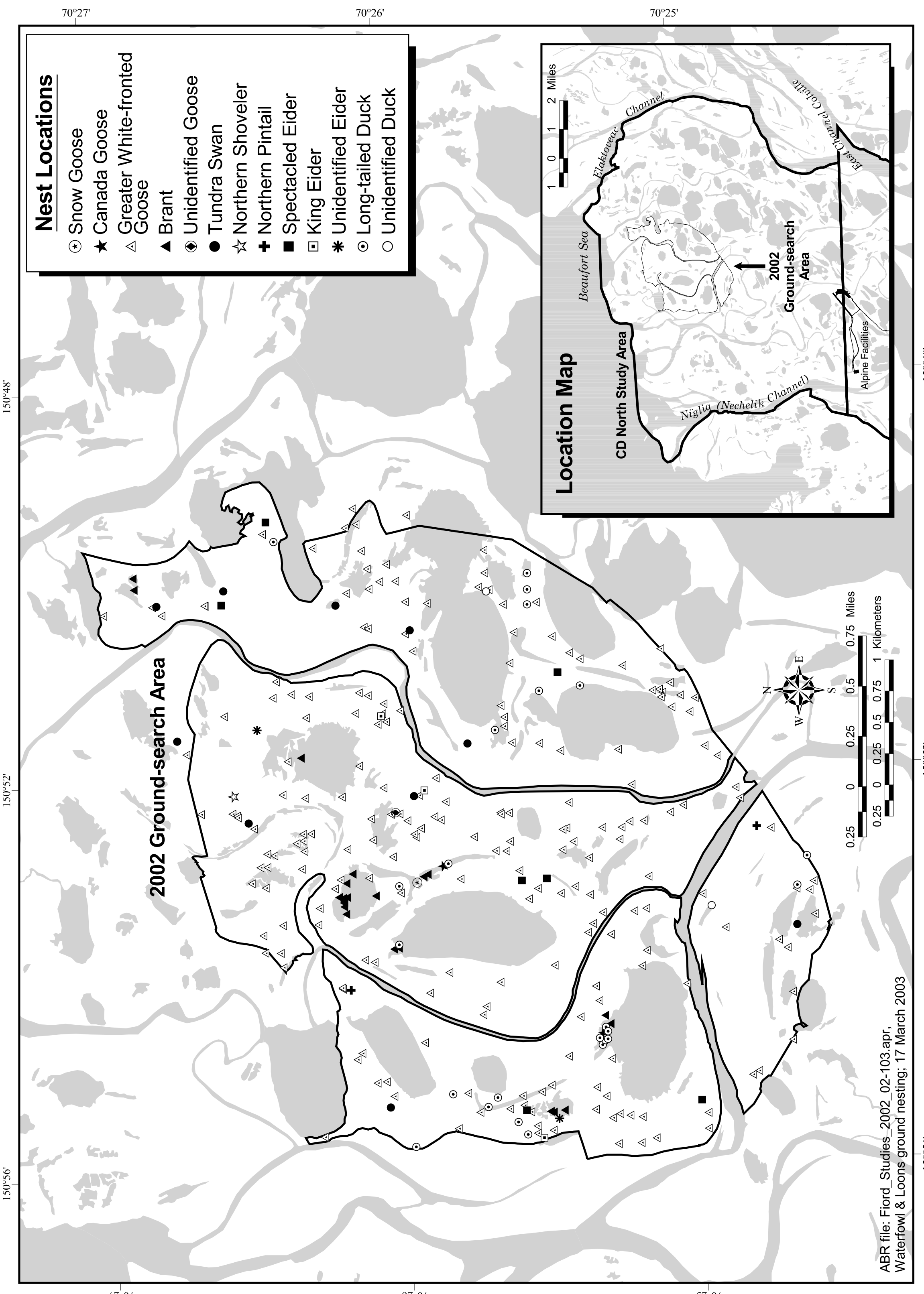

Figure 5. Distribution of waterfowl nests recorded on ground and aerial surveys in the CD North ground-search area, Colville River Delta, Alaska, 2002.

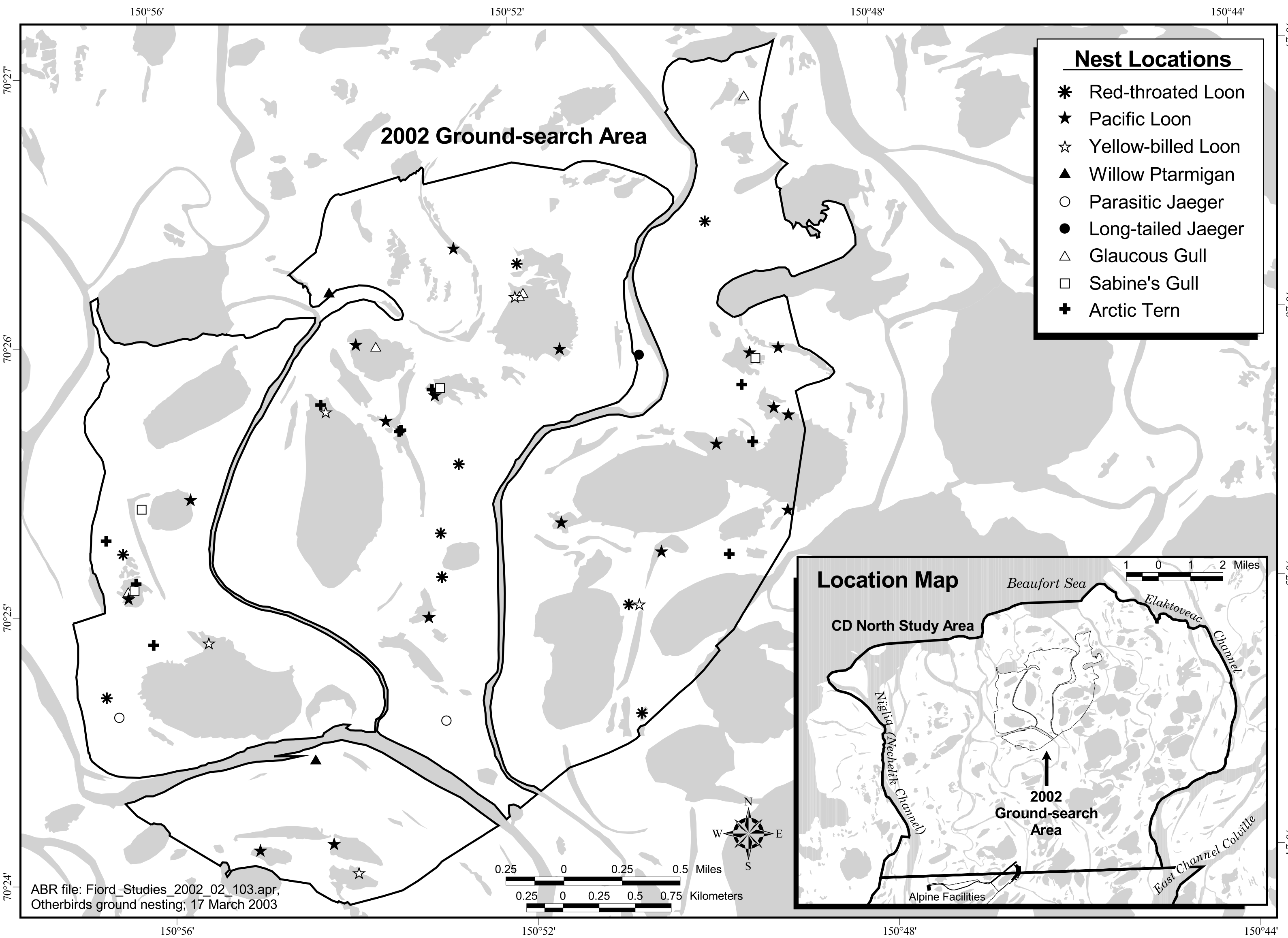

Figure 6. Distribution of selected bird nests recorded on ground and aerial surveys in the CD North ground-search area, Colville River Delta, Alaska, 2002.

Duck nests occurred most frequently in Deep Open Water with Islands or Polygonized Margins (35% of all nests) and Aquatic Sedge with Deep Polygons (21%; Table 5). Most nests in all years were found either on islands (23 nests; 37% of the total) or polygon rims (19 nests; 31%). Two to three Northern Pintail nests also were found each year, although none hatched (Table 4). The density of Northern Pintail nests in 2000–2002 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 6). 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 those recorded for any other location on the Arctic Coastal Plain (Rothe et al. 1983).

Gulls and terns were common nesters in the CD North ground-search areas in all 3 years (Figure 6, Table 4). Numbers of Glaucous Gull nests have varied among years, ranging from 3 to 10. Nesting success of Glaucous Gulls was 89% in 2000 and 33% in both 2001 and 2002. The number of Sabine's Gull nests ranged from 4 to 9, while the number of Arctic Tern nests ranged from 9 to 17. For both of these species, evidence for determining nesting success was often lacking. In 2000, all nests of Arctic Terns were judged to have hatched, but in 2001 and 2002, the fate of most nests was unknown. The fate of most Sabine's Gull nests was unknown in all years. Nest densities for all the gull and tern nests were higher in the CD North ground-search areas than in either the CD South or Alpine ground-search areas (Table 6). Glaucous Gull and Arctic Tern nests were located primarily on islands in aquatic habitats, whereas Sabine's Gull nests were located in both terrestrial and aquatic habitats (Table 5).

Two Parasitic Jaeger nests were found in the CD North ground-search area in 2002 (Figure 6), similar to previous years (Table 4). Although one nest hatched successfully, the fate of the other was unknown. Only 2 nests of Willow Ptarmigan were located in 2002, compared to 8 in each previous year. Hatching success was not calculated for ptarmigan nests because it is difficult to relocate nest bowls consistently. The mean density of Willow Ptarmigan nests (0.4 nests/km², *n* = 3 years) in the CD North ground-search area was lower than the mean density in the Alpine ground-search area (0.7 nests/km², *n* = 6 years), and substantially lower than the mean density in the CD South ground-search area (1.6 nests/km², *n* = 3 years; Table 6).

BROODS

During nest-fate checks and ground searches for broods in the CD North ground-search area in 2002, 34 broods of 10 species were recorded (Figure 7, Table 7). Although more broods and species were seen in 2002 than in 2001, the most broods were seen in 2000 (50 broods of 11 species). The number of White-fronted Goose broods ranged from 2 to 11 each year. A Yellow-billed Loon brood was seen only in 2002, but 5–7 Red-throated and 3–7 Pacific loon broods were seen each year. No broods of Arctic Terns were seen in either 2001 or 2002, 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 in all 3 years were recorded most often in Deep Open Water with Islands or Polygonized Margins (30 broods or 25% of all broods), Aquatic Sedge with Deep Polygons (22 broods, 19%), and Salt-killed Tundra (15 broods, 13%; Table 8).

EIDERS

BACKGROUND

The Spectacled Eider population on the Yukon-Kuskokwim Delta in western Alaska suffered a large decline (96%) between 1957 and 1992 (Kertell 1991, Stehn et al. 1993), and populations also may have declined in northern Alaska and in Russia (USFWS 1996). As a result, the Spectacled Eider was listed as a threatened species under the Endangered Species Act in 1993 (58 FR 27474–27480). Since 1993, the western Alaska population appears to be stable or slightly declining (Petersen et al. 2000), and the northern Alaska population has possibly declined <2%, but the trend is not significant (Larned et al. 2003). Spectacled Eiders nest on the arctic coast of Siberia (Bellrose 1980), in western Alaska on the

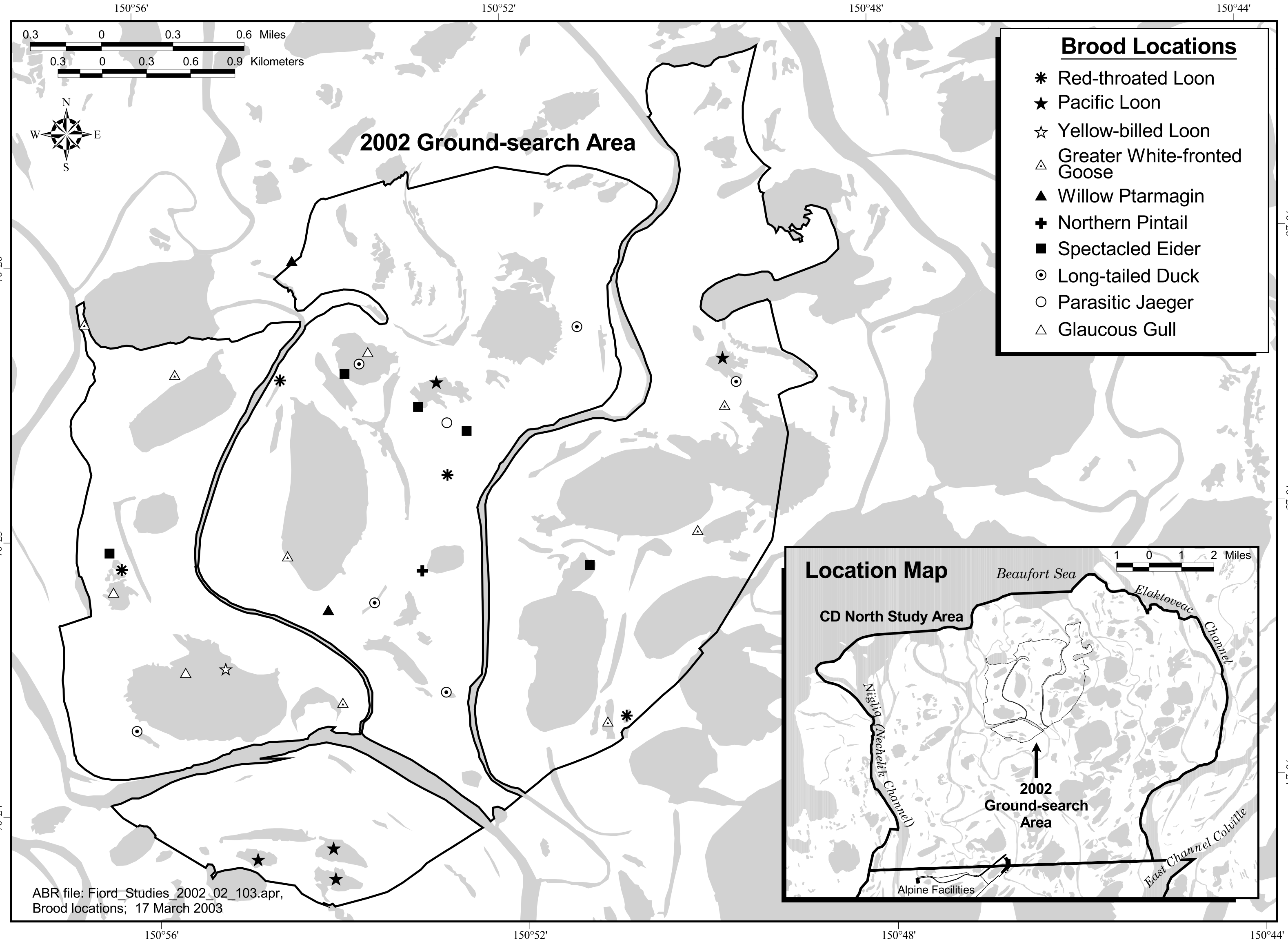

Figure 7. Distribution of broods recorded during ground and aerial surveys in the CD North ground-search area, Colville River Delta, Alaska, July and August, 2002.

Table 7. Counts of brood-rearing adults and young birds in the CD North ground-search areas in 2000 (12.2 km²), 2001 (17.9 km²), and 2002 (18.9 km²), Colville River Delta, Alaska.

	2000				2001				2002			
Species	No. of Adults	No. of Young	Total Birds	Total Broods	No. of Adults	No. of Young	Total Birds	Total Broods	No. of Adults	No. of Young	Total Birds	Total Broods
Red-throated Loon	8	9	17	7	7	5	12	5	7	5	12	4
Pacific Loon	5	4	9	3	9	7	16	7	7	7	14	5
Yellow-billed Loon	0	0	0	0	0	0	0	0	2	1	3	1
Greater White-fronted Goose	25	41	64	11	3	8	11	2	12	17	28	7
Brant	1	8	9	1	0	0	0	0	0	0	0	0
Tundra Swan	0	0	0	0	4	4	8	2	0	0	0	0
Northern Pintail	2	10	12	2	0	0	0	0	1	3	4	1
Spectacled Eider	7	26	33	7[a]	4	6	10	3	5	13	18	5
Long-tailed Duck	3	8	11	3	2	10	12	2	6	26	31	6
Red-breasted Merganser	0	0	0	0	1	5	6	1	0	0	0	0
Willow Ptarmigan	0	0	0	0	0	0	0	0	2	2	4	1
Parasitic Jaeger	1	2	3	1	0	0	0	0	2	2	4	1
Glaucous Gull	9	10	19	5	1	2	3	1	6	4	10	3
Sabine's Gull	5	4	9	3	7	7	14	4	0	0	0	0
Arctic Tern	14	10	24	7	0	0	0	0	0	0	0	0
TOTAL	80	132	210	50	38	54	92	27	50	80	128	34

[a] One brood found during helicopter survey.

Table 8. Relative abundance (%) of broods by species in each habitat type in and near the CD North ground-search areas, Colville River Delta, Alaska, 2000–2002.

Habitat	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Brant	Tundra Swan	Northern Pintail	Spectacled Eider	Long-tailed Duck	Willow Ptarmigan	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Total Broods
Brackish Water	13	13	0	5	0	33	0	0	0	0	0	20	0	0	7	8
Tapped Lake with Low-water Connection	0	0	0	0	50	0	0	6	0	0	0	10	0	0	3	3
Tapped Lake with High-water Connection	0	27	0	0	0	0	0	6	0	0	0	0	0	0	4	5
Salt Marsh	0	0	0	5	0	0	0	0	0	0	0	0	0	0	1	1
Salt-killed Tundra	6	0	0	33	50	0	0	6	9	50	50	0	29	0	13	15
Deep Open Water without Islands	6	13	0	0	0	0	33	17	27	0	0	0	14	0	9	11
Deep Open Water with Islands or Polygonized Margins	0	27	100	14	0	67	33	39	18	0	0	60	14	43	25	30
Shallow Open Water without Islands	0	0	0	0	0	0	0	0	27	0	0	0	0	0	3	3
Shallow Open Water with Islands or Polygonized Margins	19	20	0	5	0	0	0	0	0	0	0	0	14	14	8	9
Aquatic Sedge with Deep Polygons	50	0	0	19	0	0	33	22	18	0	50	10	0	14	19	22
Nonpatterned Wet Meadow	6	0	0	14	0	0	0	0	0	50	0	0	14	14	6	7
Patterned Wet Meadow	0	0	0	5	0	0	0	6	0	0	0	0	14	14	3	4
Total %	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Total Broods	16	15	1	21	2	3	3	18	11	2	2	10	7	7		118

Yukon-Kuskokwim Delta, and in northern Alaska along the Chukchi and Beaufort sea coasts from Wainwright to Demarcation Point (Gabrielson and Lincoln 1959, Dau and Kistchinski 1977, Petersen et al. 2000). 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). Spectacled Eiders arrive on the Colville Delta in early June, and nest as early as 8 June and 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).

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 Kuukpik (Colville River) (Derksen et al. 1981). On the Colville Delta, they are common visitors but uncommon or rare breeders (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). A pair of Common Eiders was seen on the delta in 1992, 7 were seen in 1998, and 3 were seen in 2001; one nest was found on an island in the outermost delta in 1994 (Johnson et al. 2002).

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.; a pair in 2001, Johnson et al. 2002).

DISTRIBUTION AND ABUNDANCE

Pre-nesting

In 2002, the eider pre-nesting survey was conducted on 12–13 June, within the time-frame typically flown in previous years. All Spectacled Eider groups seen on the survey contained 1–3 birds and appeared to be dispersed into potential breeding habitat. We suspect our survey timing relative to spring phenology was slightly later than the timing of surveys conducted in 2000 and 2001. Snowmelt was advanced and temperatures were higher in early June 2002 compared with conditions in 2000–2001.

The distribution of both Spectacled and King eiders during pre-nesting in 2002 was similar to that observed in previous surveys between 1993 and 2001 (no survey occurred in 1999; Figure 8, Appendices C1 and C2). Spectacled and King eiders on the Colville Delta were closely associated with coastal areas in all years. During 2002, the mean (3.7 km, $n = 15$ sightings) and maximal distances (8.8 km) of Spectacled Eiders from the coast were slightly less than the distances for all years combined ($\bar{x} = 4.0$ km, maximum = 14.3 km, $n = 233$ sightings, 1993–2002 [1992 not included because survey coverage of the delta was incomplete]). Derksen et al. (1981) also reported that Spectacled Eiders in the NPRA were attracted to coastal areas. On the Indigirka River 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 1993 and 2002 was 14.2 km, and the mean was 4.9 km ($n = 154$ sightings).

Spectacled Eiders have been the numerically dominant eider species during the pre-nesting surveys in the CD North study area in all 8 previous years. This pattern was broken in 2002

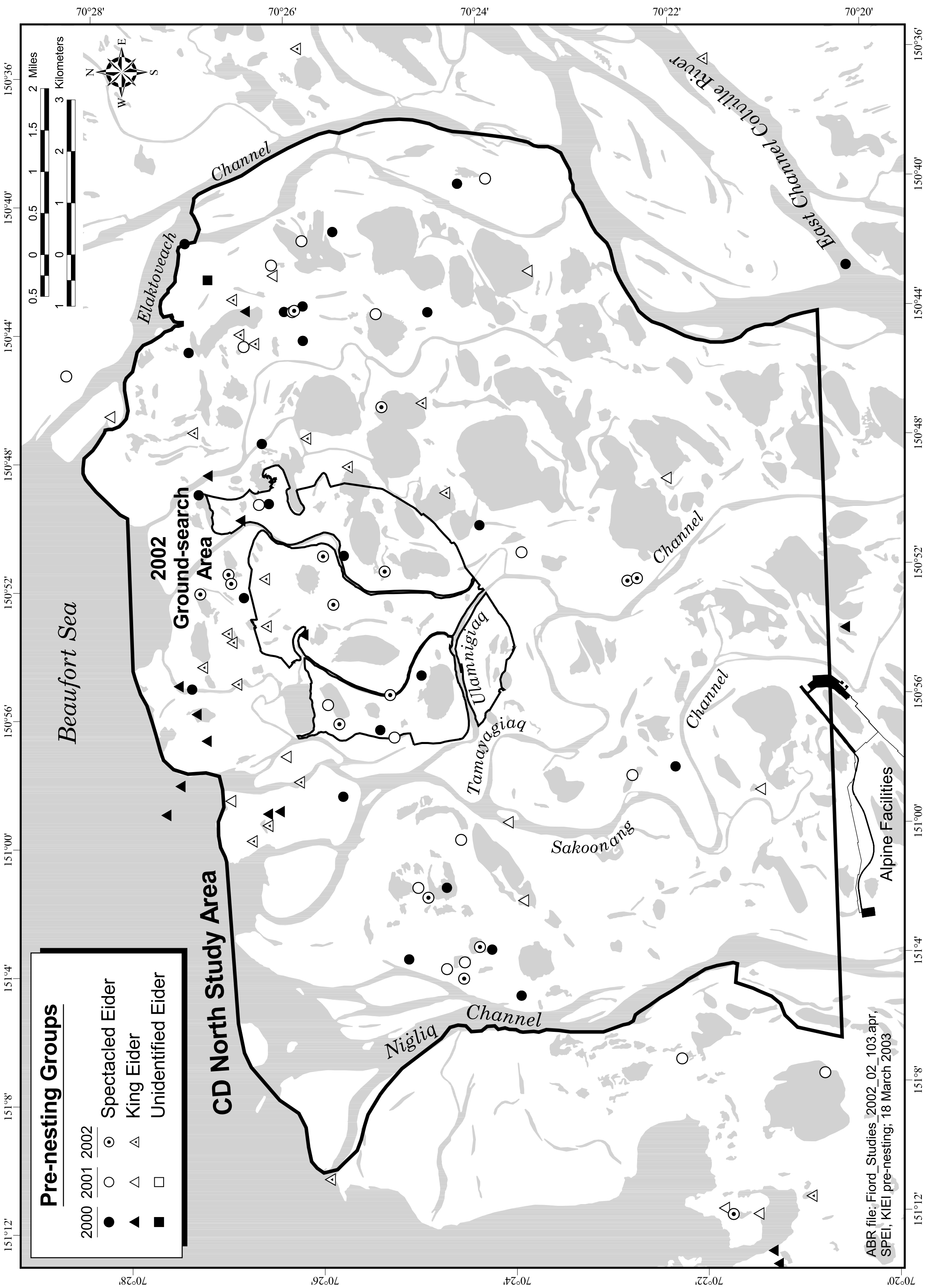

Figure 8. Distribution of Spectacled and King eider groups (flying and on the ground) recorded during pre-nesting aerial surveys in the CD North study area, Colville River Delta, Alaska, 2000–2002.

with Spectacled Eiders making up 46% (26 birds) and King Eiders 54% (31 birds) of the total eiders observed (Table 9). However, Spectacled Eiders were numerically dominant (30 birds) in indicated total birds (USFWS 1987a), because 12 King Eiders were flying, which are not counted towards indicated totals (Table 9).

The observed density of Spectacled Eiders in the CD North study area in 2002 (0.13 birds/km², Table 10) was the lowest since 1993 (1992 was not included because the sample of plots was not representative of the delta). In 2002, break-up of lakes and channels was more advanced than in 2000 and 2001, and observation conditions during the survey were good. Low numbers of Spectacled Eiders in 2002 may be an artifact of the survey timing being late relative to the departure of male Spectacled Eiders. Low densities also occurred in 1996, when 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 to those recorded across the entire Arctic Coastal Plain and do not indicate growth or decline of the Spectacled Eider population (Figure 9). The indicated density of Spectacled Eiders in CD North ($\bar{x}$ = 0.20, *n* = 9 years) was similar to the density measured on the entire Arctic Coastal Plain ($\bar{x}$ = 0.23, *n* = 10 years; Larned et al. 2003). The growth rate for the coastal plain population is slightly negative (0.987 growth) but not significantly different from a growth rate of 1.0 (90% CI = 0.95–1.02; Larned et al. 2003), which suggests that numbers are stable. Counts of pre-nesting Spectacled Eiders in the nearby Kuparuk Oilfield also fail to display an obvious trend (Figure 9).

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 study area lacks (Burgess et al. 2003a). The CD North study area also attracts higher densities of Spectacled Eiders than the Kuparuk Oilfield immediately to the east ($\bar{x}$ = 0.08 birds/km², *n* = 9 years; Anderson et al. 2003) and the NPRA development area immediately to the west (0.02 birds/km²; Burgess et al. 2003b); however, the Kuparuk and NPRA survey areas extended farther inland and probably included areas of less favorable habitat.

King Eiders in CD North displayed different distributions and annual trends during pre-nesting than did Spectacled Eiders. Most King Eiders on the delta during pre-nesting are located in the large river channels on the delta's east side, outside the CD North study area boundaries (Appendix C2). The densities (both observed and indicated) of King Eiders in 2000–2002 (0.08–0.15 observed birds/km² and 0.08–0.11 indicated birds/km², respectively) in the CD North study area were the 3 highest annual densities recorded since 1993 (Table 10). However, the low density of King Eiders in the CD North study area relative to other areas on the Arctic Coastal Plain obscures any long-term trend (Figure 10). 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 10). The CD South study area inland on the delta supported even lower densities of King Eiders (Burgess et al. 2003a) than occurred in the CD North study area.

Nesting

Seven Spectacled Eider nests (including 2 that were identified by color patterns on contour feathers in the nest; Anderson and Cooper 1994) were found in the CD North ground-search area (18.9 km²) during 2002, for a density of 0.4 nests/km² (Figure 11). The same number was found in 2001, and twice that number was found in 2000 in an overlapping but different search area (Figure 2). Clutch sizes were counted only for those nests whose hens were flushed unintentionally. Mean clutch size for Spectacled Eider nests in 2002 (2.5 eggs/nest, *n* = 2 nests) was lower than the overall mean since 1992 (4.0 eggs/nest, *n* = 27 nests). Apparent nesting success for Spectacled Eiders in 2002 (29%, *n* = 7 nests) was slightly lower than the overall success of Spectacled Eider nests on the delta since 1992 (33%, *n* = 42 nests of known fate). Of the 5 nests that failed to hatch in 2002, 2 had failed before they were found, and one that subsequently failed had its hen flushed during the nest search. To

Table 9. Numbers and densities (uncorrected for sightability) of eiders during pre-nesting aerial surveys (100% coverage) of the CD North study area (206.9 km^2), Colville River Delta, Alaska, 12–13 June 2002.

	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	15	10	25	30	10	0.12	0.15	0.05
King Eider	11	8	19	22	8	0.09	0.11	0.04
FLYING BIRDS								
Spectacled Eider	1	0	1	–	–	0.00	–	–
King Eider	8	4	12	–	–	0.06	–	–
NON-FLYING + FLYING BIRDS								
Spectacled Eider	16	10	26	–	–	0.13	–	–
King Eider	19	12	31	–	–	0.15	–	–

[a] Total indicated calculated according to standard USFWS protocol (USFWS 1987b).
[b] Pairs indicated = number of non-flying males.

Table 10. Observed numbers (flying and non-flying birds), indicated numbers, and densities (birds/km^2) of eiders during pre-nesting aerial surveys in the CD North study area (206.9 km^2), Colville River Delta, Alaska, 1993–2002. Pre-2000 data are from Johnson et al. (1999a).

	Spectacled Eider				King Eider				Common Eider			
	Number		Density		Number		Density		Number		Density	
Year	Observed	Indicated[a]	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1993[b]	21	26	0.20	0.25	11	10	0.11	0.10	0	0	0	0
1994	69	55	0.33	0.27	12	12	0.06	0.06	0	0	0	0
1995	44	28	0.21	0.14	5	2	0.02	0.01	0	0	0	0
1996	33	32	0.16	0.15	13	4	0.06	0.02	0	0	0	0
1997	47	44	0.23	0.21	7	8	0.03	0.04	0	0	0	0
1998	57	58	0.28	0.28	16	12	0.08	0.06	2	2	0.01	0.01
2000	36	36	0.17	0.17	16	18	0.08	0.09	0	0	0	0
2001	30	32	0.15	0.15	18	16	0.09	0.08	3	0	0.01	0
2002	26	30	0.13	0.14	31	22	0.15	0.11	0	0	0	0
Mean	42.7	40.8	0.21	0.20	15.6	12.7	0.08	0.06	0.6	0.2	<0.01	<0.01

[a] Total indicated calculated according to standard USFWS protocol (USFWS 1987b).
[b] Survey coverage was 50% in 1993. Numbers in 1993 were doubled for calculation of overall means.

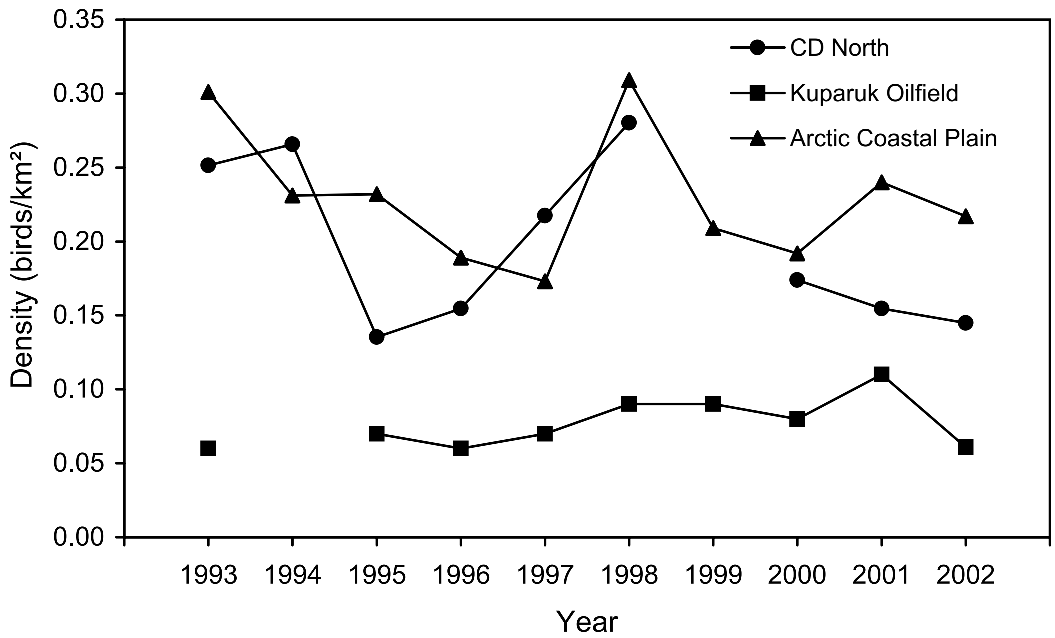

Figure 9. Trends in density of Spectacled Eiders (indicated birds; USFWS 1987a) counted on aerial surveys during pre-nesting in the CD North study area, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2002. Data are from Anderson et al. (2003), Larned et al. (2003), and this study.

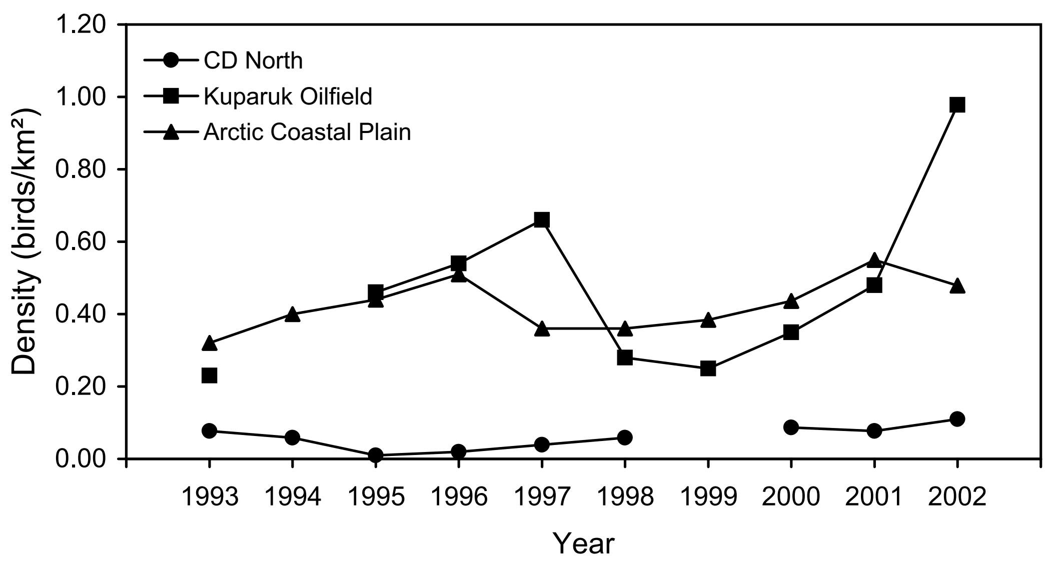

Figure 10. Trends in density of King Eiders (indicated birds, USFWS 1987a) counted on aerial surveys during pre-nesting in the CD North study area, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2002. Data are from Anderson et al. (2003), Larned et al. (2003), and this study.

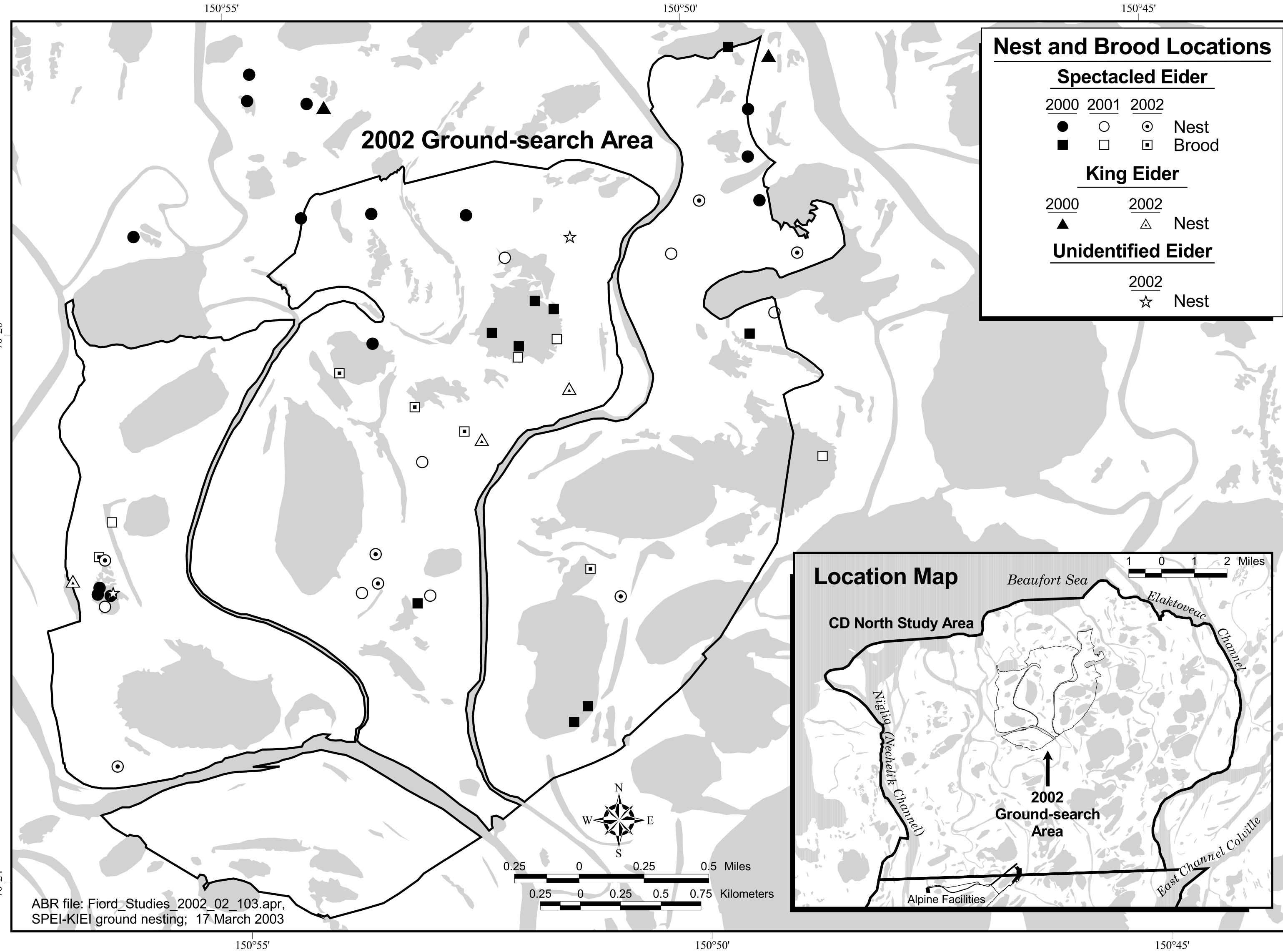

Figure 11. Distribution of Spectacled and King eider nests and broods recorded during aerial and ground surveys in the CD North ground-search area, Colville River Delta, Alaska, 2000–2002.

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. Nesting success for 14 hens that were flushed was higher (50%) than nesting success of 14 hens that remained on their nest (29%), suggesting that flushing Spectacled Eiders off their nests once did not reduce nesting success. However, we emphasize that extra care was taken to cover nests when 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 cannot adequately evaluate that possibility.

In 4 previous years—1992, 1993, 1994, and 1997—portions of the CD North ground-search areas were searched 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 one King Eider nest were found in the same search areas where nests were found in 2000–2002 (Appendices C3 and C4). During nest searches in various portions of the delta from 1992 to 2002, we have found 62 Spectacled Eider nests. Eleven additional Spectacled Eider nests were recorded on the Colville Delta during bird studies conducted from 1981 to 1987 by the USFWS (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). In 1993 and 1994, 4 nests were found on the same lakes where these earliest nests were recorded (near the Niġliq Channel, Appendix C3), which indicates that some sites may be traditional nesting areas.

Few nests of other eider species have been found on the delta. Three nests of King Eiders (including one that was identified by contour feathers) were found in 2002. In 11 years of nest searching on the delta, only 10 of 72 (14%) identified eider nests belonged to species other than Spectacled Eiders: one Common Eider nest and 9 King Eider nests (3 identified by contour feathers). An additional 3 nests were never identified to species. Although the entire delta has not been thoroughly searched for eider nests, these results, along with the results of the pre-nesting surveys, indicate the delta does not support much nesting by eider species other than Spectacled Eiders.

The coastal portion of the delta, where Spectacled Eiders concentrate during pre-nesting, also is where Spectacled Eiders nest most commonly (Figure 8, 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 ($n = 62$) for Spectacled Eider, 3.7 km ($n = 9$) for King Eider, and 1.4 km ($n = 1$) for Common Eider. No records have been found of Spectacled Eider nests on the delta that were farther than 12.6 km from the coast.

Only 5 Spectacled Eider nests (8% of 62 nests) found on the delta since 1992 were found outside of the CD North study area, and this low number was not due to lack of search effort in other areas. The vicinity of the Alpine project area was thoroughly searched (10.6–17.2 km²) for 7 years, and only 3 Spectacled Eider nests and one probable King Eider nest (identification based on contour feathers) have been found (Johnson et al. 2002). Another 2 Spectacled Eider nests were found in the CD South ground-search areas (5.8–10.0 km²) during 3 years of nest searching (Burgess et al. 2003a). 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.

Brood-rearing

The distribution of Spectacled Eider broods on the delta was similar to the distribution of eiders during pre-nesting and nesting (Appendices C1, C3, C5); that is, no broods occurred >13 km from the coast. Five Spectacled Eider broods were counted in the CD North ground-search area in 2002 (Figure 11). In 2000 and 2001, 9 and 4 Spectacled Eider broods, respectively, were observed in or near the CD North ground-search area. Mean brood sizes were 3.4, 2.5, and 2.6 young/brood in 2000–2002, respectively. Since 1992, 34 Spectacled Eider broods have been recorded on the delta ($\bar{x}$ = 3.5 young/brood, *n* = 29 broods with young counted), and they have been seen primarily on the outer portion of the delta (Appendix C5). Only 3 King Eider broods ($\bar{x}$ = 4.7 young/brood) have been found since 1992. 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. 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 for other species.

HABITAT USE

Pre-nesting

During the pre-nesting season in 2000–2002, Spectacled Eiders were found in 14 of the 21 habitats available in the CD North study area (Table 11). Groups of Spectacled Eiders seen during the aerial survey were recorded most often in Aquatic Sedge with Deep Polygons (19% of all sightings), Brackish Water (13%), Patterned Wet Meadow (13%), and Salt-killed Tundra (11%). Three of these habitats (Aquatic Sedge with Deep Polygons, Brackish Water, and Salt-killed Tundra) were significantly preferred (i.e., habitat use was greater than availability), along with Salt Marsh and Shallow Open Water with Islands or Polygonized Margins according to a habitat selection analysis of 9 years of sightings for the entire delta (1993–1998, and 2000–2002; 1992 was not included because the sample of plots that year was not representative of the delta; Appendix D1).

Elsewhere in arctic Alaska, 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 Kuukpik in the Kuparuk Oilfield, most 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 also are not abundant in CD North study area. Aquatic Sedge with Deep Polygons occupied only 4% of the CD North study area, but over all years, it was used more than any other habitat (Appendix D1.)

King Eiders used some of the same habitats during pre-nesting as were used by Spectacled Eiders but in different proportions (Table 11). The largest proportions of King Eiders in the CD North study area during 2000–2002 occurred in Salt-killed Tundra (21% of the total groups), Brackish Water (17%), Tapped Lake with Low-water Connection (17%), and River or Stream (17%). Of these frequently used habitats, only Tapped Lake with Low-water Connection was not preferred by pre-nesting King Eiders on the delta over 9 years of surveys (Appendix D1). River or Stream was used by 48% of the King Eider groups on the delta (Appendix D1). The disproportional use of River or Stream and low use of typical nesting habitat (i.e., lakes with islands 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 since 1992 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 Eiders used almost all habitats but preferred wet, aquatic nonpatterned; aquatic strangmoor; and water with and without emergents (Warnock and Troy 1992).

Table 11. Habitat use by Spectacled Eider and King Eider groups during pre-nesting in the CD North study area, Colville River Delta, Alaska, 2000–2002.

SPECIES Habitat	No. of Groups	No. of Adults	Use (%)[a]
SPECTACLED EIDER			
Brackish Water	6	12	12.8
Tapped Lake with Low-water Connection	3	7	6.4
Tapped Lake with High-water Connection	1	2	2.1
Salt Marsh	3	6	6.4
Salt-killed Tundra	5	9	10.6
Deep Open Water without Islands	4	5	8.5
Deep Open Water with Islands or Polygonized Margins	2	4	4.3
Shallow Open Water without Islands	1	2	2.1
Shallow Open Water with Islands or Polygonized Margins	1	2	2.1
River or Stream	2	4	4.3
Aquatic Sedge with Deep Polygons	9	16	19.1
Nonpatterned Wet Meadow	3	5	6.4
Patterned Wet Meadow	6	9	12.8
Moist Tussock Tundra	1	2	2.1
TOTAL	47	85	100
KING EIDER			
Brackish Water	4	7	16.7
Tapped Lake with Low-water Connection	4	8	16.7
Salt Marsh	1	2	4.2
Tidal Flat	1	2	4.2
Salt-killed Tundra	5	10	20.8
Deep Open Water without Islands	1	4	4.2
Deep Open Water with Islands or Polygonized Margins	2	5	8.3
River or Stream	4	9	16.7
Aquatic Sedge with Deep Polygons	2	3	8.3
TOTAL	24	50	100

[a] Use = (Number of groups / total groups) × 100.

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], 1995–2002). Thus, a representative sample of habitats from which selection could be calculated for the Colville Delta was not searched. Instead, we used the nesting data from the delta to summarize habitat associations. The CD North ground-search area was completely searched for eider nests in 2000–2002, and the data from those searches was used to qualitatively evaluate habitat selection during nesting.

Nesting Spectacled Eiders in the CD North study area used many of the same habitats that were used during pre-nesting (Table 12). In 2000–2002, Spectacled Eider nests were most abundant in 3 habitats: Salt-killed Tundra, Aquatic

Table 12. Habitat selection (pooled among years) by Spectacled Eiders nesting in the CD North ground-search area, Colville River Delta, Alaska, 2000–2002.

Habitat	No. Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	1	3.6	3.8	ns
Tapped Lake with Low-water Connection	0	0	1.2	ns
Tapped Lake with High-water Connection	0	0	3.6	ns
Salt Marsh	0	0	4.8	ns
Tidal Flat	0	0	<0.1	ns
Salt-killed Tundra	11	39.3	16.7	prefer
Deep Open Water without Islands	0	0	3.3	ns
Deep Open Water with Islands or Polygonized Margins	2	7.1	9.8	ns
Shallow Open Water without Islands	0	0	0.2	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.7	ns
River or Stream	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	6	21.4	12.6	ns
Aquatic Grass Marsh	0	0	0.1	ns
Nonpatterned Wet Meadow	3	10.7	13.3	ns
Patterned Wet Meadow	5	17.9	22.8	ns
Moist Sedge–Shrub Meadow	0	0	2.7	ns
Riverine or Upland Shrub	0	0	0.9	ns
Barrens	0	0	3.6	ns
TOTAL	28	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.

Sedge with Deep Polygons, and Patterned Wet Meadow. Salt-killed Tundra alone contained 39% (11 of 28 total) of the nests and was the only habitat found to be preferred in an analysis of nesting habitat selection (Table 12). However, the number of nests (28) in this analysis is low relative to the number of habitats (18) 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 11 years of searching in various locations on the delta, 62 nests of Spectacled Eiders have been found in 9 habitats (Appendix D2). Most nests were located in Salt-killed Tundra (24% of all nests), Aquatic Sedge with Deep Polygons (23%), Patterned Wet Meadow (17%), and Nonpatterned Wet Meadow (16%).

Delta-wide, Spectacled Eider nests were closely associated with water, averaging 3.7 m (range 0.1–80 m, $n = 62$) from permanent water. Brackish Water was the nearest waterbody type to 37% of the nests, and Deep Open Water with Islands or Polygonized Margins was the nearest waterbody type to 29% 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. 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 2); therefore, nesting habitat on the delta differs somewhat from areas with abundant emergent grass and sedge waterbodies.

As mentioned earlier, King Eider nests are not common on the Colville Delta. Between 2000 and 2002, 2 King Eider nests were found in Salt-killed Tundra, 2 were found in Aquatic Sedge with Deep Polygons, and one was found in Patterned Wet Meadow. Only 9 King Eider nests (2 were identified by contour feathers) were found during 11 years of nest searches on the delta, and all were found in the same 3 habitats: Aquatic Sedge with Deep Polygons (4 nests), Salt-killed Tundra (3 nests), and Patterned Wet Meadow (2 nests). The distance of King Eider nests from permanent water was greater ($\bar{x}$ = 12 m, n = 9, range 0.2–80 m) than it was for nests of Spectacled Eiders. King Eiders nested near almost every type of waterbody: Brackish Water, both types of Tapped Lakes, both types of Deep Open Water, Shallow Open Water without Islands, and River or Stream. 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 2000–2002, 18 Spectacled Eider brood-rearing groups were seen in the CD North ground-search area, 78% of which were in 3 habitats: Deep Open Water without Islands, Deep Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons (Table 13). Only 34 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 (15%), and Aquatic Sedge with Deep Polygons (15%). Brood-rearing groups appear to be attracted to coastal lakes; the mean distance to the coast was 3.6 km (n = 34 groups). 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 3 King Eider broods have been seen on the delta since studies began in 1992. One brood each was found in Tapped Lake with High-water Connection, Aquatic Sedge with Deep Polygons, and Patterned Wet 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, Patterned Wet Meadow also was well-used, but because it was the most abundant habitat on the Colville Delta (Table 2), 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 are common breeders across the Arctic Coastal Plain of Alaska. Tundra Swans mate for life and pairs defend a nesting territory to which they return annually, often using the same nest mounds in successive years (Palmer 1976, Monda et al. 1994, Anderson et al. 1999, Johnson et al. 2003). Because of their fidelity to nesting territories, they have been used as indicators of the general ecosystem health within the region (King 1973, Ritchie et al. 1990, Anderson et al. 1998).

Tundra Swans arrive on the Colville Delta in mid- to late May (Simpson et al. 1982, Hawkins 1983) and occupy breeding territories soon after

Table 13. Habitat use by brood-rearing Spectacled Eiders in the CD North study area, Colville River Delta, Alaska, 2000–2002. Broods were located during aerial and ground surveys.

Habitat Type	No. of Brood-rearing Groups	No. of Young	Use (%)[a]
Tapped Lake with Low-water Connection	1	3	5.6
Tapped Lake with High-water Connection	1	4	5.6
Salt-killed Tundra	1	2	5.6
Deep Open Water without Islands	3	8	16.7
Deep Open Water with Islands or Polygonized Margins	7	19	38.9
Aquatic Sedge with Deep Polygons	4	11	22.2
Patterned Wet Meadow	5	7	5.6
TOTAL	18	54	100

[a] Use = (Number of groups / total groups) × 100.

arrival, although nest initiation can be delayed by late snow melt (Lensink 1973, McLaren and McLaren 1984). Broods stay on or near territories until the young are fledged (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).

DISTRIBUTION AND ABUNDANCE

Nesting

Of the 55 Tundra Swan nests counted on the Colville Delta during aerial surveys in 2002, 31 were located in the CD North study area (Figure 12, Table 14, Appendix C6). An additional 7 nests not observed during the aerial survey also were found, 6 during intensive foot searches of the CD North ground-search area (Figure 5) and one nest during helicopter-based surveys for loon nests. The previous high count of swan nests (21 nests) in the CD North area was recorded in 1995. The high count in 2002 was a reflection of the regional increase in nesting observed on the coastal plain from the Kuparuk River to the Colville Delta (Anderson et al. 2003). Of the swan nests on the delta in 1992–2002, 42–70% were located within the CD North study area. In 2002, the density of swan nests in the CD north study area was 0.15 nests/km², the highest density estimate since surveys began in 1992 (Table 14). During the previous 8 survey years, nest density in the CD North study area ranged from 0.04 to 0.10 nests/km². Nest densities for the entire Colville Delta over the 9 years of surveys ranged from 0.03 to 0.10 nests/km² (Appendix D4, Appendix C6). Similar swan nest densities were 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. 2003).

Unlike the number of nests, the number of swans counted on the Colville Delta during the 2002 nesting survey was the lowest since 1995. However, more pairs of swans were counted on the delta in 2002 than in any other year, and the greatest percentage of pairs since 1996 nested in the 2002 breeding season (Appendix D5). Thus the number of swans seen in flocks, which are presumed to be non-breeders, was low in 2002.

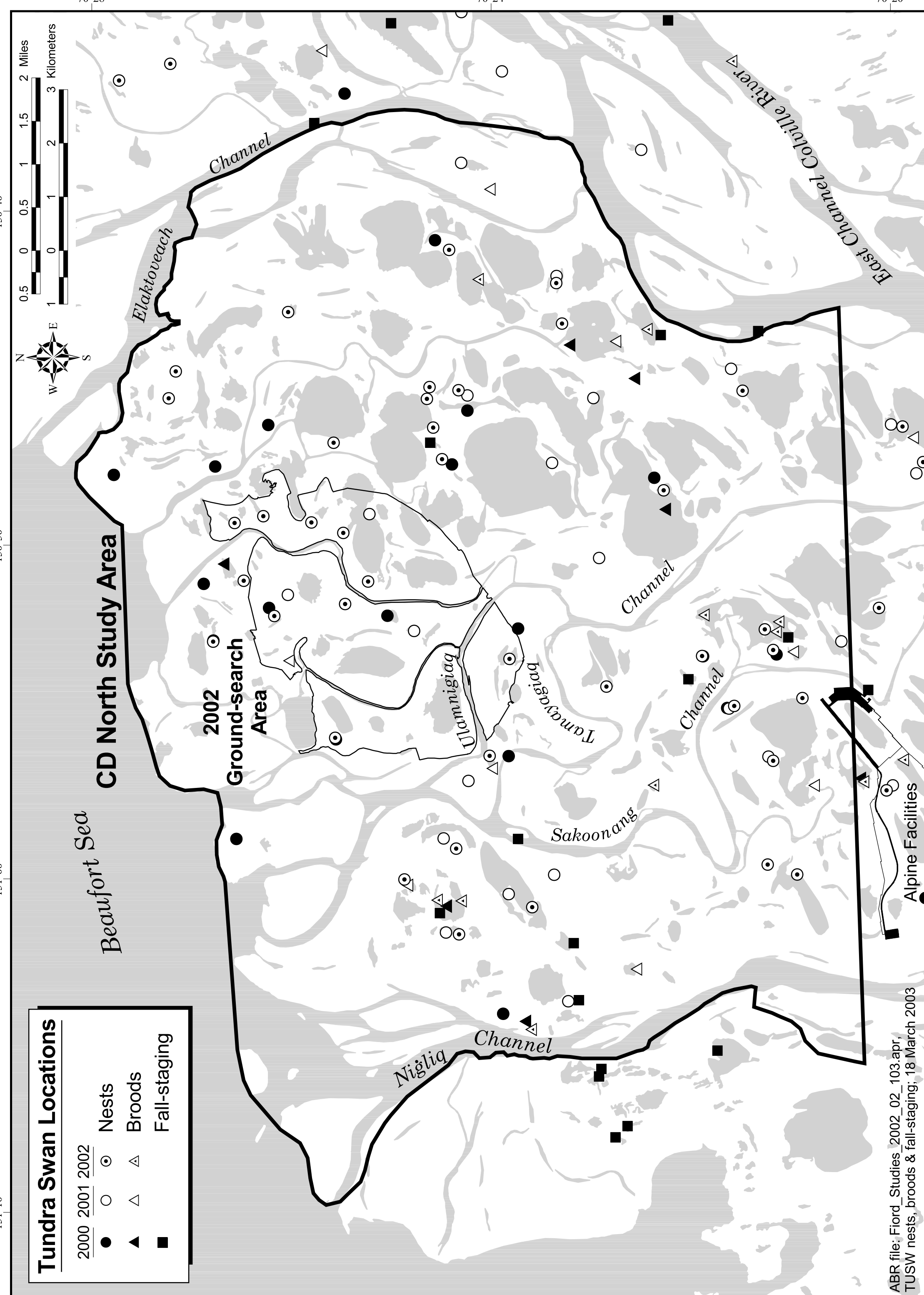

Figure 12. Distribution of Tundra Swan nests, broods, and fall-staging groups recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000–2002. Fall-staging surveys were not conducted in 2001–2002.

Table 14. Numbers and densities of Tundra Swan nests and broods counted on aerial surveys of the CD North study area (206.9 km²), Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a).

Year	Nests		Broods		Mean Brood Size	Nest Success (%)[a]
	No.	No./km²	No.	No./km²		
1992[b]	9	0.04	8	0.04	2.1	89
1993	14	0.07	5	0.02	3.2	36
1995	21	0.10	12	0.06	3.4	57
1996	19	0.09	14	0.07	3.5	74
1997	15	0.07	12	0.06	2.7	80
1998	14	0.07	10	0.05	2.4	71
2000	16	0.08	6	0.03	1.8	38
2001	13	0.06	8	0.04	1.4	62
2002	31	0.15	9	0.04	3.4	29
Mean	17	0.08	9	0.04	2.7	55

[a] Percent nest success = (nests / broods) × 100.
[b] Survey conducted by the Alaska Department of Fish and Game.

Brood-rearing

Nine swan broods were counted in the CD North study area in mid-August 2002 (Figure 12; Table 14). The distribution of broods across the entire delta has been relatively uniform during the years surveyed (Appendix C7). Nesting success in the CD North study area, estimated by dividing numbers of broods by the number of nests (data from aerial surveys only), was 29% in 2002 (Table 14). That estimate of nesting success was the lowest since surveys began in 1992. Nesting success rates for the previous 8 survey years in the study area ranged from 36 to 89%. The density of broods for the study area in 2002 was 0.04 broods/km², which was average relative to densities from past years (Table 14). Mean brood size for the CD North study area in 2002 was 3.4 young/brood (n = 9 broods) and much higher than average (2.7 young/brood).

On the entire Colville Delta, brood densities, nesting success, and mean brood sizes (Appendix D4) were similar to those in the CD North study area. The density of broods on the Colville Delta in 2002 was 0.03 broods/km² and averaged 0.04 broods/km² over 9 years of surveys. The estimated nesting success for the entire delta in 2002 was 31% (17 of 55 nests), the lowest ratio that has been observed over the 9 years of surveys of the delta. In contrast, mean brood size (3.2 young/brood, n = 17 broods) in 2002 on the Colville Delta was the highest recorded since 1996 (Appendix D4). A similar situation existed in the Kuparuk Oilfield and vicinity during 2002. Although the nesting success (58%) was low, mean brood size ($\bar{x}$ = 2.4 young/brood, n = 67) was the highest on record there since 1996 (Anderson et al.2003). The larger than average brood sizes found over a broad area from the Colville Delta to the Kuparuk River may be indicative of a regional cause for brood loss; we suspect poor weather in late June–early July may have contributed to low numbers of broods (see Conditions in the Study Area).

Productivity (as indicated by nesting success, brood density, and brood size) on the delta during the 9 years that aerial surveys have been conducted was similar to or greater than values reported in other studies of swans on the Arctic Coastal Plain. In 1981, Rothe et al. (1983), using intensive ground surveys, measured 91% nesting success (n = 32 nests) and 2.1 young/brood on the Colville Delta. In 1982, nesting success was 71% (n = 48 nests), and mean brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). In a 3-year study (1988–1990) of swans nesting on the

Canning and Kongakut river deltas, the overall nesting success was 76% (n = 110 nests) (Monda et al. 1994). Aerial surveys between the Kuparuk and Kuukpik (Colville) rivers (1988–1993, 1995–2002) recorded mean brood sizes of 2.0–2.8 young/brood and densities of 0.02–0.04 broods/km² (Anderson et al.2003). Platte and Brackney (1987) estimated 63–85% nesting success, 0.04 broods/km², and 2.5 young/brood on portions of the Arctic National Wildlife Refuge during 1982–1985.

Fall Staging

Fall-staging surveys for swans have not been flown since 2000 (Johnson et al. 2000a). During swan staging surveys in past years, most swans have generally occurred in several large flocks that occupy river channels on the outer Colville Delta (Appendix C8). 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. Large flocks of swans also have been found on the Iqalliqpik delta (labelled the Tingmeachsiovik River at the coast on USGS maps), adjoining the Colville Delta on the west, during fall-staging surveys. Surveys in 4 of the 9 years considered here documented large numbers (286–411 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 from 2000 to 2002, 75 nests were found in 14 habitat types (Table 15). Sixty-six nests (88% of all nests) were found in 7 preferred habitats (based on the delta-wide multi-year analysis): Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, Nonpatterned Wet Meadow, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow (Appendix D6). Patterned Wet Meadow was used by the largest percentage (35%) of the swans nesting in the CD North study area (Table 15). Swans nesting in the CD North study area used similar habitats to those used on the entire delta over all years surveyed. During 9 years of surveys on the delta, swan nests (n = 294) were located in 20 of 24 available habitats (Appendix D6).

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 River delta, 42% of 36 nests were in areas classified as saline graminoid-shrub (probably equivalent to Salt Marsh). On the Canning River delta, 52% of 54 nests were in graminoid-marsh (probably equivalent to Aquatic Grass and Aquatic Sedge marshes), and 26% were in graminoid-shrub-water sedge (probably equivalent to Patterned Wet Meadow).

Brood-rearing

In 2000–2002 in the CD North study area, 15 of the 23 broods were observed in 5 habitats that were preferred—Brackish Water, Tapped Lake with Low-water Connection, Tapped Lake with High-water Connection, Salt Marsh, and Deep Open Water without Islands—based on a selection analysis of 9 years of surveys on the entire delta (Table 15; Appendix D6). Tapped Lake with Low-water Connection was used by the highest percentage (35%) of broods in the CD North study area. On the Colville Delta, Tundra Swans with broods (data pooled over 9 years) used 18 of 24 available habitats (Appendix D6). Seven habitats were preferred, and 4 were avoided. Patterned Wet Meadow was used by the most broods (16% of the total) on the delta, but was used in proportion to its availability because it was also the most abundant habitat (19% of the area; Appendix D6).

The use of salt-affected habitats (e.g., Brackish Water, Salt Marsh, Salt-killed Tundra, and Tapped Lake with Low-water Connection) by brood-rearing swans may reflect a seasonal change in distribution or habitat preference, in that 37% of all swan broods on the delta were in salt-affected habitats, compared with only 21% of all nests (Appendix D6). Brood-rearing swans also may change habitat preferences as the season progresses (Monda et al. 1994), although our surveys,

Table 15. Habitat use by nesting and brood-rearing Tundra Swans in the CD North study area, Colville River Delta, Alaska, 2000–2002. Nests were found during aerial and ground surveys, and broods were found during aerial surveys.

	Nests		Broods	
Habitat Type	No.	Use (%)	No.	Use (%)
Brackish Water	1	1.3	1	4.4
Tapped Lake with Low-water Connection	0	0	8	34. 8
Tapped Lake with High-water Connection	0	0	1	4.4
Salt Marsh	3	4.0	2	8.7
Tidal Flat	1	1.3	0	0
Salt-killed Tundra	16	21.3	1	4.4
Deep Open Water without Islands	2	2.7	3	13.4
Deep Open Water with Islands or Polygonized Margins	1	1.3	0	0
Shallow Open Water with Islands or Polygonized Margins	1	1.3	0	0
Aquatic Sedge with Deep Polygons	10	13.3	0	0
Nonpatterned Wet Meadow	9	12.0	1	4.4
Patterned Wet Meadow	26	34.7	3	13.0
Moist Sedge–Shrub Meadow	1	1.3	0	0
Moist Tussock Tundra	1	1.3	0	0
Riverine or Upland Shrub	2	2.7	0	0
Barrens	1	1.3	3	13.0
TOTAL	75	100	23	100

conducted once per brood-rearing period, could not document this change. 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 also were reported to favor pondweed during the brood-rearing and molting periods (Johnson and Herter 1989). Monda et al. (1994) found that pondweed was an important component of the diet of swans on the Kongakut and Canning river deltas; pondweed, along with another important food, alkali grass (*Puccinellia phryganodes*), grows well in salt-affected environments. Although data on the feeding habits of swans were not collected during our study, 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 2002, 23 Yellow-billed Loons were counted in the CD North study area during the nesting aerial survey. The number of loons recorded during nesting in 2002 was within the range of the number of loons (17 to 34 adults) seen during previous years (Table 16). The density of Yellow-billed Loons in the CD North study area ranged from 0.08 to 0.16 birds/km² during 8 years of aerial surveys (1993, 1995–1998, and 2000–2002—plot surveys in 1992 not included because they were not a representative sample of loon habitat; Table 16). Densities similar to those found during 8 years of surveys in the CD North study area ($\bar{x}$ = 0.13 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 2002 was similar to that recorded on previous aerial surveys (Smith et al. 1994, Johnson et al. 2002), and during ground studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

In 2002, 9 Yellow-billed Loon nests were found in the CD North study area during the initial aerial survey (Table 16, Figure 13). One additional nest was found during the revisit survey, and another nest was found during ground searches in the CD North study area. The total of 10 nests found during aerial surveys in 2002 was within the range of nests (6–11) recorded in the CD North study area during 8 years of aerial surveys (Table 16). With the additional nests found in some years during revisit surveys, densities in the CD North study area ranged from 0.03 to 0.05 nests/km² over 8 years (Table 16). Two broods were seen during the brood-rearing aerial survey in lakes where nests were not found, suggesting that 2 additional nests were active in the CD North Study area in 2002 (Figure 13). The 13 Yellow-billed Loon nests (counting the 2 broods as nests) in 2002 matches the number of nests found by North (1986) during repeated intensive ground surveys in 1984 in the CD North study area. All nests found in the CD North study area in 2002 were on lakes where Yellow-billed Loons have nested in previous years (Appendix C9). Five of the 13 nests were within the 2002 CD North ground-search area (Figure 6); nesting has occurred within this area in all years that surveys were conducted (Appendix C9; North 1986, Johnson et al. 2002).

Ten nests of Pacific Loons were located opportunistically during the Yellow-billed Loon nest survey in 2002, but no nests of Red-throated Loons were seen on that survey (Figure 14; Table 16). 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 differences in species detectability) or annual changes in abundance (because of annual variation in survey intensity) (Appendix C10). Therefore, densities have not been calculated for these 2 species from aerial surveys of the CD North study area. 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 16).

Within the CD North ground-search area, 16 Pacific and 9 Red-throated loon nests were found in 2002 during ground searches (Figure 6). Two additional Pacific Loon nests were found during the aerial survey, and we assumed from the number and locations of Red-throated Loon broods found during the brood search that one additional Red-throated Loon nest was in the area but not detected (Figure 7, Table 4). Densities in the CD North ground-search area in 2002 were 1.7 birds/km² and 1.0 nests/km² for Pacific Loons and 1.1 birds/km² and 0.5 nests/km² for Red-throated Loons. Nest densities of Pacific Loons were slightly lower within the CD North ground-search areas in 2000 (0.7 nests/km²) and 2001 (0.6 nests/km²), while nest densities of Red-throated Loons were higher in 2000 (0.8 nests/km²) and the same in 2001 (0.5 nests/km²; Table 6). Summarizing ground surveys on the delta, Rothe et al. (1983) reported similar findings and suggested that Pacific and Red-throated loon densities on the Colville Delta were comparable to other areas on the Arctic Coastal Plain. Density estimates from sample plots

Table 16. Numbers and densities (no./km²) of loons, nests, and broods counted on aerial surveys in the CD North study area (206.9 km²), Colville River Delta, Alaska, 1993–2002. 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	
2002	23	9 (10)		0.11	0.04 (0.05)	23	10		3	0	
Mean	25.9	7.6 (9.5)		0.13	0.04 (0.05)						
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
2002	30	5	6	0.15	0.02	36	3	3	2	0	0
Mean	28.0	4.1	4.5	0.14	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.

in 1981 were 1.5 birds/km² for Pacific Loon and 0.6 birds/km² for Red-throated Loon (Rothe et al. 1983).

Brood-rearing

Thirty adult Yellow-billed Loons and 5 broods were seen during the brood-rearing aerial survey in the CD North study area in 2002 (Figure 13, Table 16). One additional brood was seen during ground searches in the CD North study area. During survey years prior to 2000 (1993 and 1995–1998), ≥20 loons and ≥3 broods were counted in the same area (Table 16, Appendix C11). Poor production occurred in 2000 and 2001, when 8–16 adults and 0–2 broods were seen on aerial surveys. The highest number of Yellow-billed Loon broods recorded in the CD North study area during 8 years of surveys was in 1998, when 7 broods and 8 young were counted (Appendix C11). Brood densities during all 8 years ranged from 0 to 0.03 broods/km² (Table 16). The distribution of adults during brood-rearing was similar to that during nesting. 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.

Thirty-six Pacific Loons and 3 broods were counted on the brood-rearing aerial survey in the CD North study area in 2002 (Figure14, Table 16).

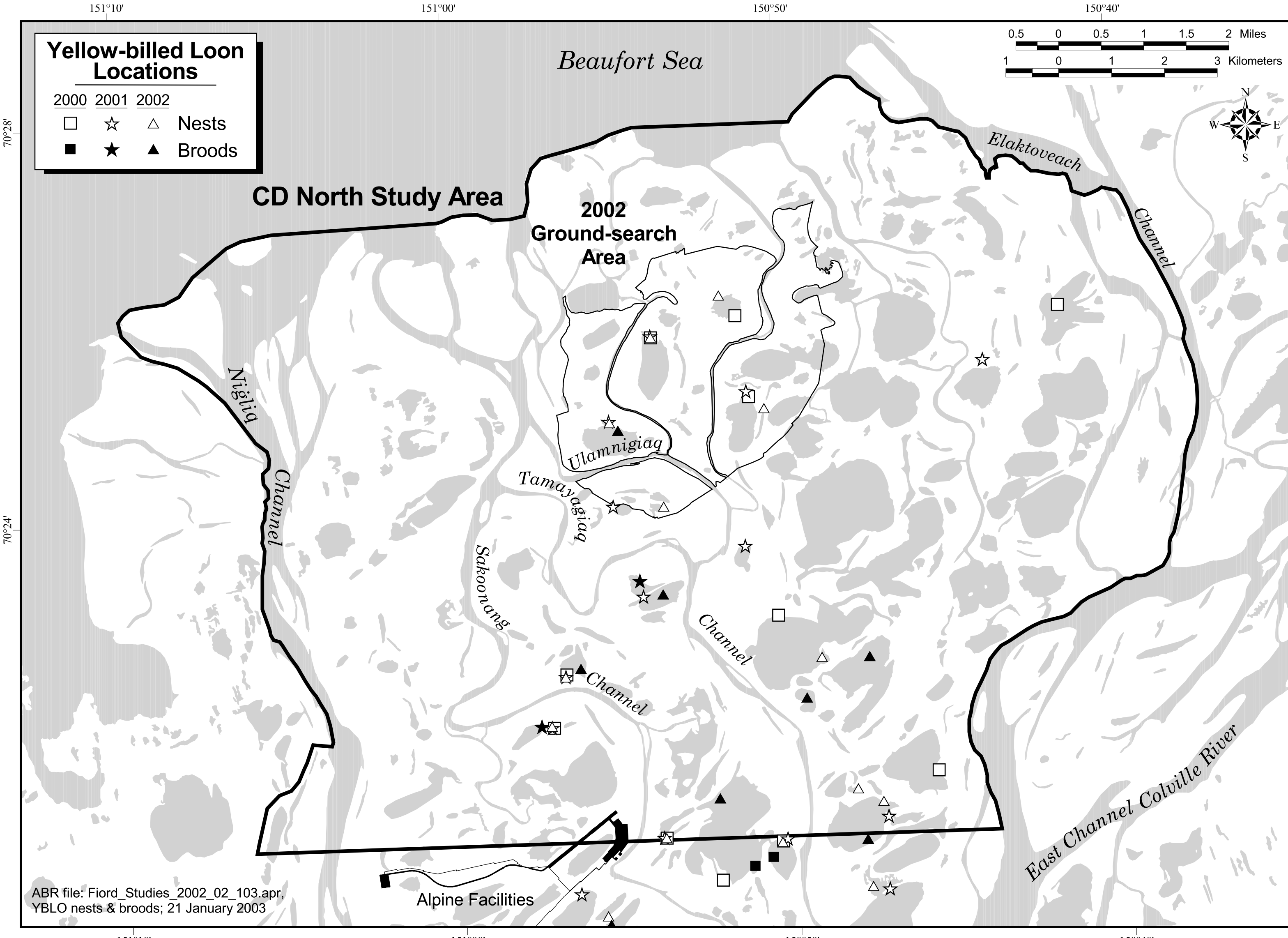

Figure 13. Distribution of Yellow-billed Loon nests and broods recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000–2002. No broods were seen in the CD North study area in 2000.

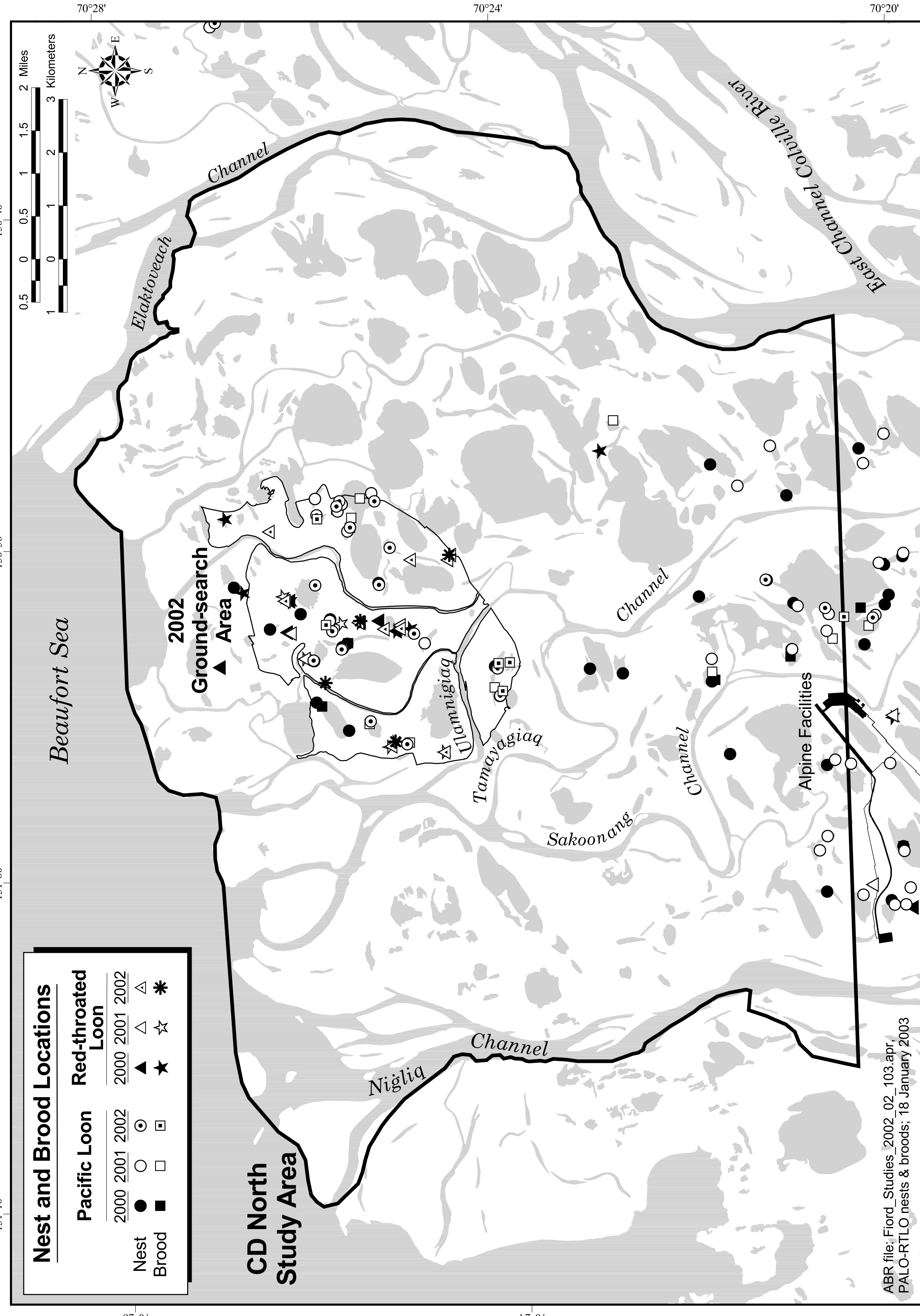

Figure 14. Distribution of Pacific and Red-throated loon nests and broods recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000–2002.

Two Red-throated Loons and no broods were seen on the same survey. 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 the aerial survey did not include all waterbodies, most broods of these species were uncounted. Moreover, because survey intensity for these smaller waterbodies varied among years and survey coverage was never complete, annual abundance cannot be compared nor can densities be calculated for these 2 species from these survey data (Appendix C12). However, on an intensive ground survey in the CD North ground-search area conducted primarily for loon broods, brood density was 0.3 broods/km² for Pacific Loons (5 broods) and 0.2 broods/km² for Red-throated Loons (4 broods) in 2002 (Figure 7). Brood density for Pacific Loons within the CD North ground-search areas was about the same in 2000 and 2001 (0.2–0.4 broods/km²), while brood density for Red-throated Loons was somewhat higher in both years (0.3–0.6 broods/km²).

HABITAT USE

Nesting

The habitat most frequently used for nesting (45% of all nests) by Yellow-billed Loons in the CD North study area in 2000–2002 was Patterned Wet Meadow (14 nests). The remaining 17 nests were found in both types of Deep Open Water, Tapped Lake with High-water Connection, and Nonpatterned Wet Meadow (Table 17). 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 8 years of nesting aerial surveys on the Colville Delta, 123 Yellow-billed Loon nests were found in 8 of 24 available habitats (Appendix D7). Seventy-eight nests (63%) were located in the 2 preferred habitats: Deep Open Water with Islands or Polygonized Margins and Patterned Wet Meadow. Patterned Wet Meadow was the habitat most frequently used for nesting (38% of all nests), and it was the most abundant habitat on the delta (25% of the loon survey area; Appendix D7). Nesting Yellow-billed Loons avoided 7 habitats—Tapped Lake with Low-water Connection, Tidal Flat, Salt-killed Tundra, River or Stream, Moist Sedge–Shrub Meadow, Riverine or Upland Shrub, and Barrens—that were unused and together occupied a large portion of the loon survey area (44%).

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 2000–2002 occurred most commonly near both types of Deep Open Water (97% of all nests; Table 17). 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 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 Connection 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 Connection, 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 2002, 6 Yellow-billed Loon broods were found in 3 different habitats: Tapped Lake with High-water

Table 17. Habitat use by nesting Yellow-billed Loons in the CD North study area, Colville River Delta, Alaska, 2000–2002. Nests were found during aerial and ground surveys.

Habitat	No. Nests	Use (%)
HABITAT USED		
Tapped Lake with High-water Connection	1	3.2
Deep Open Water without Islands	5	16.1
Deep Open Water with Islands or Polygonized Margins	10	32.3
Nonpatterned Wet Meadow	1	3.2
Patterned Wet Meadow	14	45.2
TOTAL	31	100
NEAREST WATERBODY TYPE		
Tapped Lake with High-water Connection	2	6.5
Deep Open Water witho Islands	16	51.6
Deep Open Water with Islands or Polygonized Margins	13	45.2
TOTAL	31	100

Connection and both types of Deep Open Water. During aerial surveys in 1995–1998 and 2000–2002, 46 Yellow-billed Loon broods were found in the same 3 habitats on the delta, all of which were preferred (Appendix D7). Deep Open Water without Islands was used by most broods (59% of total), followed by Tapped Lake with High-water Connection (22%) and Deep Open Water with Islands or Polygonized Margins (20%). 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). $\bar{x}$

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). Glaucous Gulls also feed on human food waste and are attracted to landfills (Campbell 1975, Murphy and Anderson 1993), which may artificially increase their numbers (Day 1998). The nearest landfill to CD South is 8.8 km away at Nuiqsut, which has the largest concentration of Glaucous Gulls in the area (ABR, unpubl. data).

DISTRIBUTION AND ABUNDANCE

Fifteen Glaucous Gull nests were counted in the CD North study area during aerial surveys for Tundra Swans and Yellow-billed Loons in 2002 (Figure 15). An additional 5 nests were found during ground surveys in the CD North ground-search area (Figure 6). Seventeen of the 20 nests were found in the northern part of the CD

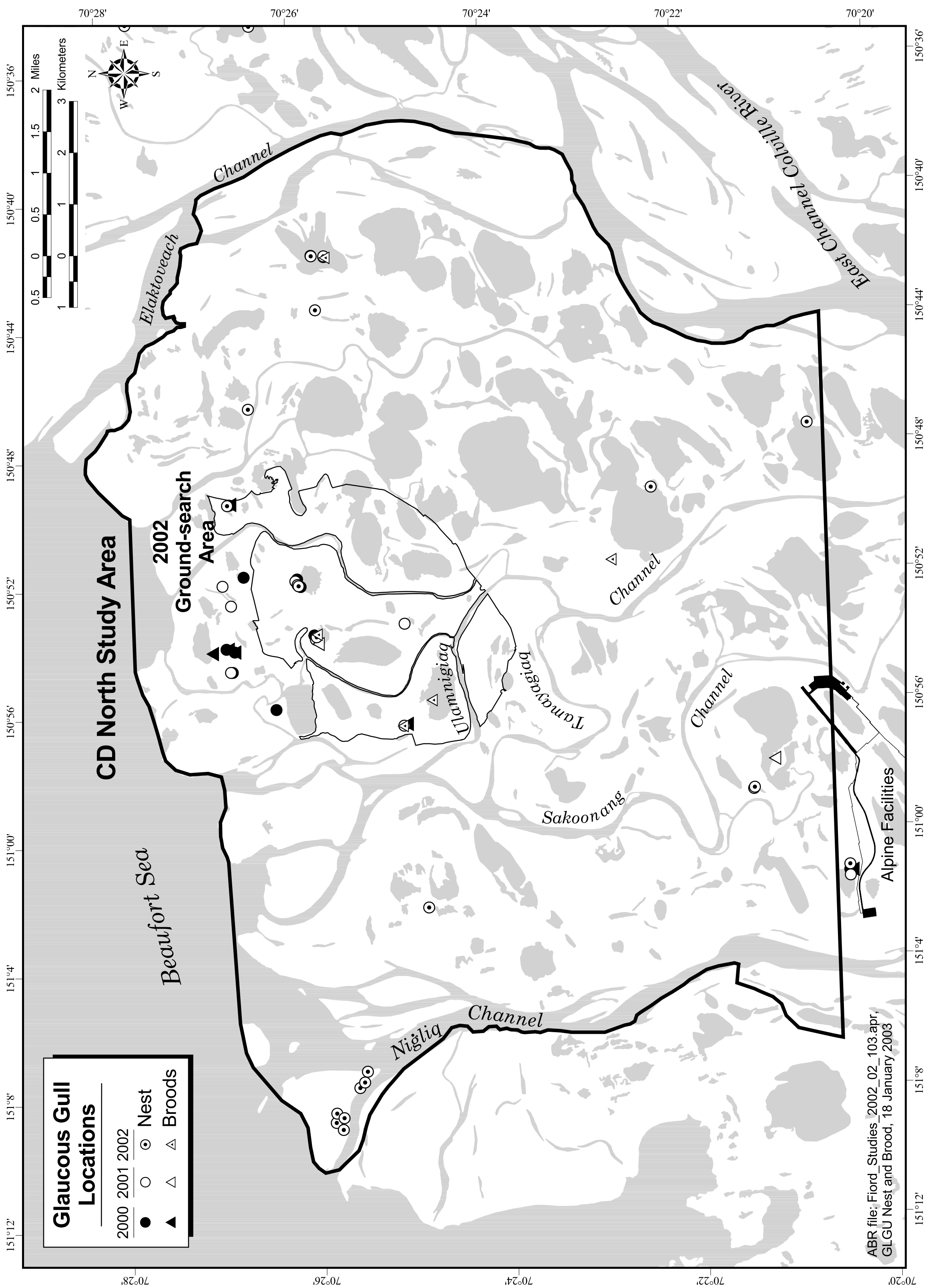

Figure 15. Distribution of Glaucous Gull nests and broods recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000–2002.

North study area, with a cluster of 7 nests located in the northwestern corner of the study area near the Niġliq Channel (Figure 15). The density of Glaucous Gull nests in the CD North study area in 2002 was 0.10 nests/km². Fewer Glaucous Gull nests were found during surveys in the CD North study area in 2000 and 2001, but because Glaucous Gulls were counted on aerial surveys designed to survey other species, some nests probably were missed (Figure 15). In the CD North ground-search areas, 10 Glaucous Gull nests were found in 2000 (0.8 nests/km²), 3 nests in 2001 (0.2 nests/km²), and 5 nests in 2002 (0.3 nests/km²; Figures 6 and 15, Table 4).

Glaucous Gull broods were recorded incidentally during the aerial survey for brood-rearing Yellow-billed Loons. Two Glaucous Gull broods were recorded on that aerial survey in 2002, and 3 additional broods were seen in the CD North ground-search area during searches on foot (Figures 7 and 15). Six broods were seen in 2000 and 2 broods were seen in 2001 in the CD North ground-search areas on similar searches (Figure 15).

Of the 39 Glaucous Gull nests found in the CD North study area in 2000–2002, most nests (31% of all nests) were located on islands in Deep Open Water with Islands or Polygonized Margins. Nests were also common in Brackish Water (23% of all nests), Tidal Flat (18%), and Tapped Lake with High-water Connection (10%).

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). Additional locations supporting 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%) of brood-rearing groups from the Anachlik Colony-complex moves northeast towards Oliktok and Milne points, while some remain on Anachlik Island, and others move to the area northwest of the East Channel (Stickney et al. 1994; Anderson et al. 1997; J. Helmericks, pers. comm.). Brant from the smaller colonies probably use salt marshes from the Elaktoveach Channel west to the Iqalliqpik (labeled the Tingmeachsiovik River at the coast on USGS maps) (Smith et al. 1994). The fall migration of Brant along the arctic coast of Alaska usually begins in mid–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

DISTRIBUTION AND ABUNDANCE

Nesting

In 2002, 23 Brant nests were located in the CD North ground-search area, compared with 30 and 24 nests located in the 2000 and 2001 (Figure 16, Table 4). Brant was the second most numerous species nesting in all years with densities of 1.2–2.5 nests/km². Nesting success for Brant was moderate in 2002 (62%), but was low (<30%) in the previous 2 years.

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) that had 1–5 years of occupation were recorded in the CD North study area, and 5 solitary nests were found with only one year of occupation (Appendix C13). During the ground search for nests in 2002, 4 colonies with 2–15 nests each and one solitary nest location were recorded. The largest colony (occupying 3 adjacent lakes) in the ground-search area contained 15–20 nests in 2000–2002 and was estimated to have up to 10 nests during 1992–1998 aerial counts (Appendix C13). The other colonies found in 2002 included one that has ranged between 1 to 4 nests

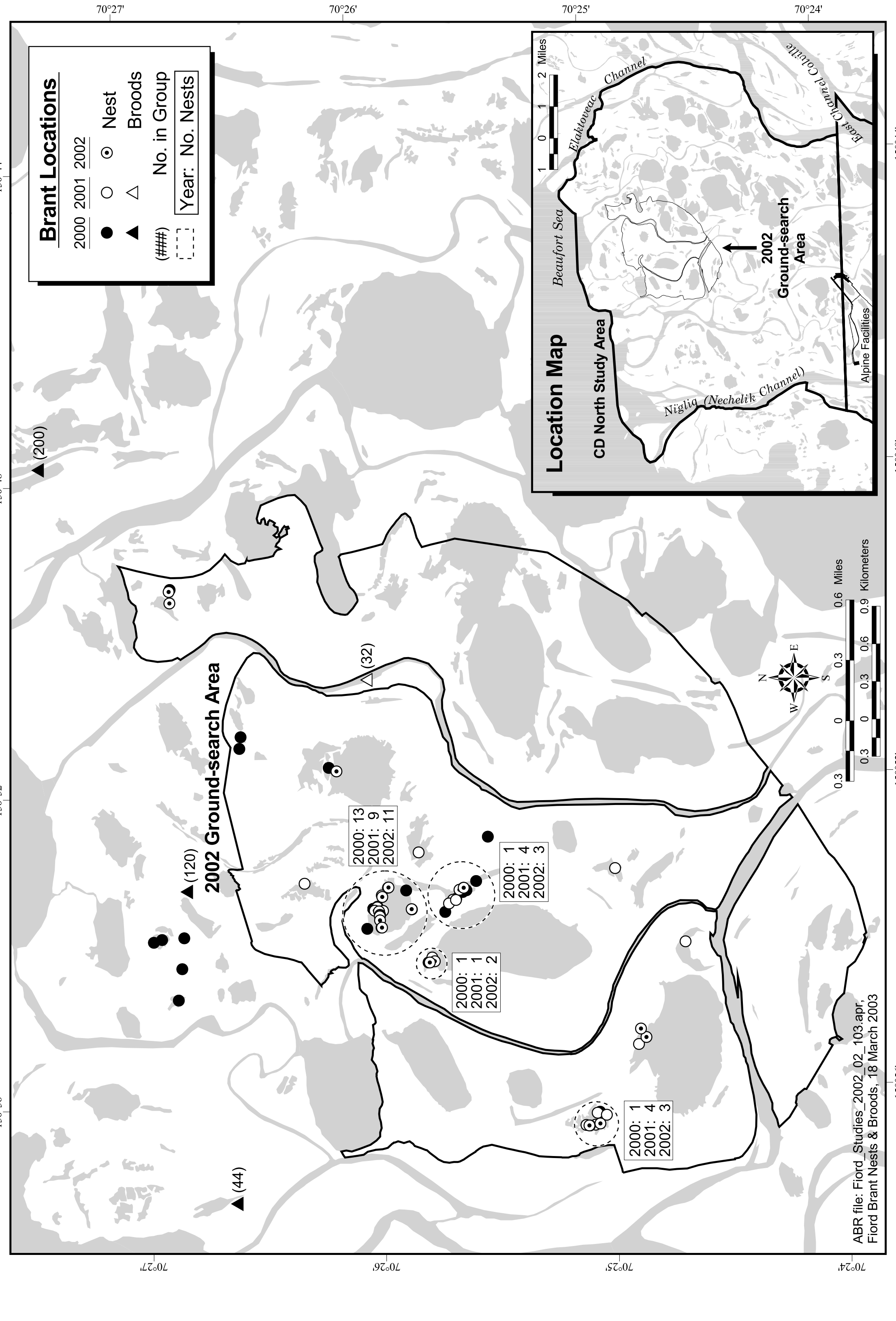

Figure 16. Distribution of Brant nests and brood-rearing groups recorded during aerial and ground surveys in the CD North ground-search area, Colville River Delta, Alaska, 2000–2002. Annual numbers of nests are listed by 4 lakes; total birds are listed by brood locations.

in 3 years of ground searches and 2 colonies containing solitary nests occupied for multiple years.

Brood-rearing

Data from both a multi-year banding study in the neighboring oilfields and 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 Iqalliqpik on the coast (Tingmeachsiovik River on USGS maps) (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 2002, 34 Brant were recorded in one group (12 adults and 22 goslings) during a brood-rearing aerial survey. The percentage of goslings was 65%, which was higher than that recorded in previous years (38–60% goslings). In 2002, no brood-rearing groups were observed within the CD North ground-search area; however, a single brood-rearing group was observed within those ground-search areas in 2001 (Figure 16).

The number of Brant observed in the CD North study area during brood-rearing in 2002 was well below average for the numbers recorded since aerial surveys were started by USFWS in 1988 ($\bar{x}$ = 243 geese, n = 12 years, range 32–934) and among the lowest ever recorded in this area (Table 18). 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 than were recorded between the Elaktoveach and Niġliq channels (Appendix C14).

Fall Staging

During fall-staging aerial surveys in 2002, 101 Brant were recorded in 4 locations in the CD North study area (Figure 17); group size ranged from 20 to 36 birds. The number of Brant recorded in 2002 was among the lowest observed in any survey year (1992–1993, 1995–1998, and 2000–2001). In previous years, numbers of Brant ranged from 46 to 314 birds in 2–7 groups, with mean group sizes between 21 and 70 birds (Appendix C15).

HABITAT USE

Nesting

Detailed information was collected on the habitats occupied by 77 individual Brant nests found on ground surveys in the CD North ground-search areas in 2000–2002 (Table 19). Over 90% of the nests were in aquatic habitats, with 77% in Deep Open Water with Islands or Polygonized Margins. Nests were most often on islands (66 nests, 86%), polygon rims (6 nests, 8%), or along shorelines (4 nests, 5%). The largest colony (15–20 nests in 2000–2002) 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 67 nests located <1 m from permanent water, and the remaining 10 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 were compiled during aerial surveys of the CD North study area in 1992–1993 and 1995–1998 and during foot searches in the CD North ground-search areas (2000–2002). Brant were found nesting in 9 of 21 available habitats on the outer delta, with Salt-killed Tundra and Aquatic Sedge with Deep Polygons being preferred in an analysis of habitat selection (Appendix D8). Those 2 habitats contained the most colonies and the most nests of all habitats in the CD North study area.

Brood-rearing

In the CD North study area in 2000–2002, 5 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 50 m of water (Brackish Water and Shallow Open Water without Islands) and between 0.8 and 6.7 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

Table 18. Abundance, distribution, and percentage of goslings in brood-rearing groups of Brant between the Elaktoveach and Niġliq channels on the Colville River Delta, Alaska, during late July-early August, 1988-2002. Pre-1992 data are from K.Bayha (USFWS, unpubl.data); 1992-1998 data are from Johnson et al. (1999a).

Year	No. of Geese	No. of Groups	Goslings (%)
1988[a]	103	no data	no data
1990[a]	195	no data	no data
1991	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
2002[c]	34	1	65

[a] Counts were a mean of 2 surveys.
[b] Includes a group of 16 that was just outside the CD North study area in the Elaktoveach Channel.
[c] Counts from systematic brood-rearing surveys, all others counts from non-systematic coastal surveys.

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 20 m (n = 40 groups).

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, mean nest densities of 3.4 nests/km² and 4.6 nests/km² have been recorded on the delta in the Alpine project area (Johnson et. al. 2003) and CD South (Burgess et al. 2003a), respectively.

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, ranging in size from 26 to ≥900 nests, are known from the Sagavanirktok, Ikpikpuk, and Kukpowruk river deltas, and small numbers of Snow Geese and nests have been recorded between the Kuparuk River and Kasegaluk Lagoon (King 1970; Ritchie and Burgess 1993; Ritchie et al. 2002; ABR, unpubl. data).

Prior to 1996, Canada Geese were not reported nesting either on the Colville Delta or in the NPRA, although local residents had 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 along the upper Kuukpik (Colville River) and east of the Kuukpik (Kessell and Cade 1957; Troy 1985; Ritchie et al. 1991; Murphy and Anderson 1993; ABR, unpubl. data). A major molting area for these geese is located near Teshekpuk Lake, west of the Colville Delta

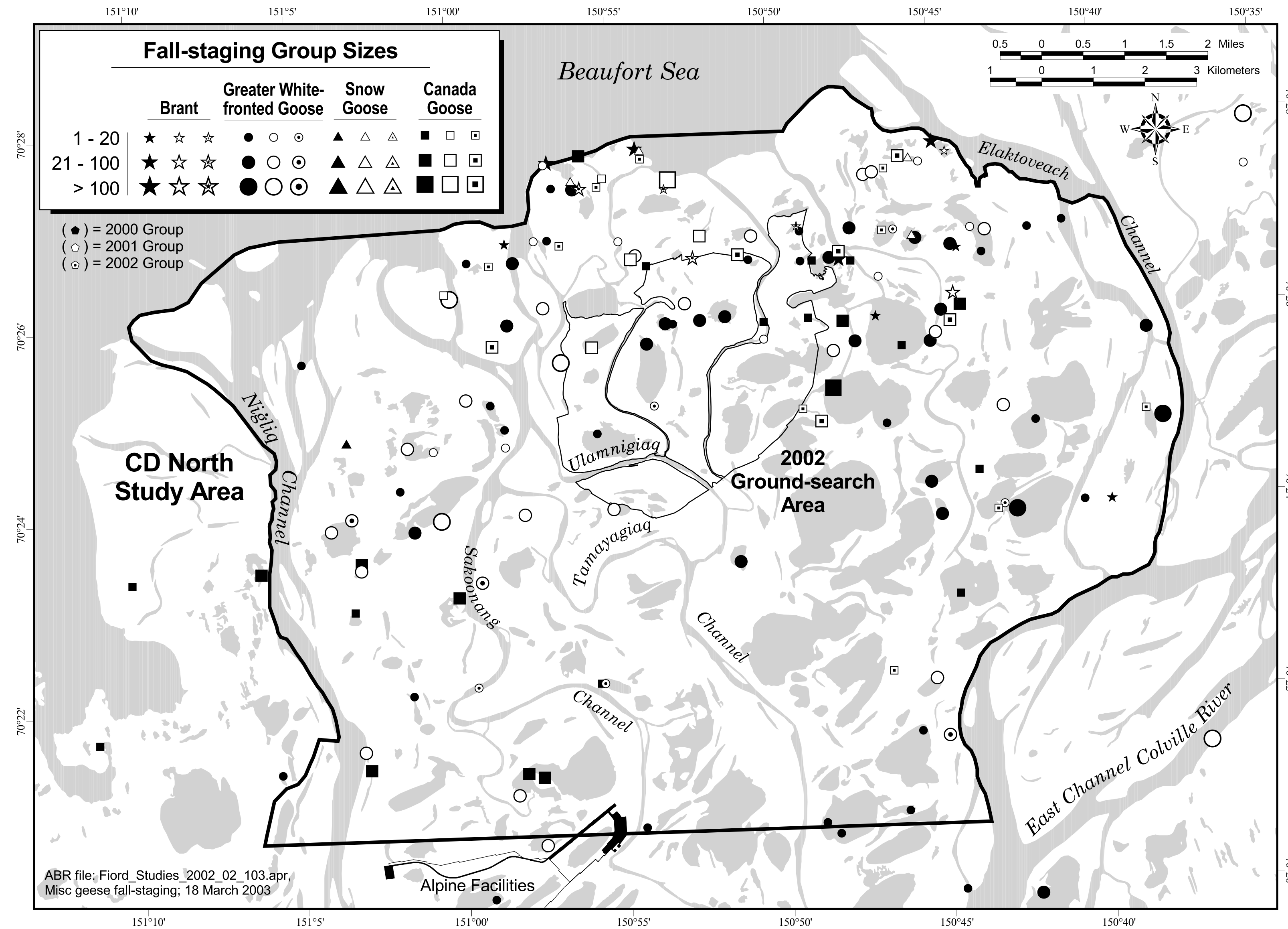

Figure 17. Distribution of fall-staging groups of Brant, Greater White-fronted, Snow, and Canada geese recorded during aerial surveys in the CD North study area, Colville River Delta, Alaska, August 2000–2002.

Table 19. Habitat use and nearest waterbody type of Brant nesting in the CD North ground-search areas, Colville River Delta, Alaska, 2000–2002.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Brackish Water	6	7.8
Salt-killed Tundra	1	1.3
Deep Open Water with Islands or Polygonized Margins	59	76.6
Shallow Open Water with Islands or Polygonized Margins	1	1.3
Aquatic Sedge with Deep Polygons	5	6.5
Aquatic Grass Marsh	1	1.3
Nonpatterned Wet Meadow	2	2.6
Patterned Wet Meadow	2	2.6
TOTAL	77	100
NEAREST WATERBODY TYPE		
Brackish Water	8	10.4
Deep Open Water with Islands or Polygonized Margins	65	84.4
Shallow Open Water with Islands or Polygonized Margins	1	1.3
River or Stream	2	2.6
Aquatic Grass Marsh	1	1.3
TOTAL	77	100

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

(Derksen et al. 1979). The Colville Delta is heavily used by Canada Geese 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 2002, the nests of White-fronted Geese accounted for 62% of the nests found in the ground-search area (Figure 6). The 213 nests found within the ground-search area were the most found in any year (Table 4). The annual densities of those nests (9.8 nests/km² in 2000, 9.9 nests/km² in 2001, and 11.3 nests/km² in 2002) were greater than densities found in either the Alpine project area or the CD South ground-search areas (Table 6), and greater than any density previously reported for the delta (Simpson et al. 1982, Rothe et al. 1983, Johnson et al. 1999a, 2003). More than 60% of the nests found in the ground-search areas hatched each year.

In 2002, one Snow Goose nest was found during foot surveys in the CD North ground-search area. In previous years, 2 Snow Goose nests in 1994 and one in 1997 were found during ground searches in this same area, and 1–2 nests each year were located in the CD North study area during surveys in 1993 and 1995. All Snow Goose nests were <5 km from the coast.

Two Canada Goose nests were found within the CD North ground-search areas in 2002, the first reported for the CD North ground-search area. In 1997, a Canada Goose nest was found near the Niġliq 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 (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. 2003) and appear to be increasing their distribution and numbers on the delta.

Brood-rearing

In the CD North ground-search areas in 2002, 7 groups of White-fronted Geese with 12 adults and 17 young were observed during foot searches (Figure 7, Table 7). During the systematic aerial survey (50% coverage) of the CD North study area in 2002, 803 White-fronted Geese were recorded in 17 groups (Figure 18, Table 20). Group sizes ranged from 7–116 birds ($\bar{x} = 47$) and goslings comprised 37% of the total number of geese. The number of White-fronted Geese seen in 2002 in the CD North study area was lower than all but one count in the previous survey years (331–1,354 birds in 1996–1998 and 2000–2001; Table 20, Appendix C16). In previous survey years, goslings comprised 35–58% of the birds seen during the systematic surveys. Prior to 1996, brood counts of 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. In 2002, a group of 35 adult Snow Geese with no young were observed during the brood-rearing survey (Table 20). In previous survey years, numbers of Snow Geese recorded during systematic brood-rearing surveys ranged from 0 birds in 2001 to 72 birds in 1998 (Table 20, Appendix C16). No Snow Geese were recorded in the CD North study area during surveys for other species in 1992 and 1993.

In 2002, 2 groups of Canada Geese were recorded during the brood-rearing aerial survey, including a molting group of 12 geese and a brood-rearing group of 35 geese (20 adults, 15 young; Table 20). Only 3 other occurrences of these geese on the delta have been recorded during the brood-rearing/molting period. In 1998 and 2000, small brood-rearing groups were observed (24 and 22 birds, respectively) during aerial surveys (Table 20, 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 2002, small numbers of White-fronted Geese, in groups that averaged 20 birds, were distributed throughout the CD North study area in a variety of aquatic and terrestrial habitats (Figure 17, Table 21). The total recorded in 2002 (159 geese) was the smallest recorded in any year. In previous systematic surveys (1996–1998 and 2000–2001), numbers ranged between 687 and 1,379 geese. Prior to 1996, observations were made opportunistically during surveys for other focal species, such as Tundra Swans. Counts of fall-staging White-fronted Geese seen on the delta during these other surveys in 1991, 1992, and 1995, were 213, 602, and 400 geese, respectively.

No Snow Geese were recorded during the 2002 fall-staging survey. Small numbers (3–36 birds) of Snow Geese were recorded most years during this season (Appendix C17). As during brood-rearing, all Snow Geese seen during fall staging were on the outer delta.

Canada Geese occurred in larger numbers during fall staging than during brood-rearing and used coastal areas of the outer delta more than other areas on the delta (Figure 17). In 2002, 331 Canada Geese in 16 groups were observed in the CD North study area during the aerial survey (Table 21). In 1996–1998 and 2000–2001, 420–1,021 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 ~4,600 were counted in the CD North study area on a survey for other species (Smith et al. 1993). During 1991, 1993, and 1995, the numbers counted incidentally on other surveys were lower (182–792 birds). Both brood-rearing and fall-staging counts of geese have been annually variable. 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

White-fronted Geese in the CD North ground-search areas nested in almost all of the available habitats in 2000–2002 (Table 22). Most nests were found in 2 habitats with polygonal surfaces: Patterned Wet Meadow (38% of all

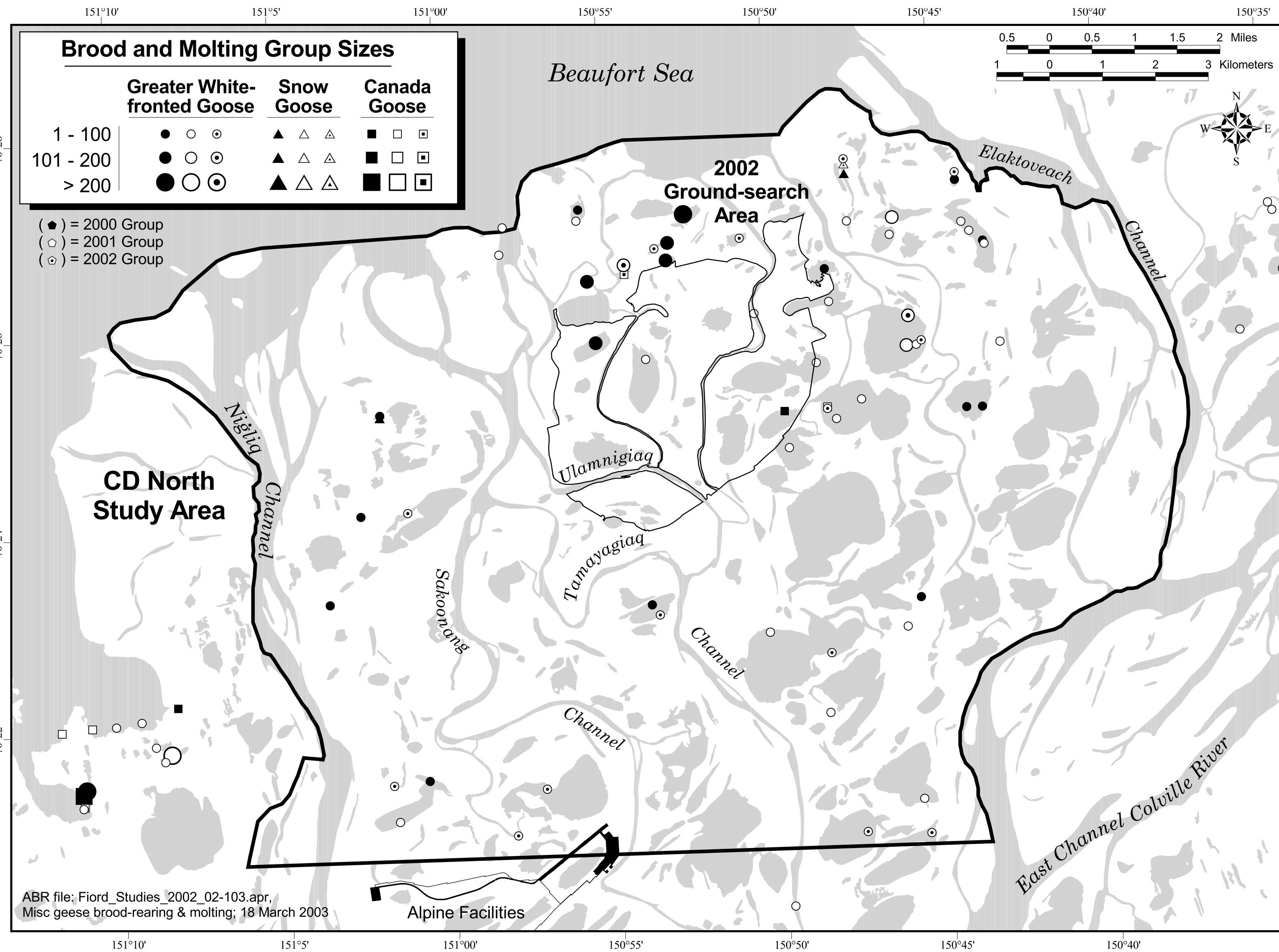

Figure 18. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese recorded during aerial surveys in the CD North study area, Colville River Delta, Alaska, July 2000–2002.

Table 20. Numbers of geese during brood-rearing aerial surveys in the CD North study area, Colville River Delta, Alaska, 1996–2002. In 1996, survey coverage was 25%; in all other years, coverage was 50%. Pre-2000 data are from Johnson et al. (1999a).

Year	No. of Birds	No. of Groups	Group Size (range)	No. of Goslings	% Groups w/ Goslings
GREATER WHITE-FRONTED GOOSE					
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
2002	803	17	7–116	297	71
CANADA GOOSE					
1996	0	0	–	0	0
1997	0	0	–	0	0
1998	24	1	24	16	100
2000	22	1	22	14	100
2001	0	0	–	0	0
2002	47	2	12–35	15	50
SNOW GOOSE					
1996	6	1	6	4	100
1997	21	2	9–12	13	100
1998	72	3	20–32	42	100
2000	45	2	20–25	29	100
2001	0	0	–	0	0
2002	35	1	35	0	0

nests) and Aquatic Sedge with Deep Polygons (30%), both of which were preferred habitats (Table 22, Appendix D9). Shallow Open Water with Islands or Polygonized Margins also was a preferred habitat when 3 years of nesting data were combined. Most (80%) 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. 2003). Nests ranged from <1 to 329 m ($\bar{x}$ = 83.1 m, n = 517 nests) 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 2000–2002, and typically occurred in or near lakes. Over 70% of all groups were observed in both types of Deep Open Water, both types of Tapped Lakes, and Brackish Water (Table 23). All 6 brood-rearing groups of Canada and Snow geese were observed in lakes (Table 23).

White-fronted and Canada geese during fall staging used many of the same habitats as during brood-rearing, but were more likely to be found in terrestrial types than they were during brood-rearing. During fall staging, 56% of White-fronted Geese and 30% of Canada Geese used water habitats (Table 23). No Snow Geese were seen during the 2002 fall-staging survey, but in 2000 and 2001, 3 groups of staging Snow Geese were seen in water habitats (Open Nearshore Water and Brackish Water) and 2 groups were seen in Tidal Flat and Moist Sedge–Shrub Meadow (Table 23).

Table 21. Numbers of geese during fall-staging aerial surveys in the CD North study area, Colville River Delta, Alaska, 1996–2002. In 1996, survey coverage was 25%; in all other years coverage was 50%. Pre-2000 data are from Johnson et al. (1999a).

	Greater White-fronted Goose				Canada Goose			
			Group Size				Group Size	
Year	No. of Birds	No. of Groups	Mean	Range	No. of Birds	No. of Groups	Mean	Range
1996	765	13	58.9	5–350	1,021	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
2002	159	8	19.9	5–55	331	16	20.7	3–50

Table 22. Habitat selection (pooled among years) by Greater White-fronted Geese nesting in the CD North ground-search areas, Colville River Delta, Alaska, 2000–2002.

Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	1	0.2	3.8	avoid
Tapped Lake with Low-water Connection	0	0	1.2	avoid
Tapped Lake with High-water Connection	1	0.2	3.6	avoid
Salt Marsh	8	1.6	4.8	avoid
Tidal Flat	0	0	<0.1	ns
Salt-killed Tundra	63	12.4	16.7	avoid
Deep Open Water without Islands	5	1.0	3.3	avoid
Deep Open Water with Islands or Polygonized Margins	8	1.6	9.8	avoid
Shallow Open Water without Islands	0	0	0.2	ns
Shallow Open Water with Islands or Polygonized Margins	9	1.8	0.7	prefer
River or Stream	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	155	30.4	12.6	prefer
Aquatic Grass Marsh	0	0	0.1	ns
Nonpatterned Wet Meadow	57	11.2	13.3	ns
Patterned Wet Meadow	196	38.4	22.8	prefer
Moist Sedge–Shrub Meadow	4	0.8	2.7	avoid
Riverine or Upland Shrub	2	0.4	0.9	ns
Barrens	1	0.2	3.6	avoid
Total	510	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.

Table 23. Habitat use by brood-rearing/molting and fall-staging groups of geese in the CD North study area, Colville River Delta, Alaska, 2000–2002.

SEASON Habitat	Greater White-fronted Goose No.	Greater White-fronted Goose Use (%)	Canada Goose No.	Canada Goose Use (%)	Snow Goose No.	Snow Goose Use (%)
BROOD-REARING						
Brackish Water	11	19.3	0	0	2	66.7
Tapped Lake with Low-water Connection	12	21.1	2	66.7	0	0
Tapped Lake with High-water Connection	2	3.5	1	33.3	0	0
Salt Marsh	2	3.5	0	0	0	0
Salt-killed Tundra	3	5.3	0	0	0	0
Deep Open Water without Islands	9	15.8	0	0	1	33.3
Deep Open Water with Islands or Polygonized Margins	7	12.3	0	0	0	0
River or Stream	2	3.5	0	0	0	0
Aquatic Sedge with Deep Polygons	2	3.5	0	0	0	0
Aquatic Grass Marsh	1	1.8	0	0	0	0
Nonpatterned Wet Meadow	1	1.8	0	0	0	0
Patterned Wet Meadow	1	1.8	0	0	0	0
Moist Tussock Tundra	1	1.8	0	0	0	0
Riparian or Upland Shrub	1	1.8	0	0	0	0
TOTAL	57	100	3	100	3	100
FALL STAGING						
Open Nearshore Water	0	0	2	6.1	1	20.0
Brackish Water	6	8.5	6	18.2	2	40.0
Tapped Lake with Low-water Connection	9	12.7	2	6.1	0	0
Tapped Lake with High-water Connection	3	4.2	0	0	0	0
Salt Marsh	5	7.0	4	12.1	0	0
Tide Flat	1	1.4	1	3.0	1	20.0
Salt-killed Tundra	6	8.5	7	21.2	0	0
Deep Open Water without Islands	6	8.5	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	9	12.7	0	0	0	0
River or Stream	7	9.9	0	0	0	0
Aquatic Sedge with Deep Polygons	3	4.2	0	0	0	0
Nonpatterned Wet Meadow	4	5.6	2	6.1	0	0
Patterned Wet Meadow	5	7.0	4	12.1	0	0
Moist Sedge–Shrub Meadow	0	0	0	0	1	20.0
Moist Tussock Tundra	1	1.4	0	0	0	0
Barrens	6	8.5	5	15.2	0	0
TOTAL	71	100	33	100	5	100

FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are much more common on the coastal plain and 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 abundant than the arctic fox (Eberhardt 1977).

Arctic foxes in northern Alaska breed in late March or April, and pups are born in late May or June (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). 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 effective 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; Fine 1980; Eberhardt et al. 1982, 1983; 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 Delta when baseline wildlife studies began there in 1992 (Smith et al. 1993).

DISTRIBUTION AND ABUNDANCE

Number and Density of Dens

Twelve fox dens have been found in the CD North study area since 1992, including active and inactive sites of both species (Figure 19, Table 24). Ten (83%) of the dens were arctic fox sites in 2002. The 2 red fox dens were located near each other on an island in the Elaktoveach Channel (Figure 19); their proximity indicates they are alternate sites used by a single denning pair (Johnson et al. 2000a). The density of arctic fox dens occupied annually during 1993–2002 (2–8 dens; Table 25) ranged from 1 den/26 km² to 1 den/104 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 since 2000, the first year this species was found denning in the CD North study area, has ranged from 0 to 1 den/104 km² (counting both dens separately).

Despite intensive search effort, we have been unable to locate 4 dens on the outer Colville Delta reported to us by other researchers (M. North, unpubl. data; S. Earnst, Boise State University, 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 several additional dens could be present in the outermost portions of the delta that have not yet been searched thoroughly.

In 10 years of surveys (1992, 1993, 1995–2002) and contacts with other observers, 77 fox dens have been located between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield. In 2002, 69 of those dens (90%) were classified as arctic fox dens and the remaining 8 dens (10%) were classified as red fox dens (Appendix C18); 4 of the red fox dens were former arctic fox sites.

The total density of fox dens (active and inactive) in the CD North study area (207 km²) was 1 den/17 km². Den density was 1 den/21 km² for arctic foxes and 1 den/104 km² for red foxes, 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. 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. 2003). The overall density also was higher than

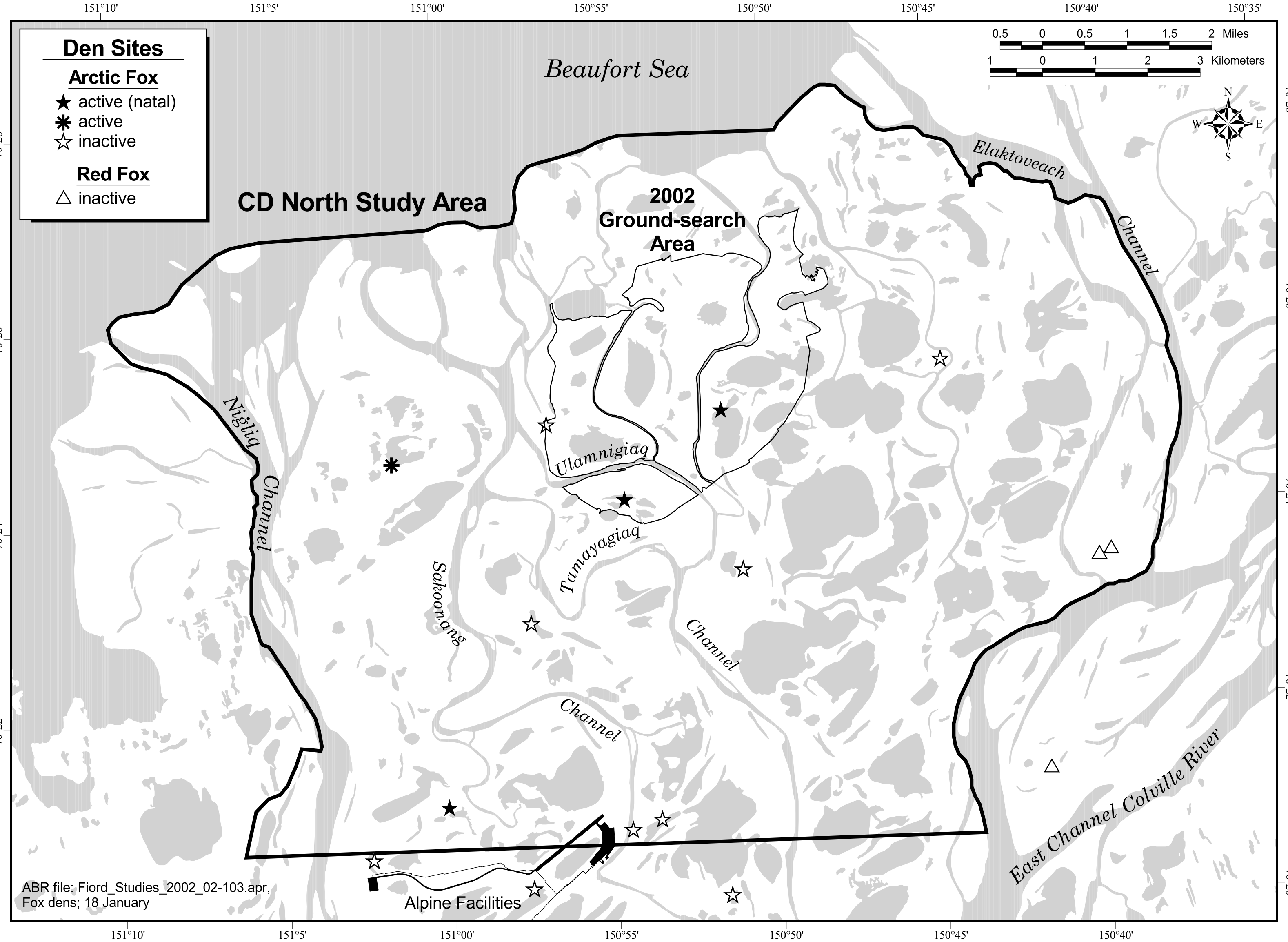

Figure 19. Distribution and status of arctic and red fox dens in the CD North study area, Colville River Delta, Alaska, 2002. Survey coverage was not uniform over the area portrayed.

Table 24. Annual status of arctic and red fox dens in the CD North study area during the 1993–2002 denning seasons, Colville River Delta, Alaska. Pre-2000 data are from Johnson et al. (2003). 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.

SPECIES	Status[a]								
Landform	1993	1995	1996	1997	1998	1999	2000	2001	2002
ARCTIC FOX									
Old dune	Natal (5)	Inactive	Natal (6)	Inactive (0)	Natal (3)	Natal (8)	Inactive	Inactive	Inactive
Dune/lake bank	Natal (3)	Inactive	Natal (3)	Inactive (0)	Inactive (0)	Inactive	Inactive	Inactive	Inactive
Lake bank	Inactive	Inactive	Natal (4)	Natal (0)	Active (0)	Inactive	Natal (3)	Natal (2)	Natal (2)
Dune/lake bank	Inactive	Natal (–)	Natal (6)	Inactive (0)	Inactive	Inactive	Inactive	Natal (3)	Active (0)
Dune/lake bank	Inactive	Active (–)	Natal (5)	Natal (3)	Active (0)	Active (0)	Natal (0)	Inactive	Natal (6)
Dune ridge	–	Natal (3)	Natal (7)	Inactive (0)	Active (2)	Natal (0)	Natal (5)	Inactive	Natal (3)
Dune/river bank	–	Secondary (3)	Natal (5)	Natal (4)	Natal (1)	Inactive	Inactive	Active (0)	Inactive
Dune/lake bank	–	Inactive	Inactive	Not checked	Not checked	Inactive	Inactive	Inactive	Inactive
Low dune ridge	–	–	Natal (6)	Natal (5)	Inactive	Natal (2)	Natal (5)	Active (1?)	Inactive
Large polygon rim	–	–	–	–	–	–	–	Inactive	Inactive
RED FOX									
Sand dune[b]	–	–	–	–	Inactive	Inactive	Secondary (2)	Active (0)	Inactive
Sand dune	–	–	–	–	–	–	Natal (0)	Inactive	Inactive

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

[b] Arctic fox den until 2000.

Table 25. Occupancy status of arctic and red fox dens in the CD North study area, Colville River Delta, Alaska, 1993–2002. Pre-2002 data from Johnson et al. (2003).

SPECIES	1993		1995		1996		1997		1998		1999		2000		2001		2002	
Status[a]	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ARCTIC FOX																		
Natal	2	40	2	25	8	89	4	50	2	22	3	30	4	44	2	20	3	30
Secondary	0	0	1	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Active	0	0	1	12	0	0	0	0	3	33	1	10	0	0	2	20	1	10
Inactive	3	60	4	50	1	11	4	50	4	45	6	60	5	56	6	60	6	60
TOTAL	5		8		9		8		9		10		9		10		10	
RED FOX																		
Natal	–		–		–		–		–		–		1	50	0	0	0	0
Secondary	–		–		–		–		–		–		1	50	0	0	0	0
Active	–		–		–		–		–		–		0	0	1	50	0	0
Inactive	–		–		–		–		–		–		0	0	1	50	2	100
TOTAL	0		0		0		0		0		0		2		2		2	

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

the 1 den/34 km² reported by Eberhardt et al. (1983) for their 1,700-km² Colville study area. However, the overall density of arctic fox dens on the delta was lower than has been reported for the 805-km² developed area of the Prudhoe Bay Oilfield (1 den/12–1 den/15 km²; Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues et al. 1994).

Den Occupancy and Production of Young

Based on brief visits at 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 3 dens (all natal sites) and suspected that pups may have been present at one other active den (Table 24). The total count was 11 arctic fox pups at the 3 confirmed natal dens, for a mean litter size of 3.7 pups. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to reliably obtain complete counts. No adults or pups were observed in 2002 at either red fox den in the CD North study area, and no sign was found to indicate that either was used as a natal den.

The estimated 40% den occupancy rate by arctic fox litters (natal and active categories combined) in the CD North study area in 2002 was at the low end of the range observed since 1993 (40–89% occupied; Table 25). In contrast, the 89% den occupancy rate in 1996 (when microtine rodent populations peaked) was the highest on record for the Colville Delta area. The occupancy rate at arctic fox dens in the CD North study area generally is higher than the overall range of 24–67% for the delta and adjacent coastal plain tundra to the east (Johnson et al. 2003). 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 in 2002 was about average. The total count of 11 pups was near the annual mean of 12.7 pups in the study area during 1993 and 1995–2002, but was substantially below the highest production observed (42 pups in 1996). The mean litter size of 3.7 pups for arctic foxes in 2002 was in the middle 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). The number of pups produced and the mean litter size we recorded in 2002 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—Nonpatterned Wet Meadow (2 dens), Patterned Wet Meadow (1 den), Moist Sedge–Shrub Meadow (1 den), and Barrens (1 den). In the CD North area, foxes tend to den in old dunes stabilized by vegetation, often those cut by lakes or river channels (Table 24). 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 (Johnson et al. 2002). Sixteen dens (70% of 23 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 Patterned Wet Meadow—all were avoided by denning foxes (Johnson et al. 2002).

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 24; 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). These observations all confirm that the primary requirement for denning habitat is well-drained soil with a texture conducive to burrowing, conditions that occur on elevated microsites within a variety of larger habitat types.

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Appendix A. Common and scientific names of birds and mammals observed on the Colville River Delta, Alaska, May-October 1992–2002.

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
BIRDS			
Red-throated Loon	*Gavia stellata*	Upland Sandpiper	*Bartramia longicauda*
Pacific Loon	*Gavia pacifica*	Whimbrel	*Numenius phaeopus*
Yellow-billed Loon	*Gavia adamsii*	Bar-tailed Godwit	*Limosa lapponica*
Red-necked Grebe	*Podiceps grisegena*	Ruddy Turnstone	*Arenaria interpres*
Greater White-fronted Goose	*Anser albifrons*	Semipalmated Sandpiper	*Calidris pusilla*
Snow Goose	*Chen caerulescens*	Western Sandpiper	*Calidris mauri*
Canada Goose	*Branta canadensis*	Least Sandpiper	*Calidris minutilla*
Brant	*Branta bernicla*	White-rumped Sandpiper	*Calidris fuscicollis*
Tundra Swan	*Cygnus columbianus*	Baird's Sandpiper	*Calidris bairdii*
American Wigeon	*Anas americana*	Pectoral Sandpiper	*Calidris melanotos*
Mallard	*Anas platyrhynchos*	Dunlin	*Calidris alpina*
Northern Shoveler	*Anas clypeata*	Stilt Sandpiper	*Calidris himantopus*
Northern Pintail	*Anas acuta*	Buff-breasted Sandpiper	*Trygites subrficollis*
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*	Violet-green Swallow	*Tachycineta bicolor*
Gyrfalcon	*Falco rusticolus*	American Robin	*Turdus migratorius*
Peregrine Falcon	*Falco peregrinus*	Bluethroat	*Luscinia svecica*
Willow Ptarmigan	*Lagopus lagopus*	Yellow Wagtail	*Motacilla flava*
Rock Ptarmigan	*Lagopus mutus*	Wilson's Warbler	*Wilsonia pusilla*
Sandhill Crane	*Grus canadensis*	American Tree Sparrow	*Spizella arborea*
Black-bellied Plover	*Pluvialis squatarola*	Savannah Sparrow	*Passerculus sandwichensis*
American Golden-Plover	*Pluvialis dominica*	Lapland Longspur	*Calcarius lapponicus*
Semipalmated Plover	*Charadrius semipalmatus*	Snow Bunting	*Plectrophenax nivalis*
Lesser Yellowlegs	*Tringa flavipes*	Common Redpoll	*Carduelis flammea*
MAMMALS			
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, 2002.

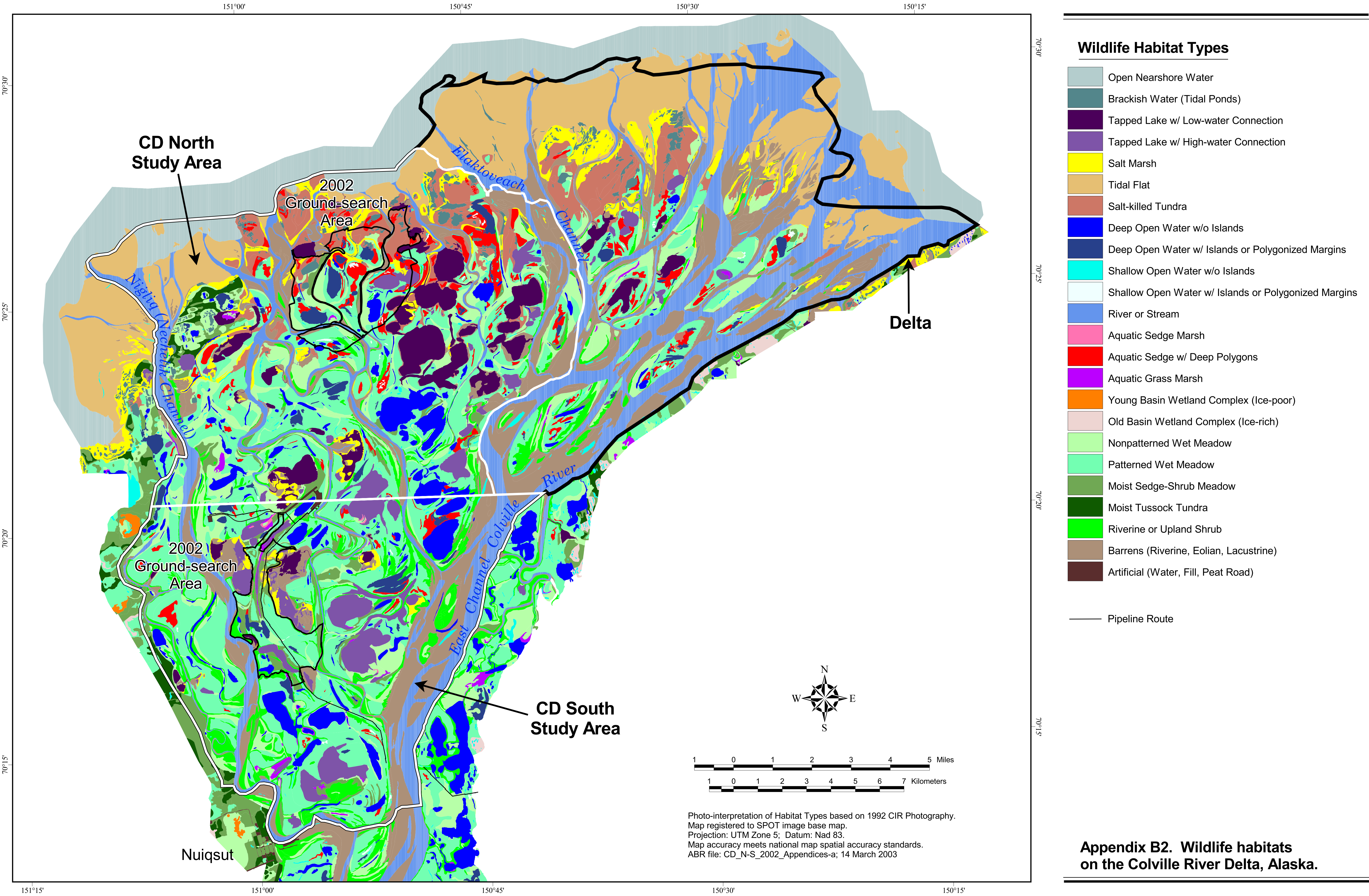
Habitat	Description
Open Nearshore Water (Estuarine Subtidal)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced by winds may raise sea level as much as 2–3 m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. This habitat is important for some species of waterfowl during molting and during spring and fall staging, and for loons while foraging.
Brackish Water (Tidal Ponds)	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake with Low-water Connection	Waterbodies that have been partially drained through erosion of banks by adjacent river channels, but which are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shorelines. Deeper lake 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 Patterned Wet Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that formerly supported Moist Sedge–Shrub Meadows and Upland Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizing plants. These areas are often polygonized, with the rims less salt-affected than the centers of the polygons.
Deep Open Water without Islands	Deep (≥1.5 m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes; most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. They do not freeze to the bottom during winter. Lakes usually are not connected to rivers. Sediments are fine-grained silt and clay. Deep Open Waters without Islands are differentiated from those with islands because of the importance of islands to nesting waterbirds.

Appendix B1. (Continued).

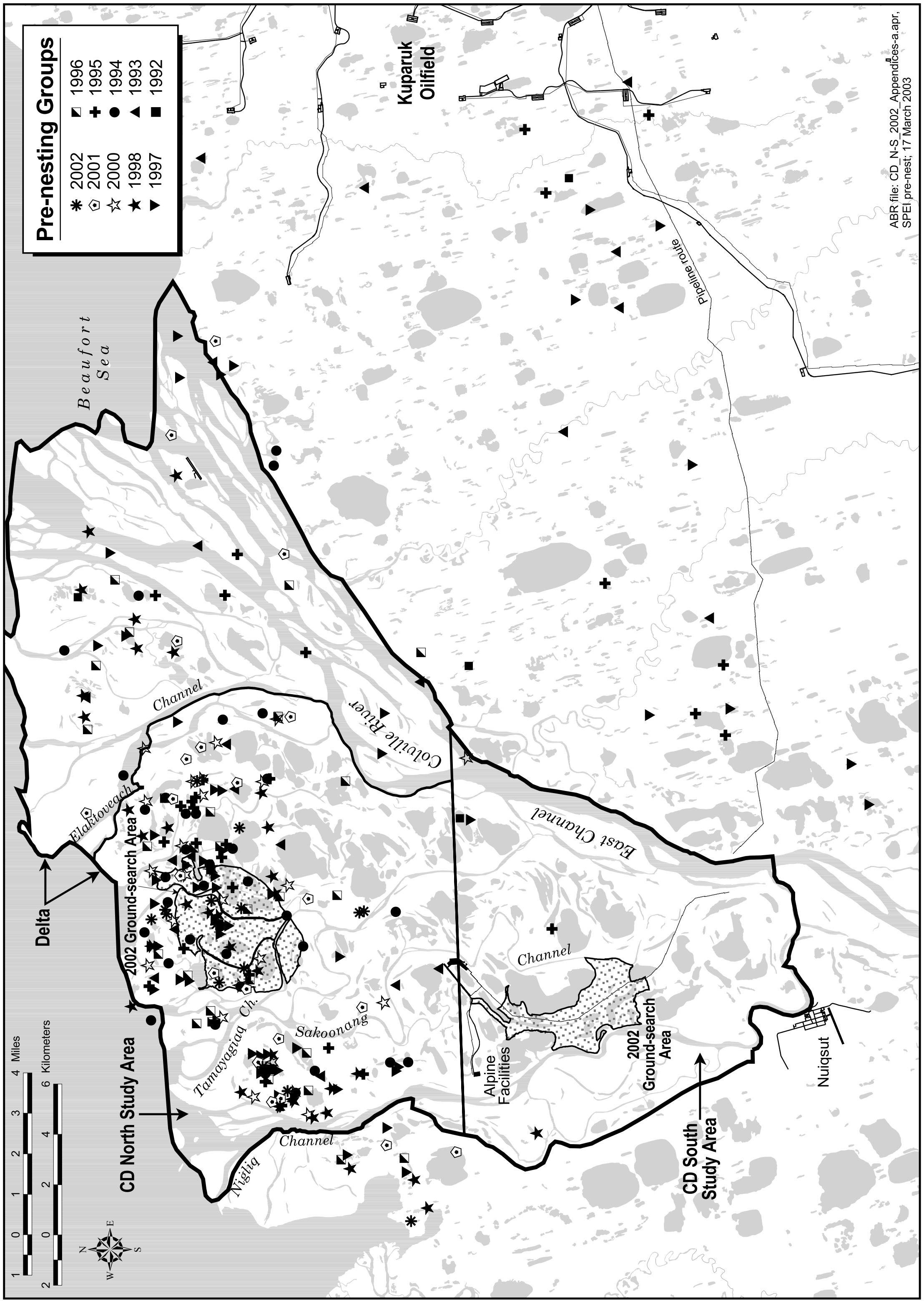
Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many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

Appendix B1. (Continued).

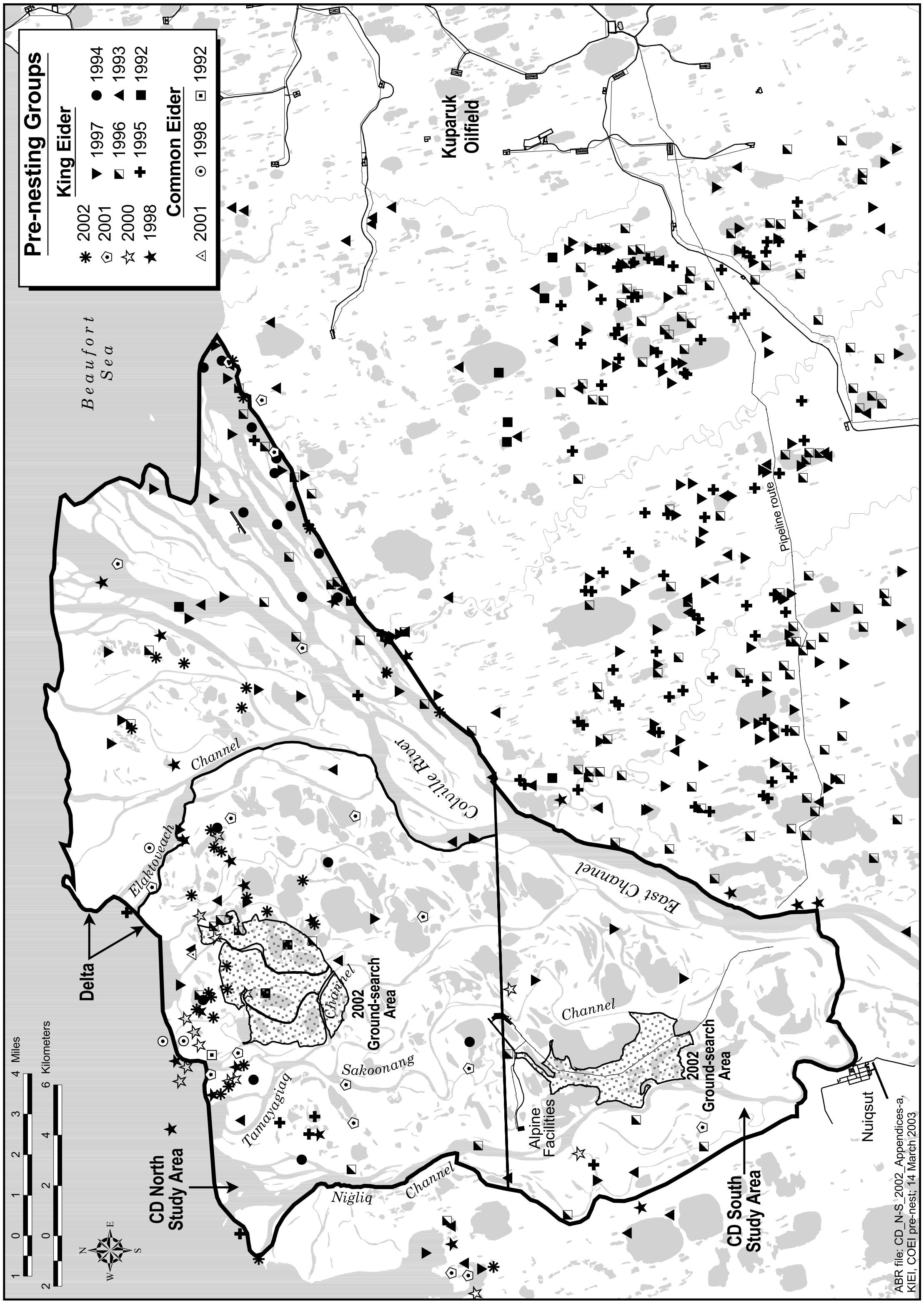
Habitat	Description
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims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



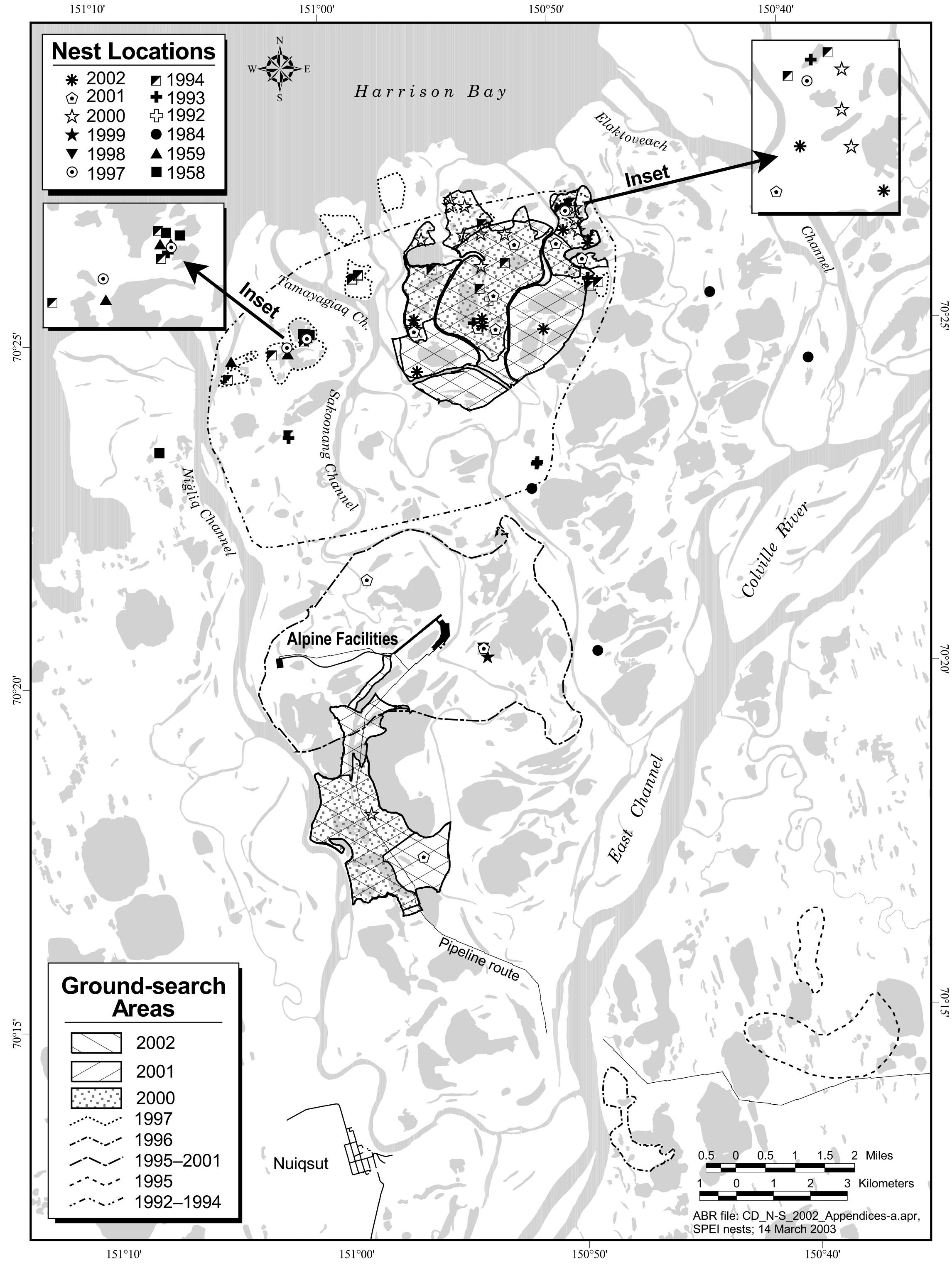
Appendix B2. Wildlife habitats on the Colville River Delta, Alaska.



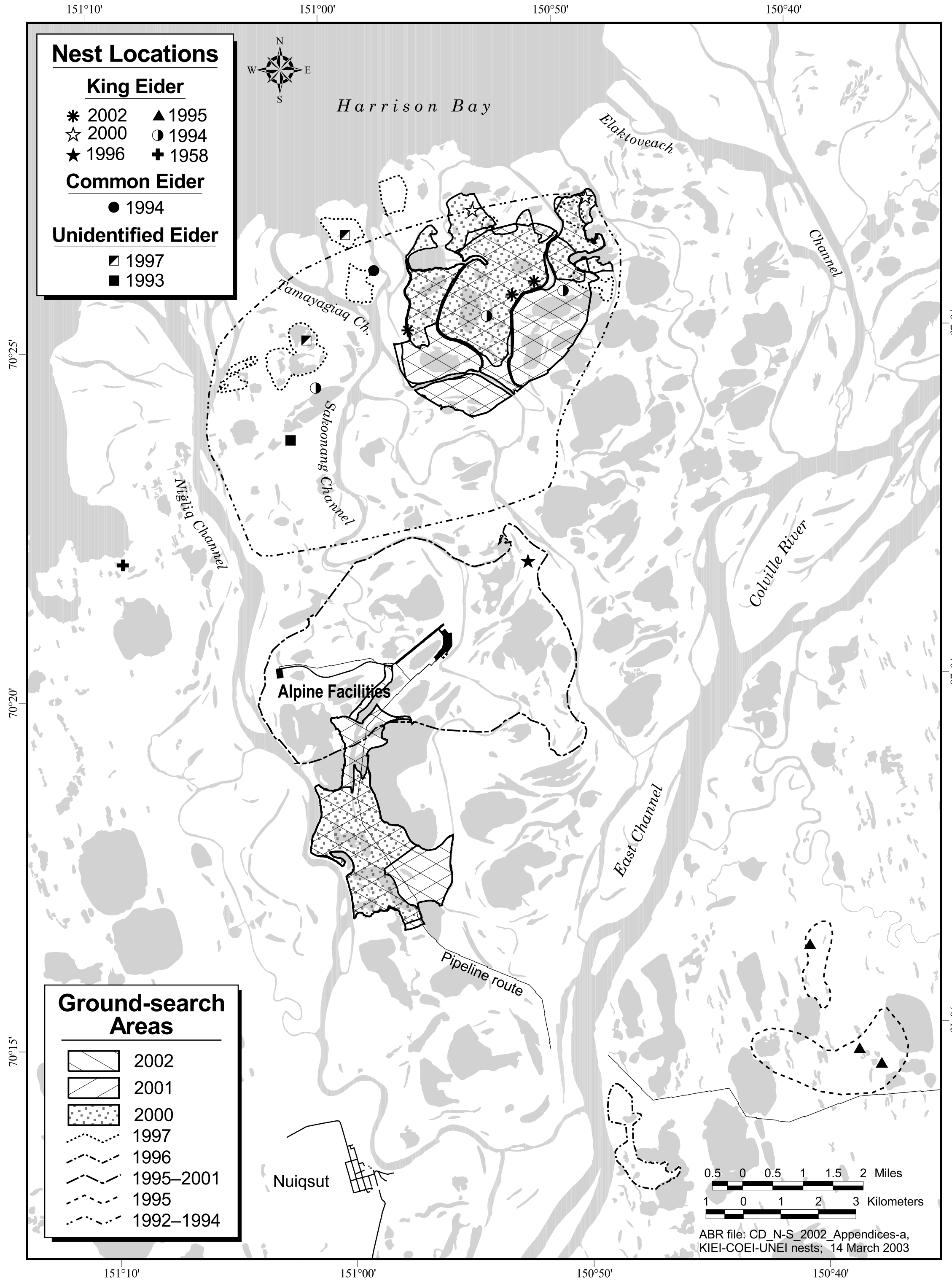
Appendix C1. Distribution of Spectacled Eider groups recorded during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a).



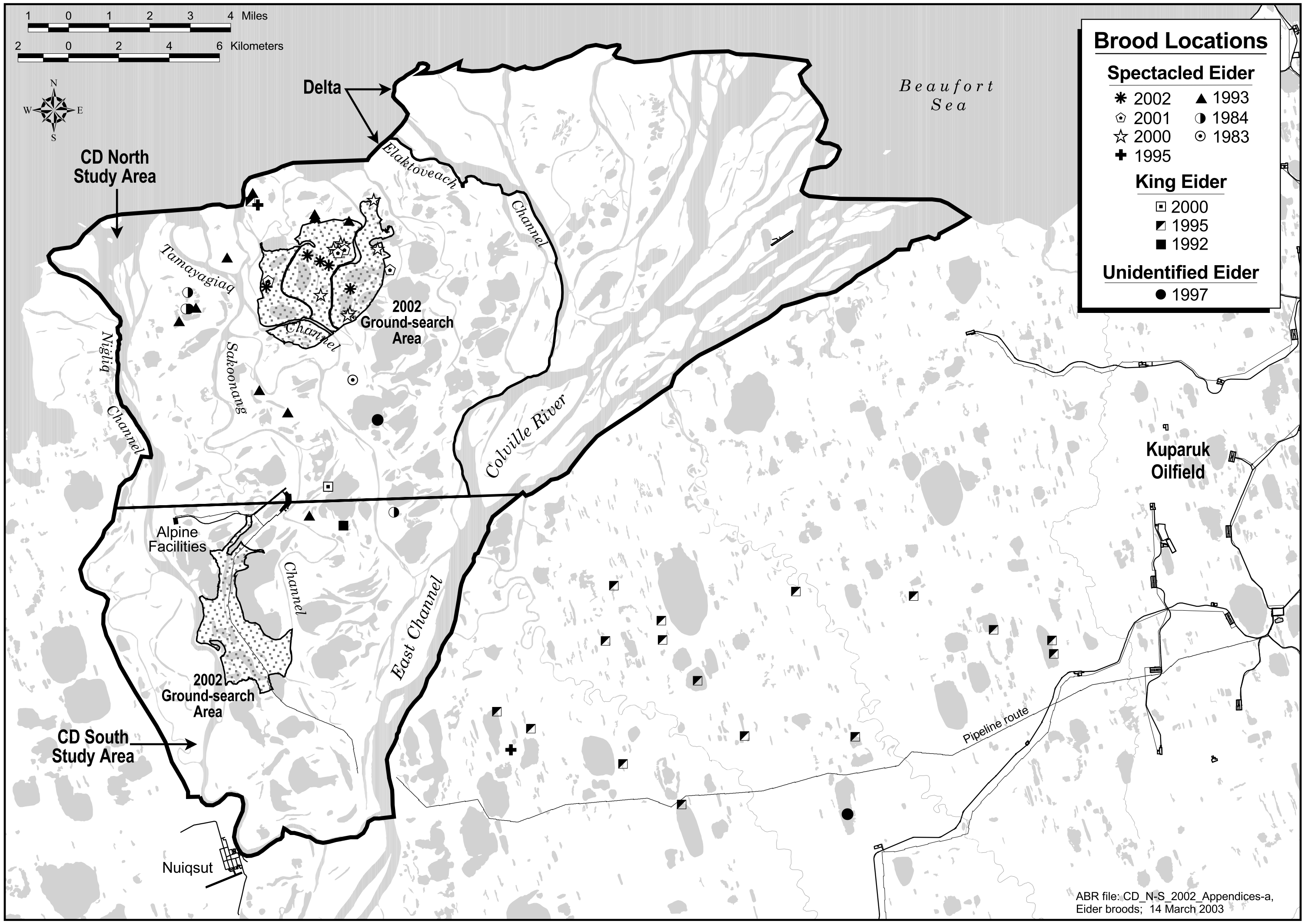
Appendix C2. Distribution of King and Common eider groups recorded during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a).



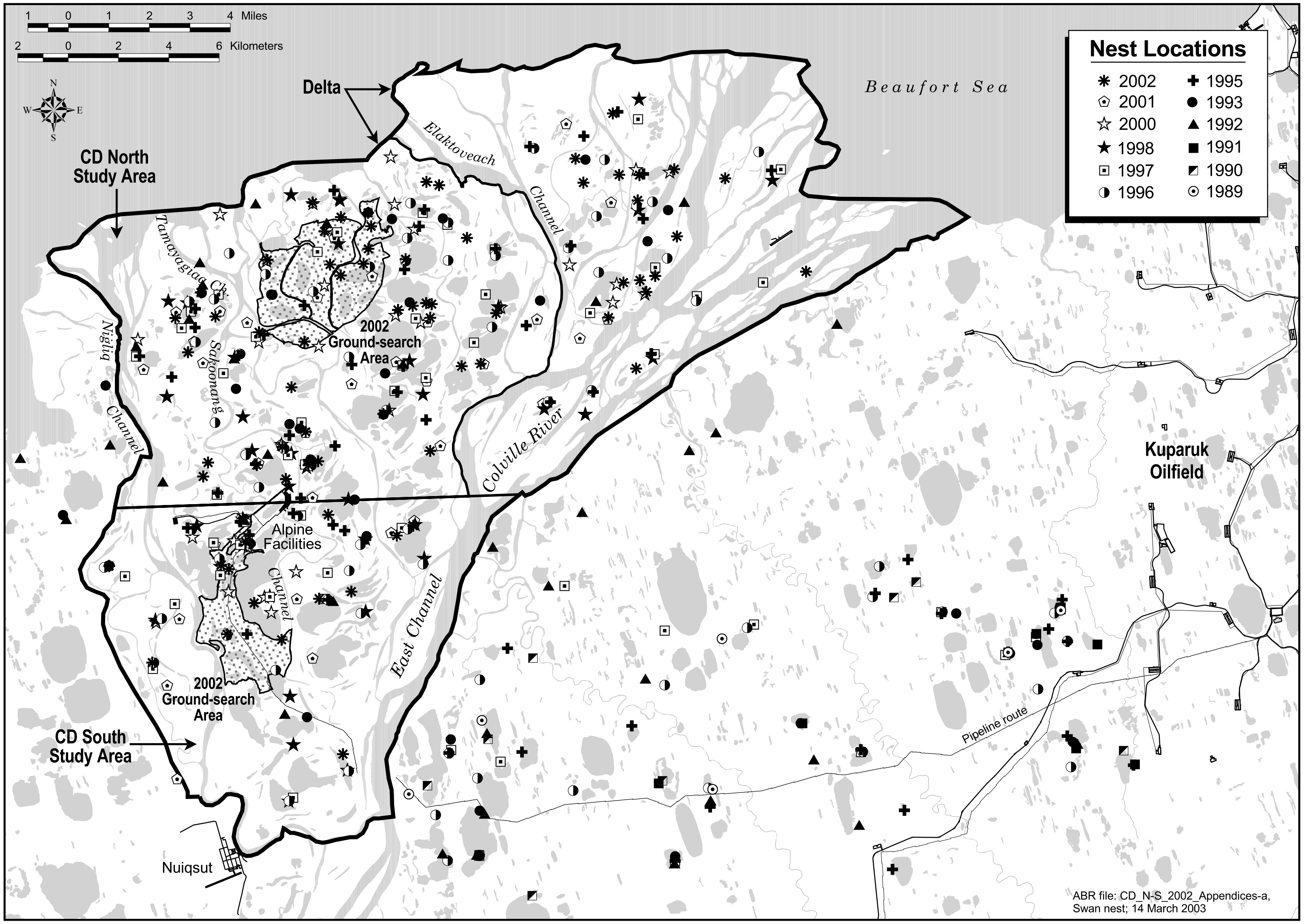
Appendix C3. Distribution of Spectacled Eider nests located during ground searches on the Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–2002. Pre-2000 data are from T. Myres (1958, 1959, unpubl. data), M. North (1984, unpubl. data), and Johnson et al. (1999a). Survey coverage was not uniform in the 1992–1994 and 1995–2001 boundaries.



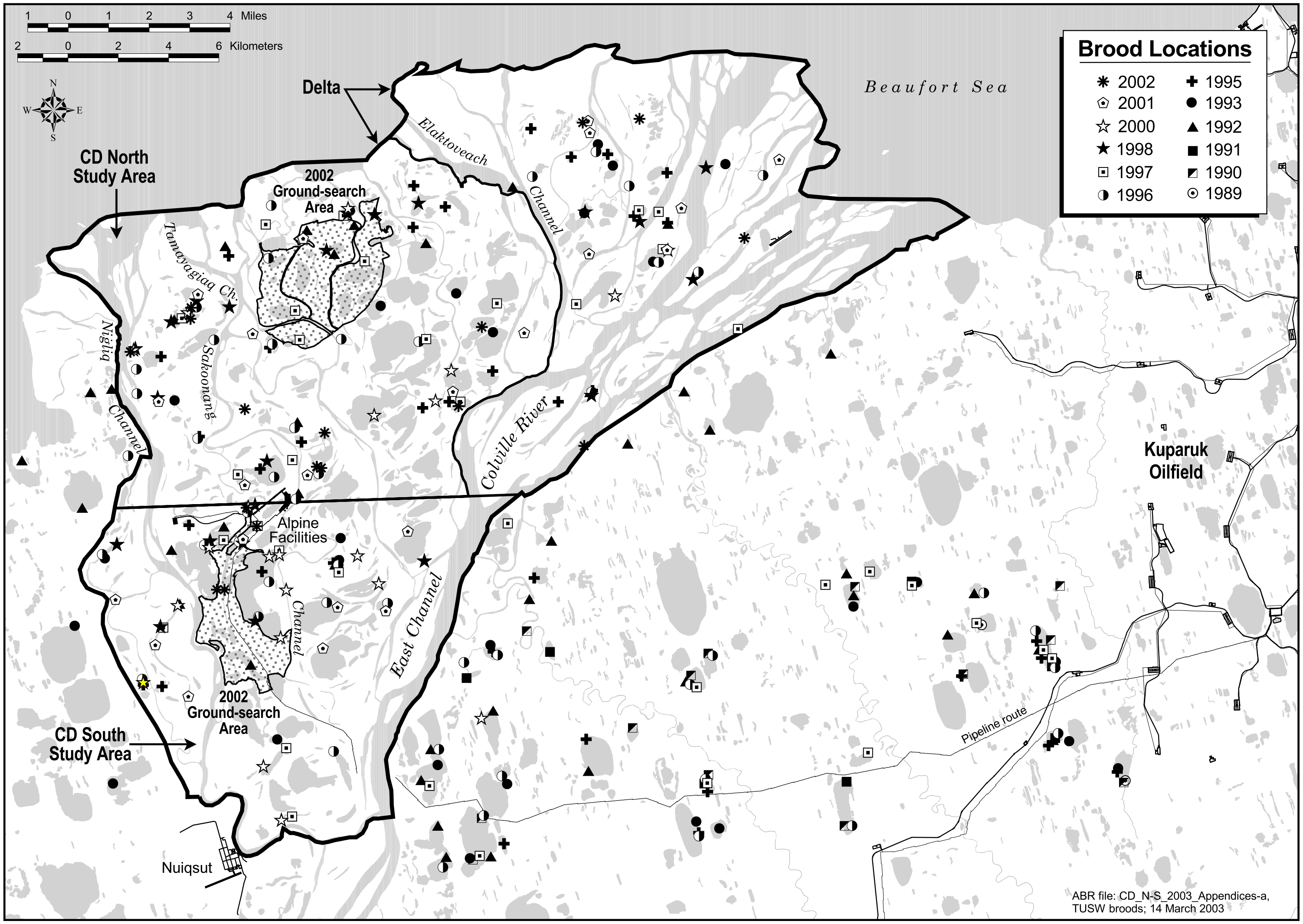
Appendix C4. Distribution of King, Common, and unidentified eider nests located during ground searches on the Colville River Delta, Alaska, 1958 and 1992–2002. Pre-2000 data are from T. Myres (1958, unpubl. data) and Johnson et al. (1999a). Survey coverage was not uniform within the 1992–1994 and 1995–2001 boundaries. .



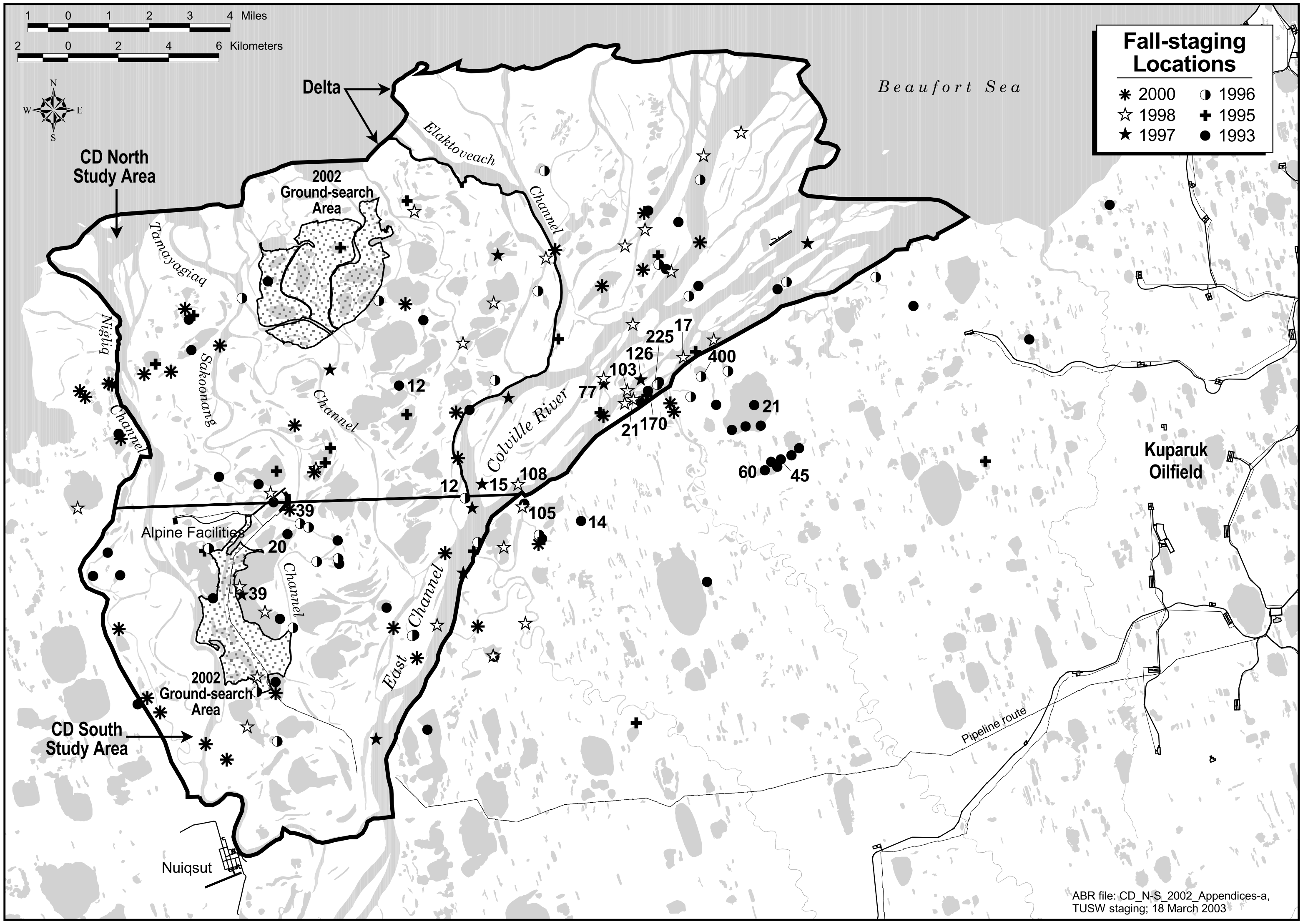
Appendix C5. Distribution of Spectacled, King, and unidentified eider broods recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1983, 1984, 1992–2002. Pre-2000 data are from M. North (1983, 1984, unpubl. data) and Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



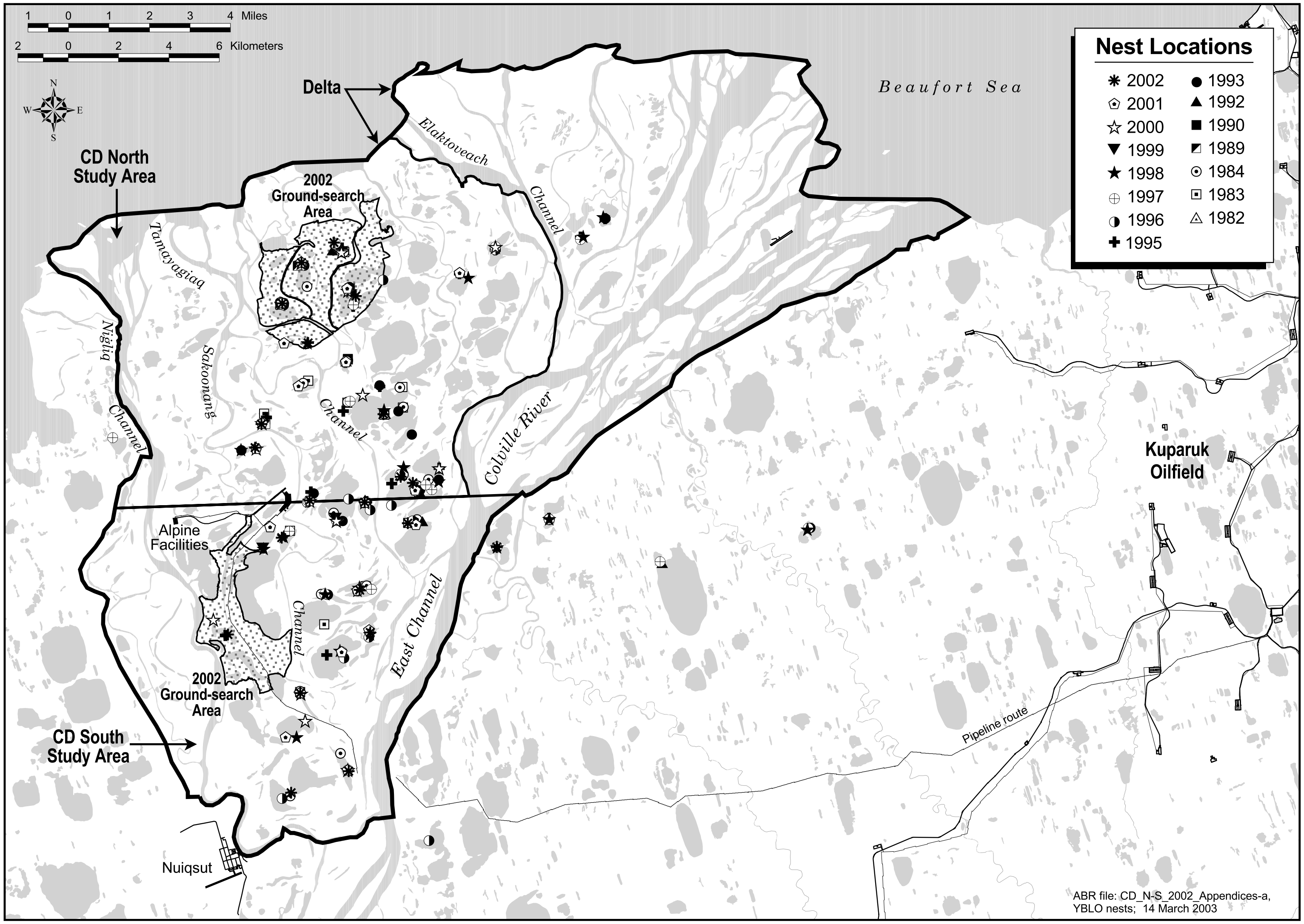
Appendix C6. Distribution of Tundra Swan nests recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), and Johnson et al. (1999a).



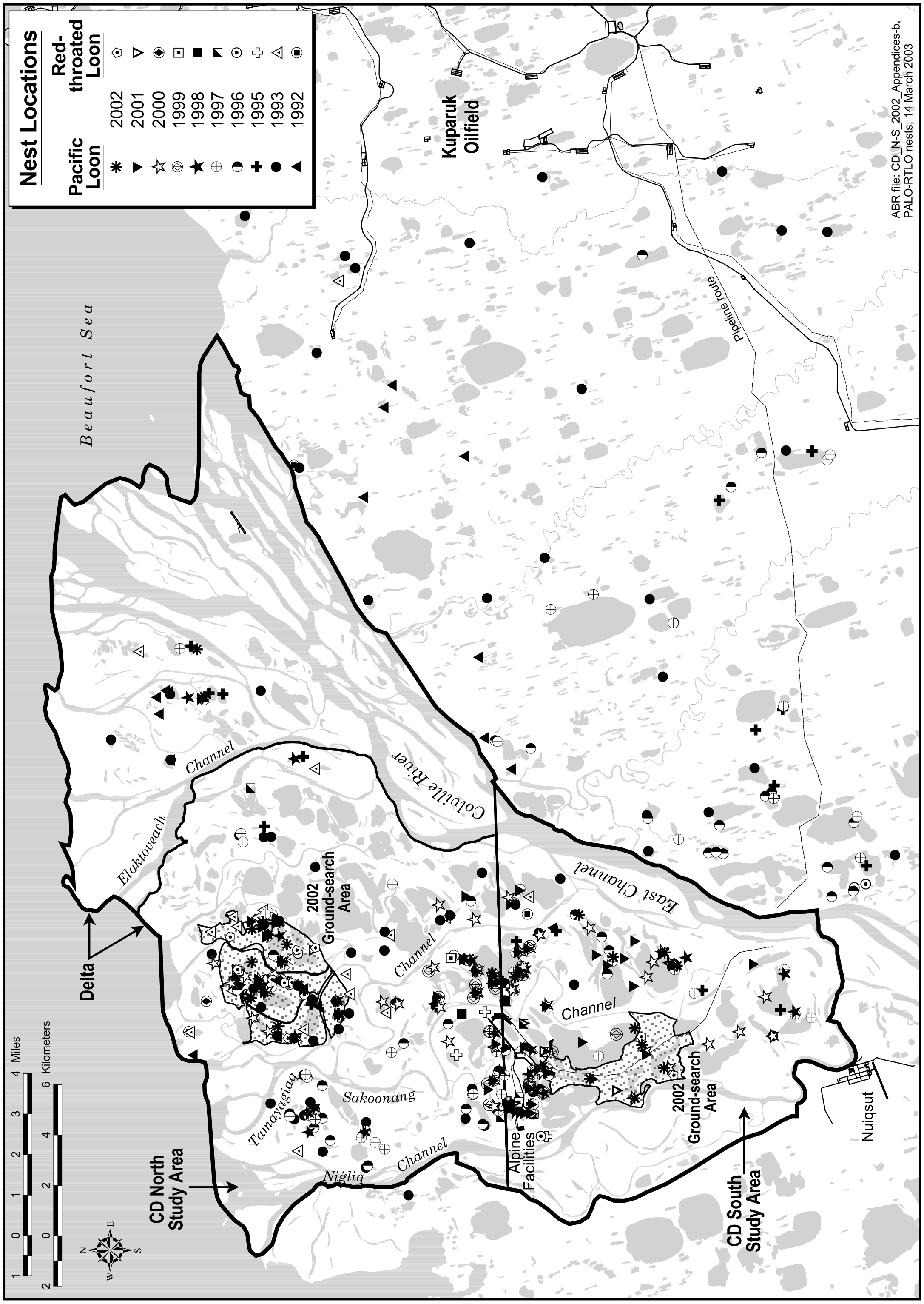
Appendix C7. Distribution of Tundra Swan broods recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), and Johnson et al. (1999a).



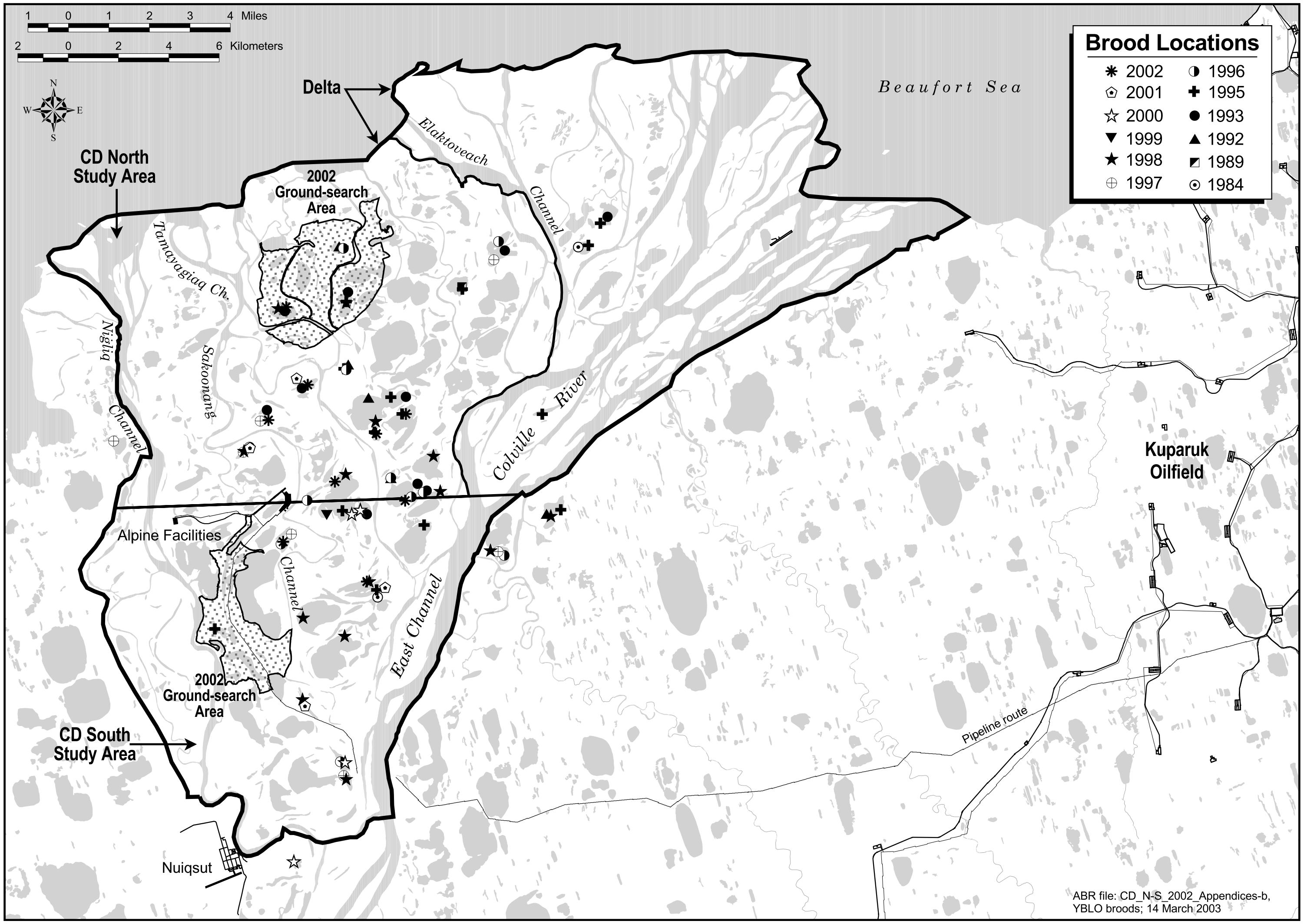
Appendix C8. Distribution of Tundra Swan fall-staging groups recorded during aerial surveys on the Colville River Delta, Alaska, 1993–2000. Numbers indicate size of groups >10. Pre-2000 data are from Johnson et al. (1999a).



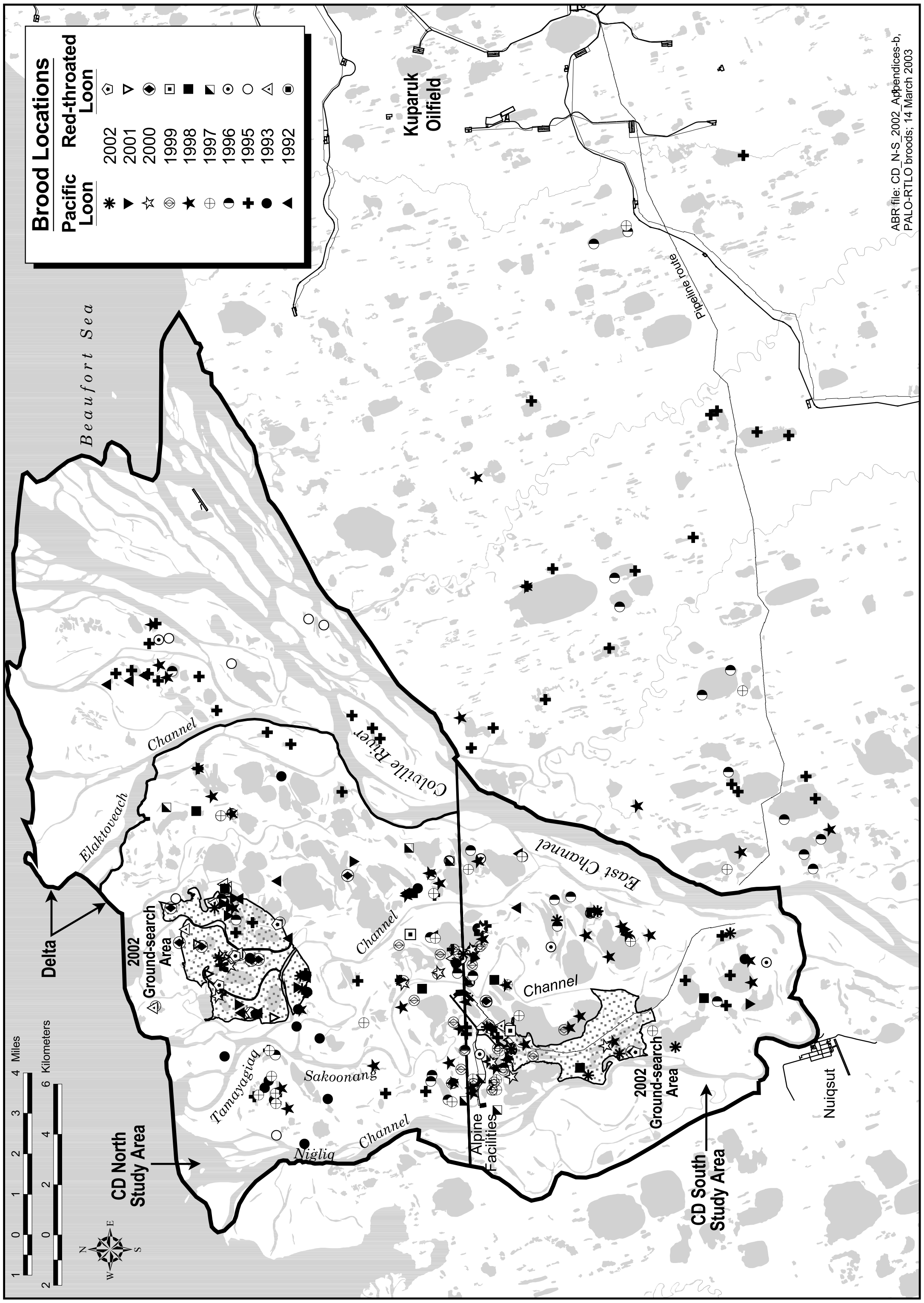
Appendix C9. Distribution of Yellow-billed Loon nests recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1982–2002. Pre-2000 data are from M. North (1982–1984, 1989, 1990, unpubl. data), S. Earnst (1995–1997, unpubl. data), and Johnson et al. (1999a).



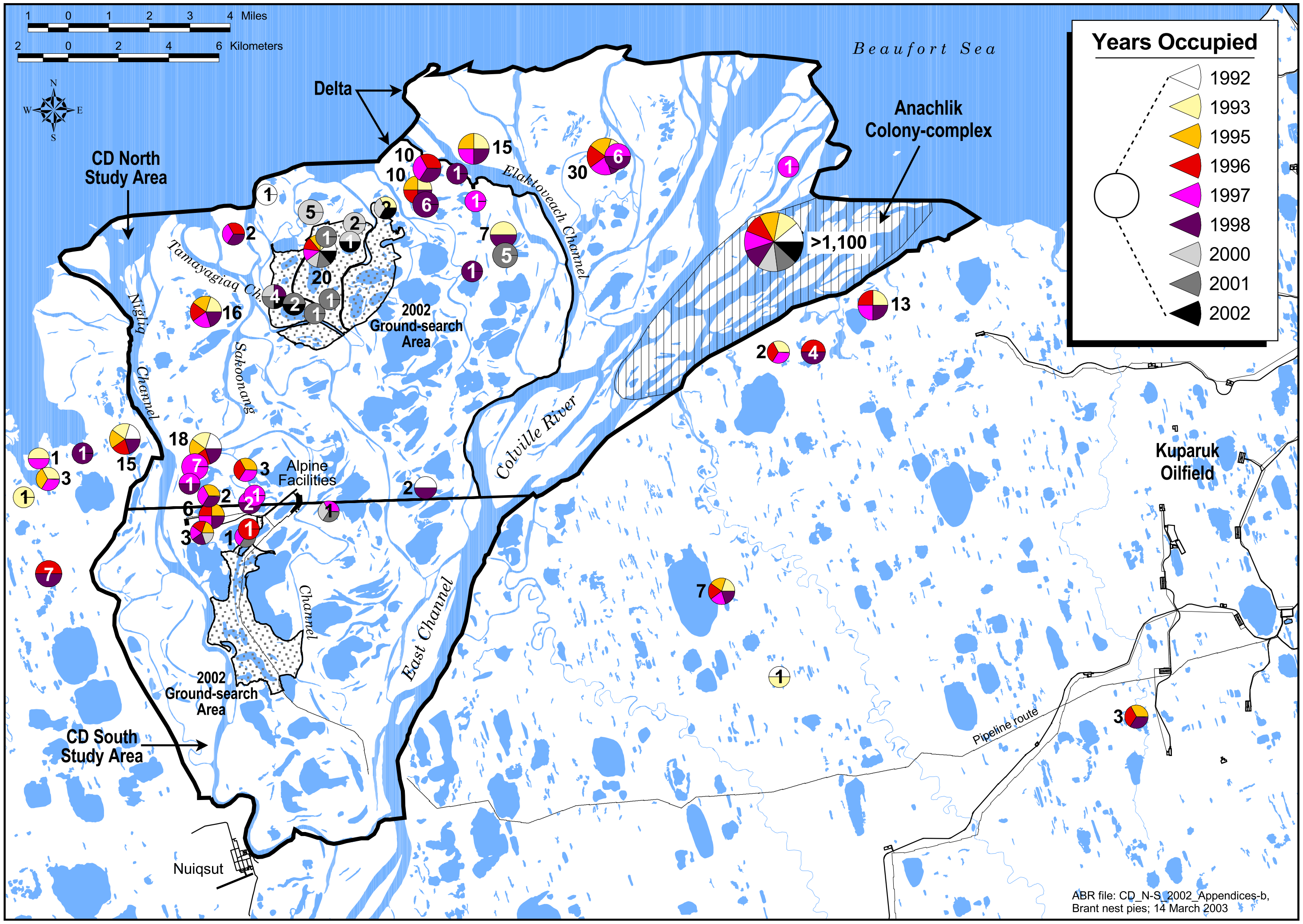
Appendix C10. Distribution of Pacific and Red-throated loon nests recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



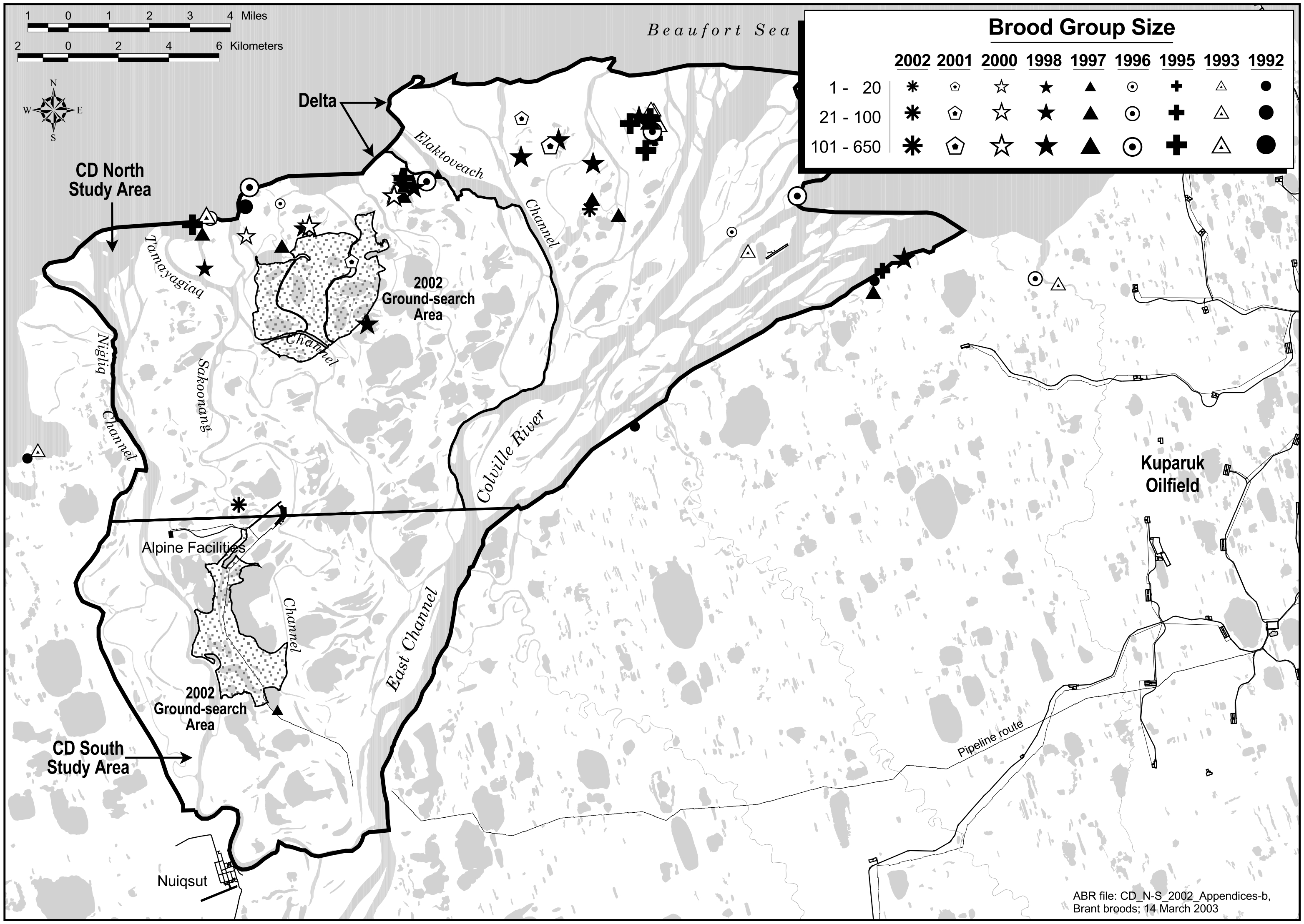
Appendix C11. Distribution of Yellow-billed Loon broods recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1984–2002. Pre-2000 data are from M. North (1984, 1989, unpubl. data), S. Earnst (1996, unpubl. data), and Johnson et al. (1999a).



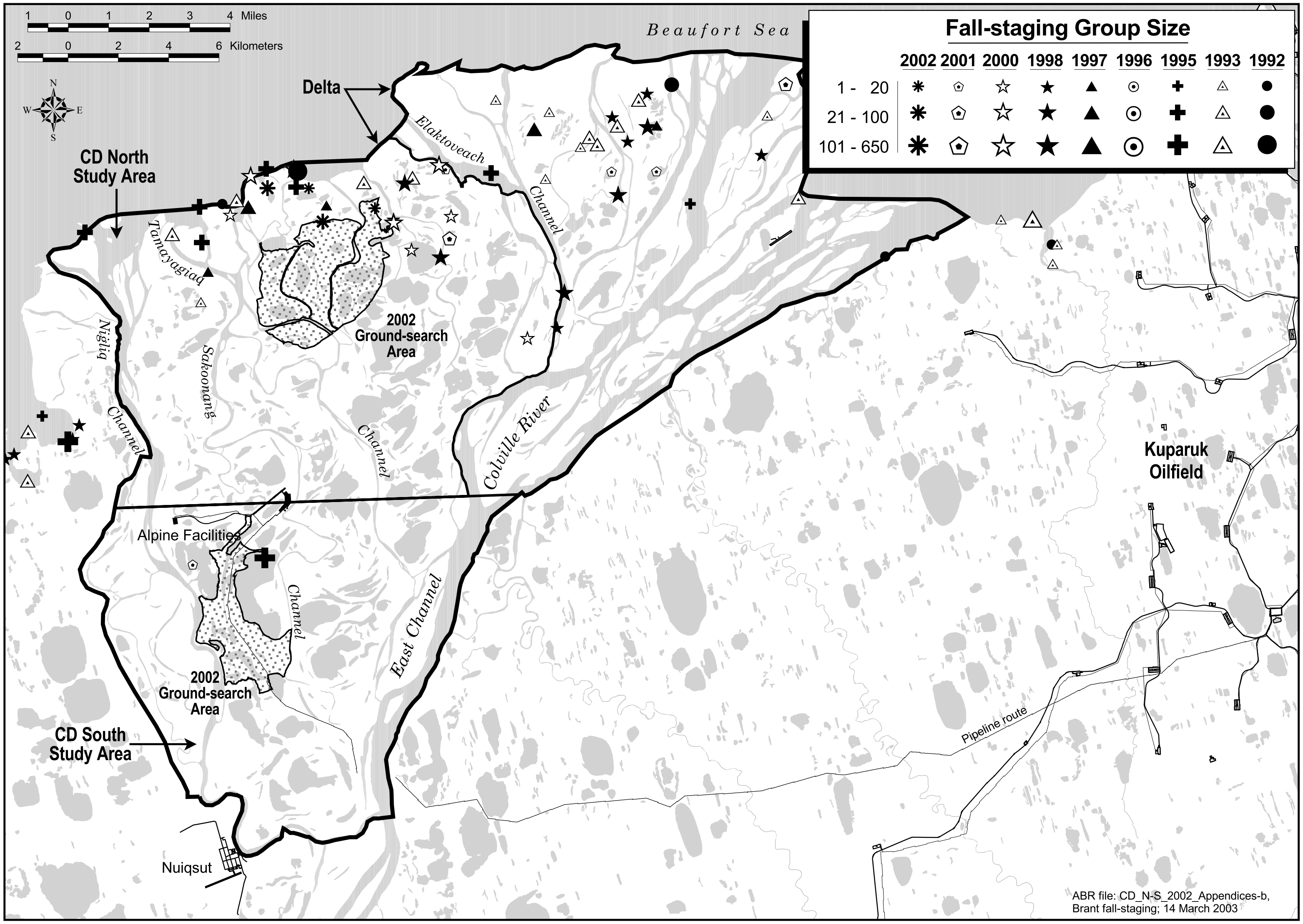
Appendix C12. Distribution of Pacific and Red-throated loon broods recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a). Survey coverage was not uniform over the area portrayed.



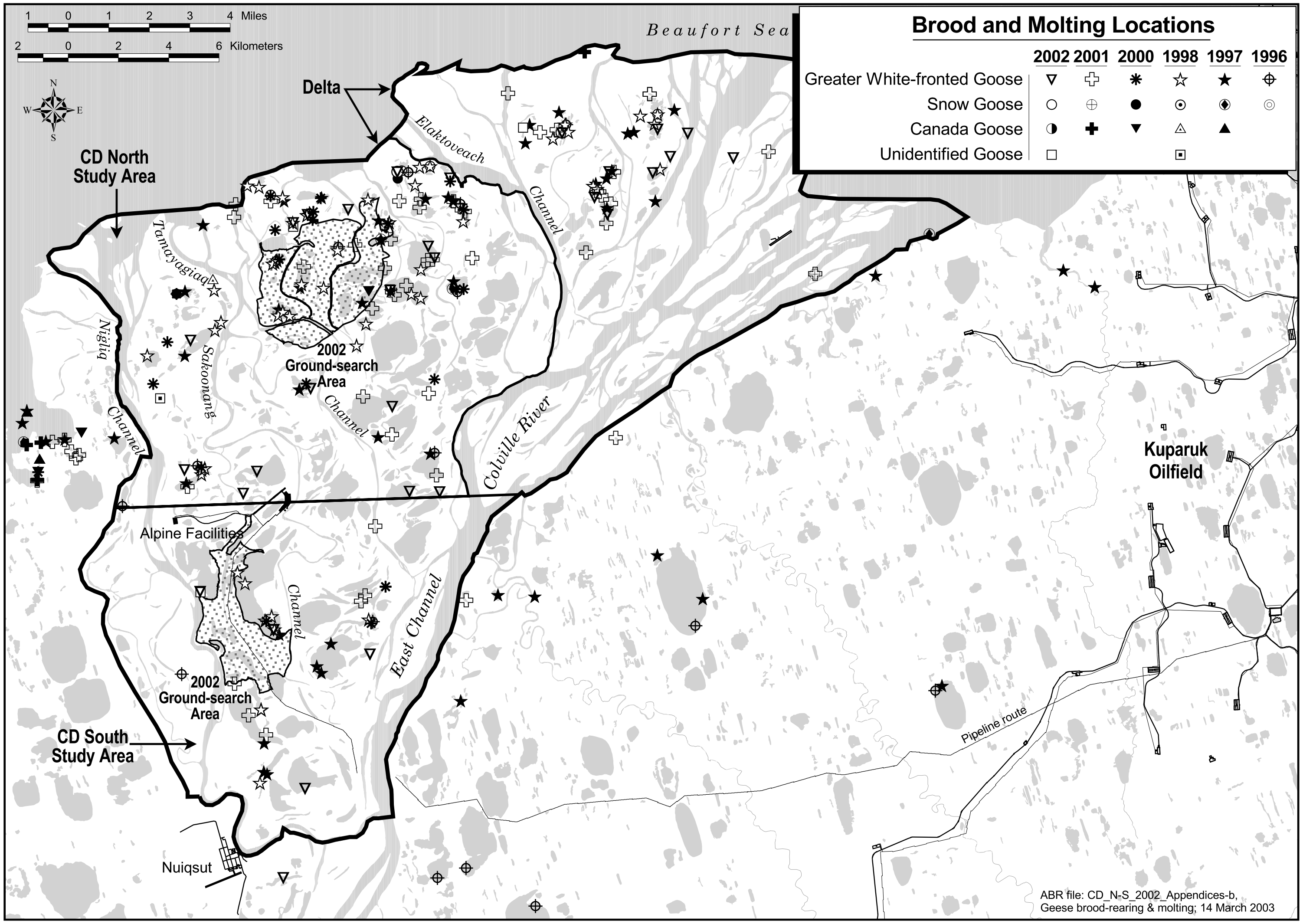
Appendix C13. Distribution and size of Brant colonies during aerial (1992–1993, 1995–1998) and ground (1995–2002) surveys on the Colville River Delta, Alaska. Pre-2000 data are from Johnson et al. (1999a). Numbers are the maximal number of nests counted. Survey coverage was not uniform over the area portrayed.



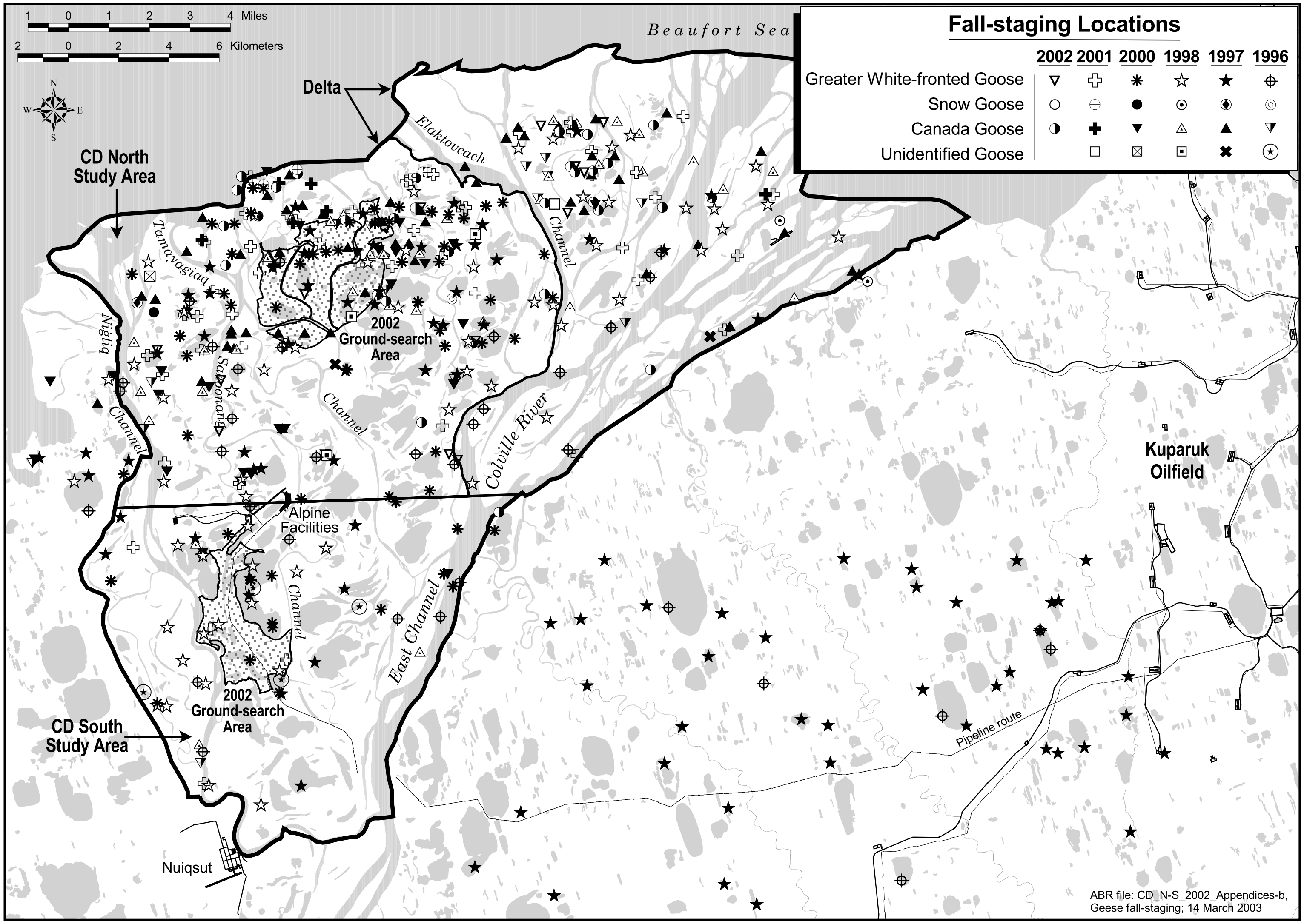
Appendix C14. Distribution and size of Brant brood-rearing groups recorded during aerial surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a).



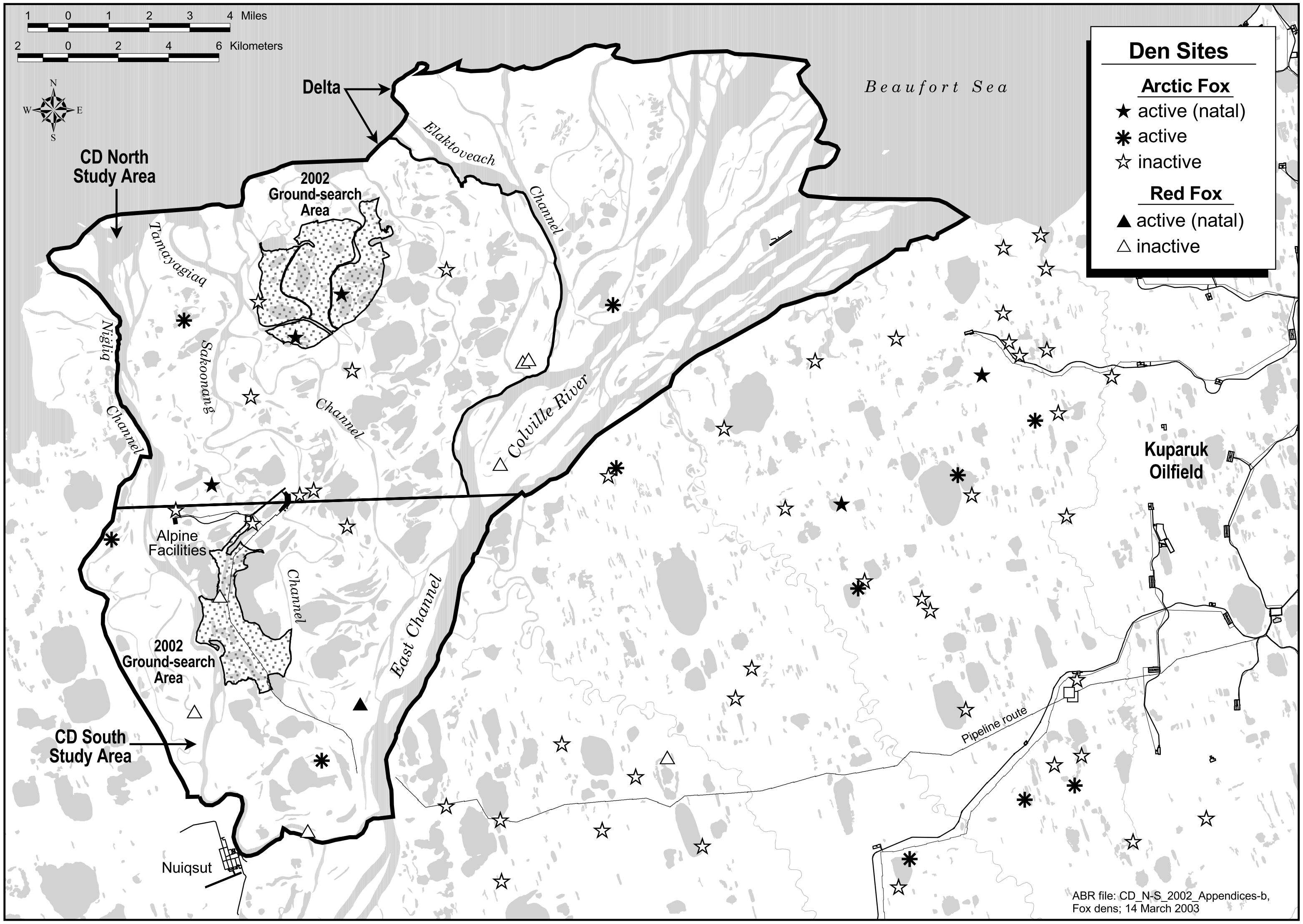
Appendix C15. Distribution and size of Brant fall-staging groups recorded during aerial surveys on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a).



Appendix C16. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese recorded during aerial surveys on the Colville River Delta, Alaska, July 1996–2002. 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 recorded during aerial surveys on the Colville River Delta, Alaska, August 1996–2002. Pre-2000 data are from Johnson et al. (1999a). Survey coverage was 25% in 1996 and 50% in subsequent years.



Appendix C18. Distribution and status of arctic and red fox dens on the Colville River Delta and adjacent coastal plain, Alaska, 2002. Survey coverage since 1992 was not uniform over the area portrayed.

Appendix D1. Habitat selection (pooled among years) by Spectacled Eider and King Eider groups during pre-nesting on the Colville River Delta, Alaska, 1993–2002. Pre-2000 data are from Johnson et al. (1999a).

SPECIES Habitat	No. Adults	No. Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
SPECTACLED EIDERS					
Open Nearshore Water	0	0	0	1.6	ns
Brackish Water	53	23	13.3	1.3	prefer
Tapped Lake with Low-water Connection	29	12	6.9	4.5	ns
Tapped Lake with High-water Connection	10	6	3.5	3.8	ns
Salt Marsh	27	13	7.5	3.3	prefer
Tidal Flat	0	0	0	7.1	avoid
Salt-killed Tundra	31	17	9.8	5.1	prefer
Deep Open Water without Islands	10	7	4.0	4.0	ns
Deep Open Water with Islands or Polygonized Margins	11	7	4.0	1.6	ns
Shallow Open Water without Islands	4	2	1.2	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	3	2	1.2	0.1	prefer
River or Stream	14	7	4.0	14.1	avoid
Aquatic Sedge Marsh	0	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	72	39	22.5	2.7	prefer
Aquatic Grass Marsh	2	2	1.2	0.2	ns
Young Basin Wetland Complex	0	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	ns
Nonpatterned Wet Meadow	37	18	8.1	8.1	ns
Patterned Wet Meadow	36	16	9.2	19.4	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	4.8	avoid
Barrens	4	2	1.2	15.0	avoid
Artificial	0	0	0	<0.1	ns
TOTAL	343	173	100	100	
KING EIDERS					
Open Nearshore Water	10	2	2.0	1.6	ns
Brackish Water	10	6	6.1	1.3	prefer
Tapped Lake with Low-water Connection	17	8	8.2	4.5	ns
Tapped Lake with High-water Connection	8	3	3.1	3.8	ns
Salt Marsh	4	2	2.0	3.3	ns
Tidal Flat	4	2	2.0	7.1	avoid
Salt-killed Tundra	20	10	10.2	5.1	prefer
Deep Open Water without Islands	4	1	1.0	4.0	avoid
Deep Open Water with Islands or Polygonized Margins	5	2	2.0	1.6	ns
Shallow Open Water without Islands	0	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0	0.1	ns
River or Stream	150	47	48.0	14.1	prefer
Aquatic Sedge Marsh	0	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	8	5	5.1	2.7	ns
Aquatic Grass Marsh	0	0	0	0.2	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	1.0	8.1	avoid
Patterned Wet Meadow	12	7	7.1	19.4	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	1.0	4.8	avoid
Barrens	1	1	1.0	15.0	avoid
Artificial	0	0	0	<0.1	ns
TOTAL	256	98	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. % use = (groups / total groups) x 100.

Appendix D2. Habitat use by nesting Spectacled Eiders on the Colville River Delta, Alaska, 1992–2002. 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 (%)
NEST LOCATION		
Brackish Water	6	9.7
Tapped Lake with High-water Connection	1	1.6
Salt Marsh	1	1.6
Salt-killed Tundra	15	24.2
Deep Open Water with Islands or Polygonized Margins	3	4.8
Shallow Open Water without Islands	1	1.6
Aquatic Sedge with Deep Polygons	14	22.6
Nonpatterned Wet Meadow	10	16.1
Patterned Wet Meadow	11	17.4
TOTAL	62	100
NEAREST WATERBODY [b]		
Brackish Water	23	37.1
Tapped Lake with Low-water Connection	3	4.8
Tapped Lake with High-water Connection	6	9.7
Deep Open Water without Islands	4	6.5
Deep Open Water with Islands or Polygonized Margins	18	29.0
Shallow Open Water without Islands	4	6.5
Shallow Open Water with Islands or Polygonized Margins	3	4.8
River or Stream	1	1.6
TOTAL	62	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 brood-rearing Spectacled Eiders and King Eiders on the Colville River Delta, Alaska, 1983–2002. Broods were located during aerial and ground surveys. Pre-2000 data are from M. North (1983, 1984, unpubl. data) and Johnson et al. (1999a).

SPECIES Habitat Type	Number of Brood-rearing Groups	Total Young[a]	Use (%)[b]
SPECTACLED EIDER			
Brackish Water	3	11	8.8
Tapped Lake with Low-water Connection	3	3	8.8
Tapped Lake with High-water Connection	1	4	2.9
Salt-killed Tundra	5	24	14.7
Deep Open Water without Islands	4	11	11.8
Deep Open Water with Islands or Polygonized Margins	8	19	23.5
Aquatic Sedge with Deep Polygons	5	11	14.7
Aquatic Grass Marsh	1	4	2.9
Patterned Wet Meadow	4	14	11.8
TOTAL	34	101	100
KING EIDER			
Aquatic Sedge with Deep Polygons	1	7	50.0
Patterned Wet Meadow	1	5	50.0
TOTAL	2	12	100

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

[b] % use = (groups / total groups) × 100.

Appendix D4. Numbers and densities of Tundra Swan nests and broods recorded during aerial surveys of the Colville River Delta, Alaska, 1992–2002. Density based on survey area of 551 km². Pre-2000 data are from Johnson et al. (1999a)..

	Nests		Broods		Mean	% Nest
Year	No.	No./km²	No.	No./km²	Brood Size	Success[a]
1992[b]	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
2002	55	0.10	17	0.03	3.2	31
Mean	33	0.06	21	0.04	2.7	65

[a] Estimated percent nest success = (nests / broods) x 100.
[b] Survey conducted by the Alaska Department of Fish and Game.

Appendix D5. Number of swans, swan pairs, and nests recorded during June aerial surveys of the Colville River Delta, Alaska, 1992–2002. Density based on survey area of 551 km². Pre-2000 data are from Johnson et al. (1999a).

Year	Total Swans	Swan Density (no./km²)	Total Pairs	% Swans in Pairs	Pair Density (pairs/km²)	% of Pairs Nesting	No. of Nests	Nest Density (no./km²)
1992[a]	249	0.45	62	50	0.11	23	14	0.03
1993	240	0.43	74	62	0.13	27	20	0.04
1995	208	0.38	72	69	0.13	53	38	0.07
1996	579	1.05	69	24	0.13	65	45	0.08
1997	749	1.36	81	22	0.15	40	32	0.06
1998	714	1.29	93	26	0.17	33	31	0.06
2000	380	0.69	83	44	0.15	39	32	0.06
2001	312	0.57	78	50	0.14	35	27	0.05
2002	282	0.51	98	70	0.18	56	55	0.10
Mean	413	0.75	79	38	0.14	41	33	0.06

[a] Data from a survey conducted by the Alaska Department of Fish and Game.

Appendix D6. Habitat selection (pooled among years) by nesting and brood-rearing Tundra Swans on the Colville River Delta, Alaska, 1992–2002. Pre-2000 data are from Johnson et al. (1999a).

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0	1.8	avoid
Brackish Water	3	1.0	1.2	ns
Tapped Lake with Low-water Connection	2	0.7	3.9	avoid
Tapped Lake with High-water Connection	5	1.7	3.8	avoid
Salt Marsh	19	6.5	3.0	prefer
Tidal Flat	4	1.4	10.2	avoid
Salt-killed Tundra	34	11.6	4.6	prefer
Deep Open Water without Islands	8	2.7	3.8	ns
Deep Open Water with Islands or Polygonized Margins	12	4.1	1.4	prefer
Shallow Open Water without Islands	1	0.3	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	1	0.3	0.1	ns
River or Stream	1	0.3	14.9	avoid
Aquatic Sedge Marsh	1	0.3	<0.1	ns
Aquatic Sedge with Deep Polygons	23	7.8	2.4	prefer
Aquatic Grass Marsh	2	0.7	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	32	10.9	7.5	prefer
Patterned Wet Meadow	112	38.1	18.6	prefer
Moist Sedge–Shrub Meadow	18	6.1	2.4	prefer
Moist Tussock Tundra	3	1.0	0.5	ns
Riverine or Upland Shrub	6	2.0	5.0	avoid
Barrens	7	2.4	14.3	avoid
Artificial	0	0	<0.1	ns
TOTAL	294	100	100.0	
BROOD-REARING				
Open Nearshore Water	0	0	1.8	ns
Brackish Water	10	5.2	1.2	prefer
Tapped Lake with Low-water Connection	30	15.6	3.9	prefer
Tapped Lake with High-water Connection	15	7.8	3.8	prefer
Salt Marsh	17	8.9	3.0	prefer
Tidal Flat	2	1.0	10.2	avoid
Salt-killed Tundra	12	6.3	4.6	ns
Deep Open Water without Islands	19	9.9	3.8	prefer
Deep Open Water with Islands or Polygonized Margins	9	4.7	1.4	prefer
Shallow Open Water without Islands	1	0.5	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	1	0.5	0.1	ns
River or Stream	8	4.2	14.9	avoid
Aquatic Sedge Marsh	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	6	3.1	2.4	ns
Aquatic Grass Marsh	3	1.6	0.3	prefer
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	10	5.2	7.5	ns
Patterned Wet Meadow	31	16.1	18.6	ns
Moist Sedge–Shrub Meadow	3	1.6	2.4	ns
Moist Tussock Tundra	0	0	0.5	ns
Riverine or Upland Shrub	3	1.6	5.0	avoid
Barrens	12	6.3	14.3	avoid
Artificial	0	0	<0.1	ns
TOTAL	192	100.0	100.0	

[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 D7. Habitat selection (pooled among years) by nesting and brood-rearing Yellow-billed Loons on the Colville River Delta, Alaska, 1993–2002. Pre-2000 data are from Johnson et al. (1999a).

SEASON Habitat	No. Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.3	avoid
Tapped Lake with High-water Connection	11	8.9	5.4	ns
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	avoid
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water without Islands	9	7.3	5.5	ns
Deep Open Water with Islands or Polygonized Margins	31	25.2	1.8	prefer
Shallow Open Water without Islands	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	1	0.8	<0.1	ns
Aquatic Sedge with Deep Polygons	6	4.9	2.9	ns
Aquatic Grass Marsh	1	0.8	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	17	13.8	8.7	ns
Patterned Wet Meadow	47	38.2	24.7	prefer
Moist Sedge–Shrub Meadow	0	0	3.5	avoid
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	123	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.3	ns
Tapped Lake with High-water Connection	10	21.7	5.4	prefer
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	ns
Salt-killed Tundra	0	0	4.2	ns
Deep Open Water without Islands	27	58.7	5.5	prefer
Deep Open Water with Islands or Polygonized Margins	9	19.6	1.8	prefer
Shallow Open Water without Islands	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	0	0	2.9	ns
Aquatic Grass Marsh	0	0	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	0	0	8.7	avoid
Patterned Wet 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	46	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 (1992–2002) and brood-rearing (1993–1998) Brant in the outer delta survey area, Colville River Delta, Alaska. Nesting selection was based on the cumulative locations of colonies. Pre-2000 data are from Johnson et al. (1999a).

SEASON Habitat	Area (km^2)	Max. Estimate of Nests	No. of Colonies/ Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING						
Open Nearshore Water	10.02	0	0	0	4.0	ns
Brackish Water	6.45	7	1	4.3	2.6	ns
Tapped Lake with Low-water Connection	5.50	0	0	0	2.2	ns
Tapped Lake with 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	22.5	avoid
Salt-killed Tundra	23.18	55	9	39.1	9.3	prefer
Deep Open Water without Islands	1.40	0	0	0	0.6	ns
Deep Open Water with Islands or Polygonized Margins	3.37	3	2	8.7	1.4	ns
Shallow Open Water without Islands	0.67	0	0	0	0.3	ns
Shallow Open Water with 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	-	-	-	0	-
Aquatic Sedge with Deep Polygons	7.38	26	4	17.4	3.0	prefer
Aquatic Grass Marsh	0.39	1	1	4.3	0.2	ns
Young Basin Wetland Complex	0	-	-	-	0	-
Old Basin Wetland Complex	0	-	-	-	0	-
Nonpatterned Wet Meadow	15.19	16	1	4.3	6.1	ns
Patterned Wet 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	32.84	0	0	0	13.2	ns
Artificial	0.02	0	0	0	<0.1	ns
Total	249.29	149	23	100	100	
BROOD-REARING						
Open Nearshore Water	10.02		1	2.5	4.6	ns
Brackish Water	6.33		15	37.5	2.9	prefer
Tapped Lake with Low-water Connection	5.11		0	0	2.3	ns
Tapped Lake with 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 without Islands	0.60		0	0	0.3	ns
Deep Open Water with Islands or Polygonized Margins	1.86		0	0	0.9	ns
Shallow Open Water without Islands	0.49		1	2.5	0.2	ns
Shallow Open Water with 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		-	-	0	-
Aquatic Sedge with 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		-	-	0	-
Old Basin Wetland Complex	0		-	-	0	-
Nonpatterned Wet Meadow	9.69		0	0	4.4	ns
Patterned Wet 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	28.25		3	7.5	13.0	ns
Artificial	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. % use = (colonies or brood groups / total) x 100.

Appendix D9. Habitat selection by nesting Greater White-fronted Geese in the CD North ground-search area, Colville River Delta, Alaska, 2002.

Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	0	0	3.1	avoid
Tapped Lake with Low-water Connection	0	0	1.5	ns
Tapped Lake with High-water Connection	0	0	4.6	avoid
Salt Marsh	4	1.9	4.0	ns
Salt-killed Tundra	21	9.9	14.7	avoid
Deep Open Water without Islands	1	0.5	4.0	avoid
Deep Open Water with Islands or Polygonized Margins	4	1.9	9.6	avoid
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	5	2.3	0.8	ns
Aquatic Sedge with Deep Polygons	62	29.1	11.8	prefer
Aquatic Grass Marsh	0	0	0.2	ns
Nonpatterned Wet Meadow	26	12.2	14.3	ns
Patterned Wet Meadow	85	39.9	24.0	prefer
Moist Sedge–Shrub Meadow	3	1.4	2.3	ns
Riverine or Upland Shrub	1	0.5	1.2	ns
Barrens	1	0.5	3.8	avoid
TOTAL	213	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.