WILDLIFE STUDIES IN THE CD NORTH STUDY AREA, 2000

FINAL REPORT

Prepared for

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

Prepared by

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

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

January 2001

EXECUTIVE SUMMARY

During spring 2000, ABR, Inc. was contracted to conduct wildlife studies for two 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, and the CD South study area encompasses Nanuq. Beginning in 1992, ARCO Alaska, Inc. (now PHILLIPS Alaska, Inc.) initiated studies to examine the biological, physical, and cultural resources of the delta. The Alpine Development Project, on the central delta, received its federal permits on 13 February 1998, and construction began that spring. With the establishment of the Alpine facilities and pipeline, oil development on other parts of the delta became more feasible. In this annual report on the 2000 field season, we present the results from the first year of study of the wildlife resources in the CD North study area and the ninth year of industry funded studies on the Colville Delta.

The CD North study area is located on the outer portion of the Colville River Delta and is delimited by the Beaufort Sea on the north, the Alpine airstrip on the south, the Elaktoveach and East channels of the Colville River on the east and the Nechelik (Nigliq) Channel on the west. The Colville Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fishes that are found there. The delta is a regionally important nesting area for Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders. In spring, the delta provides some of the earliest open water and snow-free areas on the Arctic Coastal Plain for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for feeding and staging. In addition to use by birds, the delta is used seasonally by caribou for insect-relief habitat, by arctic and red foxes for denning, and by spotted seals for fishing and for haul-out sites. The delta occasionally is used for denning by both brown and polar bears. The Colville Delta also has attracted two permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family homesite, both of which rely heavily on these fish and wildlife resources.

The primary goal of the CD North wildlife studies was to collect data on the distribution, abundance, and habitat use of selected species of birds and mammals from late spring to early fall to be used as a baseline for conditions prior to oil development. The focal species were 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, and special concern from agencies. Six species were selected: Spectacled Eiders, Tundra Swans, Brant, Yellow-billed Loons, arctic foxes, and caribou. During surveys for focal species, other species were monitored opportunistically: King Eiders, Greater White-fronted Geese, Canada Geese, Pacific Loons, Red-throated Loons, red foxes, and muskoxen. 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 km^2) were conducted throughout the summer from the air (using fixed wing aircraft and helicopters) for focal species, and with intensive foot searches for nests and broods of large waterbirds and ptarmigan in the ground-search area (12.2 km^2), where development is expected to be located. Location data was organized and analyzed in a GIS database, and habitat information was acquired from a classification of vegetation and landforms on the delta (mapped in 1992 and revised in 1995). We used data from previous years (generally, 1992–1999) in our assessments where appropriate.

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. The most abundant habitats in the CD North study area were Wet Sedge–Willow Meadow (20% of the total area), Barrens (11%), Nonpatterned Wet Meadow (10%), and Tapped Lake with Low-water Connection (9%). The ground-search area, where development is expected, contained 14 habitats. Salt-killed Tundra occurred over the most area (28%), followed by Aquatic Sedge with Deep Polygons (17%), Wet Sedge–Willow Meadow (15%), and Nonpatterned Wet Meadow (10%).

Conditions in the Study Area—The 2000 breeding season was unusual among recent years because of the extent that weather and river conditions delayed the onset of nesting for birds in much of the study area. Spring temperatures were cold and snowmelt was late relative to other years we have worked on the delta. In addition, the Colville River broke up relatively late on 8 June, and ice jams caused extensive flooding on the delta during the second week of June, which made some nesting areas inaccessible for several days.

Nests in the Ground-search Area—The density of nests in the CD North ground-search area was about twice the densities found in the CD South and the Alpine ground-search areas. In 2000, we recorded 241 nests of 15 species in the CD North ground-search area. Overall nest success was 56%. Habitats with polygonal surface forms contained the highest numbers of nests: Wet Sedge–Willow Meadow contained 64 nests (27% of the total), Aquatic Sedge with Deep Polygons contained 59 nests (25%), and Salt-killed Tundra contained 41 nests (17%). More than half of the nests belonged to geese and were composed of 120 Greater White-fronted Goose nests and 30 Brant nests. Duck nests were abundant and primarily consisted of Long-tailed Duck nests (18 nests) and Spectacled Eider nests (14). Three Tundra Swan and two Yellow-billed Loon nests were found in the ground-search area.

Spectacled Eiders—Spectacled Eiders on the Colville Delta were closely associated with coastal areas during pre-nesting surveys conducted every year since 1993. The mean distance from the coast of Spectacled Eiders in 2000 was 4.3 km, slightly farther from the coast than the mean of all sightings since 1993 ($\bar{x}$ = 4.0 km). We counted 36 Spectacled Eiders during pre-nesting in 2000, or 0.17 birds/km², the second lowest density on record since delta-wide surveys began in 1993. During 2000, frozen lakes and ponds with ice made survey conditions difficult and, along with extensive flooding, may have discouraged Spectacled Eiders from using the delta during the survey period. The CD North study area supports a higher density of Spectacled Eiders than does the more inland CD South study area, probably because of its coastal location and brackish habitats, which the CD South area lacks. One pair of Spectacled Eiders (0.01 birds/km²) was seen on the aerial survey of the CD South study area in 2000, and similarly low numbers have been recorded there in the past. During the pre-nesting season in 2000, groups of Spectacled Eiders were recorded most often in Aquatic Sedge with Deep Polygons (33% of all sightings), Wet Sedge–Willow Meadow (22%), and Deep Open Water without Islands (11%). One of these habitats, Aquatic Sedge with Deep Polygons, was significantly preferred according to the analysis of 7 years of sightings for the entire delta. Two other habitats preferred on the entire delta, Brackish Water and Salt Marsh, were also used in the CD North study area. The coastal portion of the delta also is where Spectacled Eiders nest most commonly. The mean distance from the coast of all Spectacled Eider nests on the delta, for which we have records, is 3.6 km. In the CD North ground-search area (12.2 km²) during 2000, we located 14 Spectacled Eider nests (1.2 nests/km²). Six (43%) of those nests hatched successfully. Nesting Spectacled Eiders in the CD North study area used many of the same habitats that were used during pre-nesting; most nests (8 or 57% of all nests) were found in Salt-killed Tundra. In 9 years of nest searching in various locations on the delta, 45 nests of Spectacled Eiders have been found in nine habitats; the highest number of nests occupied Salt-killed Tundra (12 nests), Aquatic Sedge with Deep Polygons (9 nests), Brackish Water (6 nests), and Nonpatterned Wet Meadow (7 nests). The results of pre-nesting and nesting habitat analyses emphasize the importance to breeding Spectacled Eiders of habitats that are more prevalent on the outer delta: Brackish Water, Salt-killed Tundra, Salt Marsh, and Aquatic Sedge with Deep Polygons. In 2000, we recorded nine Spectacled Eider broods containing a mean of 3.4 young/brood. Of those broods, six (66% of all broods) were using the two types of Deep Open Water, and one brood each was using Tapped Lake with Low-water Connection, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow. Only 20 Spectacled Eider brood-rearing groups have been seen since 1992; most groups were found in Salt-killed Tundra (20% of all locations), Deep Open Water with Islands or Polygonized Margins (20%), Deep Open Water without Islands (15%), Brackish Water (15%), and Wet Sedge–Willow Meadow (15%).

King Eiders—The density of King Eiders during pre-nesting in 2000 (0.08 birds/km²) in the CD North study area was one of the two highest densities recorded since 1993. 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 greatest number of pre-nesting groups of King Eiders occurred in Brackish Water (2 groups) and Salt-killed Tundra (2 groups). Brackish Water and River or Stream were the only habitats preferred by pre-nesting King Eiders on the delta over 7 years of surveys. In the CD North ground-search area in 2000, we found two King Eider nests and both were successful. The two nests occurred in Salt-killed Tundra and Aquatic Sedge with Deep Polygons. We have found only four other King Eider nests during 9 years of nest searches on the delta; two of nests were in Aquatic Sedge with Deep Polygons, and one nest each was in Salt-killed Tundra and Wet Sedge–Willow Meadow. Only two King Eider broods have been seen on the delta since studies began in 1992.

Tundra Swans—In 2000, we counted 16 Tundra Swan nests during aerial surveys in the CD North study area, exactly half the number counted on the entire delta. Nest density in 2000 (0.08 nests/km²) was within the range of values we have observed over the previous 6 years of surveys (0.04–0.10 nests/km²). Swan nest densities in the CD North study area were slightly higher than densities on entire Colville Delta (0.03–0.8 nests/km²). Nine nests were in preferred habitats that were determined by the delta-wide multi-year analysis: Salt-killed Tundra, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow. Six swan broods were counted in the CD North study area in 2000. Nest success in the CD North study area, estimated by dividing numbers of broods by the number of nests, was only 38% in 2000. Nest success rates estimated for the previous 6 survey years were 36–89%. Mean brood size for the CD North study area was 1.8 young/brood (n = 6), which was similar to the mean brood size for the entire delta (2.0 young/brood). Brood size in 2000 was the lowest we have recorded on the Colville Delta in 7 years of surveys. We suspect that the low nest success and small brood sizes recorded over a broad area from the Colville Delta to the Kuparuk River were caused by the cool temperatures and late snowmelt during May and June, which delayed nest initiation. In the CD North study area, four of the six broods were observed in habitats that were preferred—Brackish Water, Salt Marsh, Tapped Lake with Low-water Connection, and Deep Open Water without Islands—based on a selection analysis of 7 years of surveys on the entire delta. During fall staging, we counted 21 swans in the CD North study area and on the entire delta we counted 106 swans, among which the largest flock was 8 birds. Generally during fall staging, most swans occur in several large flocks that occupy river channels on the outer delta. We suspect the small number and size of flocks was the result of young swans being unable to fly to sites where pre-migratory aggregations form; the late spring and resulting late hatch of swan nests probably delayed their development.

Yellow-billed Loons—In 2000, we counted 32 Yellow-billed Loons and 9 nests in the CD North study area during an aerial survey. Our count of nine nests in 2000 was within the range of nests (6–11) we have recorded in the previous 5 years of surveys. Densities similar to that found in 2000 (0.15 birds/km²) have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska. All nine nests found in 2000 were on lakes where we have recorded nesting by Yellow-billed Loons in previous years. Two of the nine nests were within the CD North ground-search area, where nesting also occurred in 1995–1998. In 2000, the habitats most frequently used for nesting by Yellow-billed Loons (78% of all nests) were Wet Sedge–Willow Meadow (3 nests) and the 2 types of Deep Open Water (2 nests each). During 6 years of aerial surveys on the Colville Delta, 85 Yellow-billed Loon nests were found in 8 of 24 available habitats. Four preferred habitats accounted for 73% of the nests: Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, and Wet Sedge–Willow Meadow. Production of Yellow-billed Loons was poor in 2000. We counted eight adult

Yellow-billed Loons and saw no broods during the brood-rearing aerial survey in the CD North study area. In each of our previous 5 years of surveys, we counted ≥20 loons and ≥3 broods in the same area. The late thaw and cool spring temperatures in 2000 may have delayed nest initiation and reduced nest success, and a severe storm with high westerly winds on 11 August may have led to chick mortality. During aerial surveys in 1995–1998, we found 34 Yellow-billed Loon broods in three habitats on the delta—Tapped Lake with High-water Connection and both types of Deep Open Water—all of which were preferred.

Pacific and Red-throated Loons—During a survey in 2000 in the CD North ground-search area, we found nine Pacific and six Red-throated loon nests. We assumed from the number and location of Red-throated Loon broods found during the brood search that three additional Red-throated Loon nests were in the area, but not found initially. Within the CD North ground-search area, we saw three Pacific and seven Red-throated loon broods in 2000 during an intensive foot survey. Nest success was 44% for Pacific Loons and 78% for Red-throated Loons.

Brant—In 2000, we located 30 Brant nests in six locations (1–20 nests each) in the CD North ground-search area. Brant were the second most numerous nesting species with a density of 2.5 nests/km². However, nest success was only 10%. During aerial surveys of the entire outer delta in 1992–1998, we recorded ≥20 nesting locations in the CD North study area that had 1–5 years of occupation and 1–18 nests each. During these aerial surveys, we recorded three nesting locations that occurred in the CD North ground-search area, each containing 1–10 nests. Over 70% of the nests found in 2000 were in aquatic habitats with 60% in Deep Open Water with Islands or Polygonized Margins. The largest colony (20 nests) straddled a complex of different habitat types (Deep Open Water with Islands or Polygonized Margins and Aquatic Sedge with Deep Polygons). The preferred nesting habitats for 19 colonies located during aerial surveys in 1993 and 1995–1998 were Salt-killed Tundra and Aquatic Sedge with Deep Polygons. During brood-rearing in 2000 in the CD North study area, we recorded 364 Brant (148 adults and 216 goslings). The mean percentage of goslings was 59%, which was comparable to previous years (46–60% goslings). The number of Brant observed in the CD North study area during brood-rearing in 2000 was slightly above average for the numbers recorded since surveys were started by USFWS in 1988 ($\bar{x}$ = 286 birds). The three groups observed in 2000 occurred in each of three habitats: Salt Marsh, Salt-killed Tundra, and Barrens. In previous years during brood-rearing, Brackish Water was used by the most Brant groups (38%) and was the only preferred habitat on the delta. During fall staging in 2000, we saw 189 Brant in the CD North study area, which was within the range of numbers seen in previous years.

Greater White-fronted Geese—During the nest survey in 2000, we found 120 nests of Greater White-fronted Geese in the CD North ground-search area, which was almost half of all nests found. The density of Greater White-fronted Goose nests (9.8 nests/km²) was greater than any density previously reported for the delta and 73% of the nests hatched. Greater White-fronted Geese in the CD North ground-search area nested most often in habitats with polygonal surface forms: Wet Sedge–Willow Meadow (39% of all nests), Aquatic Sedge with Deep Polygons (33%), and Salt-killed Tundra (17%). In the CD North ground-search area, we counted 11 broods of Greater White-fronted Geese with at least 41 young. The average brood size was 3.7 young. During the aerial survey for broods in the CD North study area in 2000, we saw 1,304 Greater White-fronted Geese. Group sizes averaged 77 birds and goslings composed 51% of the total number of geese. The number of Greater White-fronted Geese seen in 2000 was about the same as in 1998 (1,354 birds) and 1997 (1,224) and more than the number in 1996 (331). Sixty-five percent of the brood-rearing groups of White-fronted Geese recorded during the aerial survey were observed in Deep Open Water (both types), Brackish Water, and Tapped Lake with Low-water Connection. During fall staging in 2000, we counted 1,227 geese, which was substantially greater than the counts in 1998 (687 geese) and in 1997 (893 geese). In 1996, we recorded 765 geese in the CD North study area, but the survey coverage was half that in subsequent years. During fall staging, 64% of all Greater White-fronted Geese used water habitats.

Canada Geese—We did not find any Canada Goose nests during our foot survey in the CD North ground-search area in 2000. In 1997, we found a Canada Goose nest near the Nechelik Channel, which was the first record of Canada Geese nesting on the delta, and we found two nests just west of the delta in the NPR–A during aerial surveys. At one of these locations in the NPR–A in 1996, we counted 10 Canada Goose nests. Since 1998, Canada Geese have been observed nesting in low numbers (1–2 nests) in the vicinity of the Alpine project area. During the aerial brood-rearing survey in 2000, we recorded a group of 8 adult and 14 gosling Canada Geese in the CD North study area, and we saw a similar number in 1998. The only other year when Canada Geese were seen during brood-rearing on the delta was 1993, when 30 geese were seen in the CD North study area. 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 2000, we observed 558 Canada Geese in the CD North study area. In 1996–1998, we counted 678–1,021 Canada Geese, and in 1992, we counted the highest number, ~4,600. Fall-staging Canada Geese were most prevalent (73% of all groups) in terrestrial habitats.

Snow Geese—We did not find any Snow Goose nests during our foot survey in the CD North ground-search area in 2000. However, in 1994, two Snow Goose nests were found during ground searches in this same area, and additional nests were located on the outer delta during ground and aerial surveys in 1993, 1995, and 1997 (1 or 2 each year). In 2000, we recorded two groups of brood-rearing Snow Geese totaling 45 birds (16 adults and 29 goslings). Higher numbers (72 geese) were seen in 1998, but lower numbers were seen during 1995–1997. During the 2000 fall-staging survey, we saw 18 Snow Geese; smaller numbers were seen during 1995–1997. As during brood-rearing, all Snow Geese were seen on the outer delta during fall-staging surveys.

Foxes—We have located 11 fox dens in the CD North study area since 1992; nine (82%) of the dens were arctic fox sites in 2000, and two were red fox dens. The density of arctic fox dens active annually (3–8 dens) ranged from 1 den/26 km² to 1 den/69 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. The total density (active and inactive) of fox dens in the CD North study area was 1 den/19 km². Arctic fox den density was 1 den/23 km² and red fox den density was 1 den/103 km². The density of arctic fox dens in the CD North study area is slightly higher than the density for the combined Colville Delta and Transportation Corridor survey areas (1 den/26 km²) but within the range of densities reported for other areas. We observed pups at a minimum of three natal dens and suspected that pups were present at another den. An estimated 44% of the dens in the CD North study area were occupied by arctic fox litters in 2000, which was at the lower end of the range observed since 1993 (40–89%). We counted 13 arctic fox pups at the 3 confirmed natal dens, for a mean litter size of 4.3 pups, which was near the upper end of the range observed since 1993 (2.0–5.3 pups/litter). We counted two pups at the secondary den site used by red foxes. Pup production by arctic foxes in the CD North study area during 2000 was close to the mean annual total of 13.8 pups recorded during 1993 and 1995–2000. In the CD North study area, the habitat type used most often for denning was Riverine or Upland Shrub (7 of 11 dens, or 64%). On the entire Colville Delta, 15 of 21 dens (71% of the total) were located in Riverine or Upland Shrub, the only denning habitat that was preferred.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

The CD North wildlife studies required the combined efforts of a large number of people in the field and office. Doug Blockolsky, Robin Corcoran, Renee Crain, Shawn Harper, Aaron Helmericks, Jim King, Mike Knoche, Randy Mullen, Steve Murphy, Dave Payer, Angela Palmer, Julie Petersen, Alex Prichard, Bob Ritchie, Loni Rossow, Sharon Schlentner, Pam Seiser, and Alison Ward 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. Helicopter pilots Lynn Voyles, Craig Wade, Rick Inskeep, and Ray Etches safely transported us around the study area. Will Lentz and Allison Zusi-Cobb digitized wildlife locations, summarized map data, and produced clear, concise figures. Sarah McGowan and Alison Ward produced the draft document and Jennifer Felkay molded it into final shape. The reviews by Betty Anderson, Mike Joyce, and Caryn Rea improved this report. Mike Joyce managed this project at its inception, but retired before its completion; nonetheless, he provided guidance and advice throughout. We wish him well in his new life. Caryn Rea replaced Mike at the helm, and ably steered us to completion. Finally, the co-authors would like to acknowledge and thank all the PHILLIPS staff and contractors in the Alpine and Kuparuk oil fields whose support has been crucial to the success of this and other environmental studies.

INTRODUCTION

During spring 2000, ABR, Inc. was contracted to conduct wildlife studies for two new oil prospects on the Colville River Delta, Fiord and Nanuq, to support the planning process for potential oil development. The CD North study area encompasses the Fiord prospect, whose discovery was announced in 1992 and 1998. The CD South study area encompasses the Nanuq prospect, which was drilled in 1996 and 2000. Neither reserve has proven economical for development as of this report, but further evaluation is planned for 2001. Wildlife studies have been conducted by the oil industry in the Colville River Delta region since 1992. Beginning in 1992, ARCO Alaska, Inc. (now PHILLIPS Alaska, Inc.) initiated studies 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. In this annual report on the 2000 field season, results are presented from the first year of study of the wildlife resources in the CD North study area and the ninth year of industry funded studies on the Colville Delta.

The primary goal of the CD North wildlife studies was to collect data on the distribution and abundance of selected species to be used as a baseline for site conditions prior to oil development. Baseline studies on the delta have been conducted since 1992, although the focal species that initially were examined and the boundaries of study areas varied somewhat in subsequent years. During a meeting with the U.S. Fish and Wildlife Service (USFWS) in spring 1992, PHILLIPS agreed to focus on select species, based primarily on the following criteria: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, or 3) special concern of regulatory agencies. Accordingly, Yellow-billed Loons, Tundra Swans, Brant, Spectacled Eiders, caribou, and arctic foxes were chosen for investigation (Smith et al. 1993). Species that were not the focus of surveys in 1992 but were monitored opportunistically included King Eiders, Red- throated Loons, Pacific Loons, Greater White-fronted Geese (hereafter, White-fronted Geese), Canada Geese, muskoxen, and red foxes. 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 Nechelik (Nigliq) Channel on the west; thus, it included the entire delta and a large area of adjacent coastal plain (Figure 1). That year we conducted intensive surveys for the aforementioned species on 6 plots ranging from 46 to 61 km² in area. The entire delta was surveyed for Tundra Swans, Brant, and Caribou. Ground-based nest searches were conducted for eiders and other waterfowl in two 10-ha plots; one 10-ha plot and one larger plot occurred in what is now the CD North project area. In 1993, the aerial survey area for focal species was expanded to include the entire delta region (Smith et al. 1994). In 1994, we surveyed the delta only for eiders (Johnson 1995). In 1995, we expanded our studies to monitor the distribution and abundance of the same suite of species investigated in 1992 and 1993, added a survey area (transportation corridor) that encompassed the pipeline route from Alpine to the Kuparuk Oilfield, and we began an investigation of habitat use by the focal species (Johnson et al. 1996). We continued with similar surveys in 1996–1998 (Johnson et al. 1997, 1998, 1999a). After federal and state permits were granted for the Alpine Development Project in 1998, a 3-year study was initiated to assess the effects of aircraft disturbance around the newly built airstrip (Johnson et al. 1999b, 2000). No delta-wide surveys for wildlife were conducted in 1999. We resumed delta-wide surveys in 2000 and returned to collecting data 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 uses the delta occasionally, was the focus of a separate more wide-ranging caribou study (Lawhead et al., in prep.).

The overall goal of the studies in 2000 was to continue the multi-year baseline on the use of the

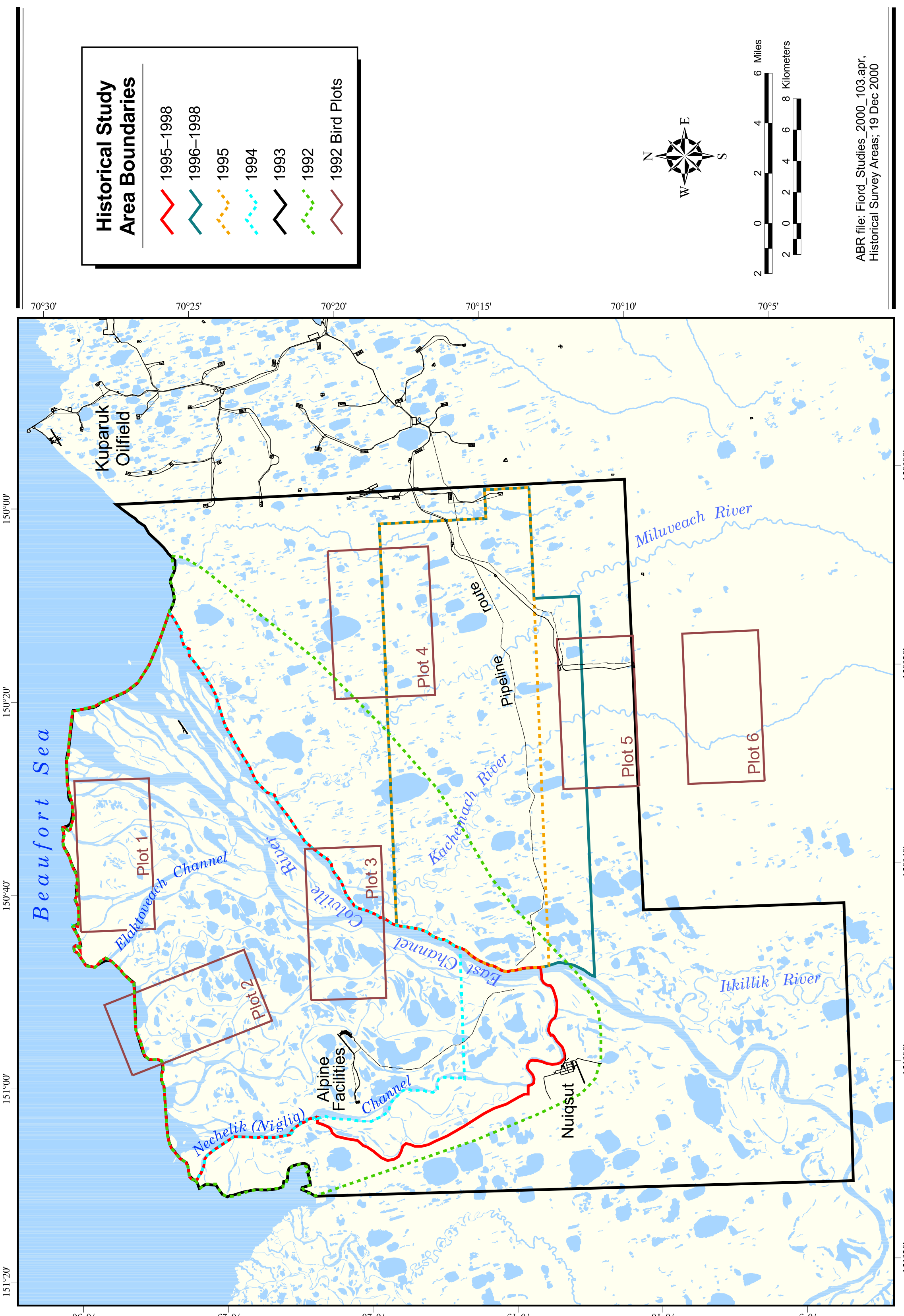


Figure 1. Map of historic wildlife study areas (1992–1998) on the Colville River Delta and adjacent areas, Alaska. Boundaries do not include caribou survey areas, which extended further south on the east side of the Colville River.

CD North study area by selected birds and mammals during June through early fall (September). Specific objectives for the CD North wildlife studies were to:

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

STUDY AREA

The CD North study area (207 km²) is located on the outer portion of the Colville River Delta (hereafter, Colville Delta or the delta) and is delimited by the Beaufort Sea on the north, the Alpine airstrip on the south, the Elaktoveach and East channels of the Colville River on the east and the Nechelik (Nigliq) 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 two permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family homesite, both of which rely heavily on these fish and wildlife resources.

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

The Colville River has two main distributaries: the Nechelik Channel and the East Channel. These two channels together carry ~90% of the water flowing through the delta during spring floods and 99% of the water after those floods subside (Walker 1983). Several smaller distributaries branch from the East Channel, including the Sakoonang, Tamayayak, and Elaktoveach channels. In addition to river channels, the delta is characterized by numerous lakes and ponds, sandbars, mudflats, sand dunes, and low- and high-centered polygons (Walker 1983). The East Channel is deep and flows under ice during winter, whereas the Nechelik and other channels are shallow and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta's channels, with the depth of the river at freeze-up being the main factor determining the inland extent of this intrusion (Walker 1983). The Colville River flows through continuous permafrost for its entire length. This extensive permafrost, combined with freezing of the upper layer of surface water in winter, influences the volume, timing, and character of river flow and erosion within the delta (Walker 1983).

Lakes and ponds are dominant physical features of the Colville Delta. Most of the waterbodies are shallow (e.g., polygon ponds ≤2 m deep), so they freeze to the bottom in winter but thaw by June. Deep ponds (>2 m deep) with steep, vertical sides are common on the delta but are uncommon elsewhere on the Arctic Coastal Plain. Lakes >5 ha in size are common and cover 16% of

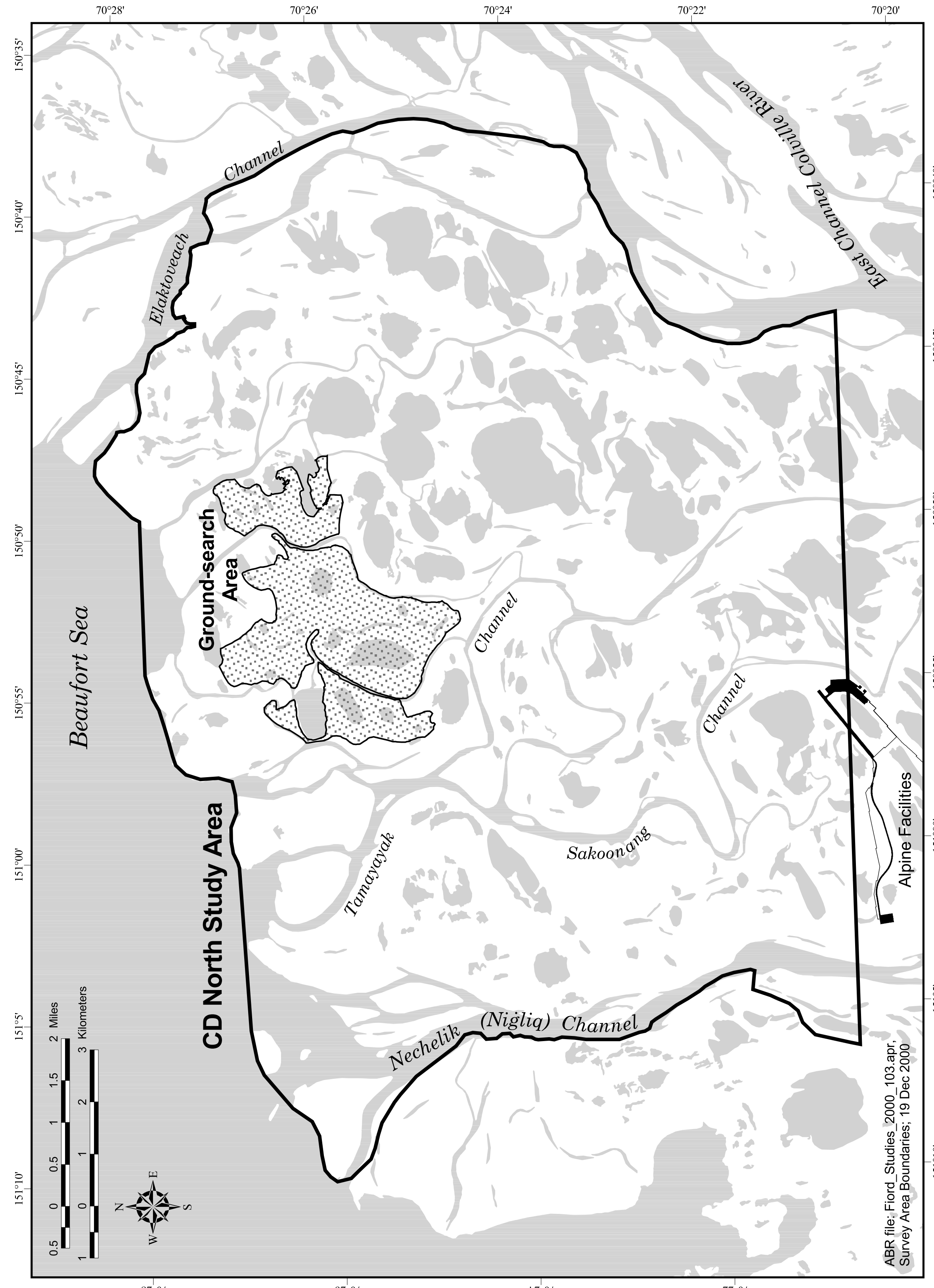


Figure 2. Boundaries for wildlife surveys in the CD North study area on the Colville River Delta, Alaska, 2000.

the delta's surface (Walker 1978). Some of those large lakes are deep (to 10 m) and freeze only in the upper 2 m; ice remains on these lakes until the first half of July (Walker 1978). Several other types of lakes, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes, occur on the delta (Walker 1983).

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

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

METHODS

In 2000, we conducted surveys 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, we conducted habitat studies to investigate what landforms and vegetation types were most important seasonally to wildlife on the Colville Delta. Habitat studies consisted of analyses of habitat selection by a subset of wildlife species. Habitat classification (Table 1) and mapping (Figure 3) of the Colville Delta were initiated in 1995 (Johnson et al. 1996) and completed in 1996; the mapping and classification process are described in detail by Johnson et al. (1997) and Jorgenson et al. (1997). Descriptions of habitats and their distribution across the entire delta are provided in Appendices B1 and B2. We have included data from previous years (generally, 1992–1999) in our assessments of distribution, abundance, and habitat use, where such inclusion was appropriate.

WILDLIFE SURVEYS

For the CD North wildlife studies, we used both fixed-wing aircraft and helicopters to fly aerial surveys over the Colville Delta for selected avian and mammalian species (Table 2). Aerial surveys covered the CD North study area (207 km^2) (Figure 2), which was the area used in comparisons of species abundance and distribution among years. Aerial surveys for some species extended beyond the CD North study area, but data from outside the boundaries were not reported for the CD North study area. Within the CD North study area, we also searched intensively on foot for nests and broods in the area proposed for oil development (ground-search area). In a separate study of the impacts of the Alpine airstrip on birds (Johnson et al., in prep.), we conducted ground and helicopter surveys near the Alpine Facility Area. As in previous years studies of the wildlife on the Colville River Delta (see Johnson et al. 1999a), the CD North wildlife studies focused on the distribution and abundance of Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, and geese during different seasons (detailed in the methods for each species). During surveys, we collected additional information opportunistically

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

MARINE WATER
- Inshore Water
- Offshore Water
- Sea Ice

COASTAL ZONE
- Nearshore Water
  - Open Nearshore Water (marine)
  - Brackish Water
    - Deep
      - without Islands
      - with Islands
      - with Polygonized Margins
    - Shallow
  - Tapped Lake (deltas only)
    - Deep
      - with low-water Connection
      - with high-water Connection
    - Shallow
      - with low-water Connection
      - with high-water Connection
- Coastal Wetland Complex
  - Salt Marsh
    - Halophytic Sedge
    - Halophytic Grass
    - Halophytic Herb
    - Halophytic Dwarf Willow Scrub
- Barren
  - Coastal Island
  - Coastal Beach
    - Cobble/gravel
    - Sand
  - Coastal Rocky Shore
    - Low
    - Cliffs
  - Tidal Flat
  - Salt-killed Tundra
  - Causeway

FRESH WATER
- Open Water
  - Deep Open Water
    - Isolated
      - without Islands
      - with Islands
      - with Polygonized Margins
    - Connected
  - Shallow Open Water
    - without Islands
    - with Islands
    - with Polygonized Margins
- River or Stream
  - Tidal
  - Lower Perennial
  - Upper Perennial
    - Deep Pools
    - Shallow
    - Riffles
    - Falls
  - Intermittent
- Water with Emergents (shallow, isolated, or connected)
  - Aquatic Sedge Marsh
    - without Islands
    - with Islands
    - with Deep Polygons
  - Aquatic Grass Marsh
    - without Islands
    - with Islands
  - Aquatic Herb
    - without Islands
    - with Islands

BASIN WETLAND COMPLEX
- Young (ice-poor)
- Old (ice-rich)

MEADOW
- Wet Meadows
  - Nonpatterned
    - Sedge (*Carex, Eriophorum*)
    - Sedge–Grass (*Carex, Dupontia*)
  - Low-relief
  - High-relief (sedge–willow)
- Moist Meadows
  - Low-relief
    - Sedge–Dwarf Shrub Tundra
    - Tussock Tundra
    - Herb
  - High-relief
    - Sedge–Dwarf Shrub Tundra
    - Tussock Tundra
- Dry Meadows
  - Grass
  - Herb

SHRUBLAND
- Riverine Shrub
  - Riverine Low Shrub
    - Willow
    - Birch
    - Alder
  - Riverine Dwarf Shrub
- Upland Shrub
  - Upland Low Shrub
    - Mixed Shrub Tundra
    - Willow
    - Alder
  - Upland Dwarf Shrub
    - *Dryas*
    - Ericaceous
- Shrub Bogs
  - Low Shrub Bog
  - Dwarf Shrub Bog

PARTIALLY VEGETATED
- Riverine Barrens (including deltas)
  - Barren
  - Partially Vegetated
- Eolian Barrens
  - Barren
  - Partially Vegetated
- Upland Barrens (talus, ridges, etc.)
  - Barren
  - Partially Vegetated
- Lacustrine Barrens (shore bottoms, margins)
  - Barren
  - Partially Vegetated
- Alpine
- Cliff (rocky)
- Bluff (unconsolidated)
  - Barren
  - Partially Vegetated
- Burned Area (barren)

ARTIFICIAL
- Fill
  - Gravel
    - Barren or Partially Vegetated
    - Vegetated
  - Medium-grained
    - Barren or Partially Vegetated
    - Vegetated
  - Sod (organic–mineral)
    - Barren or Partially Vegetated
    - Vegetated
- Excavations
  - Impoundment
    - Drainage Impoundment
    - Effluent Reservoir
  - Gravel
    - Barren or Partially Vegetated
    - Vegetated
- Structure or Debris

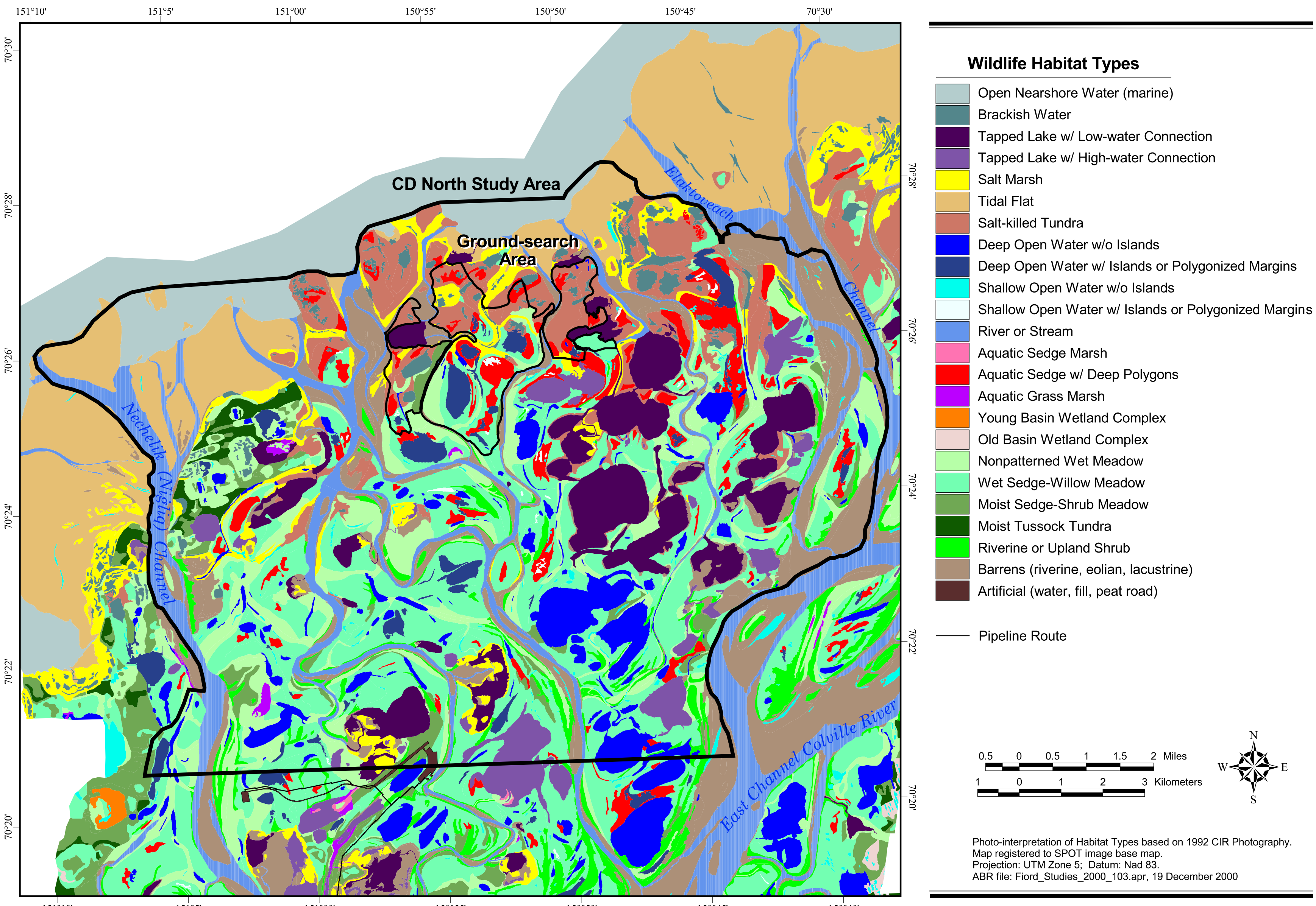


Figure 3. Habitat map of the CD North study area, Colville River Delta, Alaska.

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

Species	Survey Type	Phenological Season	Dates	Aircraft[a]	Transect[b] Width (km)	Transect[b] Spacing (km)	Aircraft Altitude (m)	Area Surveyed
BIRDS								
Eiders	Aerial	Pre-nesting	16 June	C185	0.4	0.4	30–35	Delta
Tundra Swans	Aerial	Nesting	22–24 June	C185	1.6	1.6	150	Delta
	Aerial	Brood-rearing	17–19 August	C185	1.6	1.6	150	Delta
	Aerial	Fall staging	16 September	C185	1.6	1.6	150	Delta
Loons	Aerial	Nesting	27, 30 June	206L	n/a	n/a	30–40	Delta
	Aerial	Brood-rearing	25, 27 August	206L	n/a	n/a	30–70	Delta
	Ground	Nesting	13–16 July	-	-	-	-	CD North Ground-search Area
	Ground	Brood-rearing	26 August	-	-	-	-	CD North Ground-search Area
Geese	Aerial	Brood-rearing	31 July	PA18	0.8	1.6	90	Delta
	Aerial	Fall staging	20 August	C185	0.4	1.6	90	Delta
Large Waterbirds	Ground	Nesting	24–29 June	-	-	-	-	CD North Ground-search Area
	Ground	Brood-rearing	13–16 July	-	-	-	-	CD North Ground-search Area (nest-fate checks)
MAMMALS								
Foxes	Aerial	Denning	30 June–1 July	206L	n/a	n/a	30–90	Delta (den status checks)
	Ground	Denning	11–13 July	-	-	-	-	Delta (den observations to count pups)

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

on other waterbirds, such as Pacific and Red-throated loons. We concentrated our surveys for mammals on arctic foxes, but we opportunistically collected information on other species, such as brown bears, moose, and muskoxen. A separate study was conducted for caribou in the western segment of the Central Arctic Herd during 2000 (Lawhead et al., in prep.).

HABITAT USE

To evaluate the importance of various habitats to wildlife in the CD North study area, we computed habitat use for the locations of selected species recorded in 2000. We did not analyze habitat selection (i.e., tests of preference and avoidance) specifically for the CD North study area, because it is only a portion of the Colville Delta surveyed in past years. Instead, we used the entire delta in our analysis of habitat selection, rather than just the CD North study area, so that results and conclusions would be consistent with past analyses (Johnson et al. 1999a) and encompass other parts of the delta, such as the CD South study area. We present these multi-year habitat selection analyses in the appendices. The analyses of habitat selection were based on the locations of bird groups, bird nests, and fox dens observed during aerial surveys (and ground surveys for fox dens only). For each species, we calculated habitat use for applicable combinations of season (e.g., pre-nesting, nesting, and brood-rearing) and year of survey (different years, depending on the species). For each combination, we calculated

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

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

We tested for significant habitat selection (i.e., use $\neq$ availability) by conducting Monte Carlo simulations (Haefner 1996, Manly 1997) on multi-year data for each species. Each simulation used random numbers (range = 0–100) to choose a habitat from the cumulative frequency distribution of the percent availability of habitat. The number of "random choices" in a simulation was equal to the number of nests, dens, or groups of birds from which percent use was calculated. We conducted 1,000 simulations for each species and summarized the frequency distribution by percentiles. We defined habitat preference (i.e., use > availability) to occur when the observed use by a species was greater than the 97.5 percentile of simulated random use. Conversely, we defined habitat avoidance (i.e., use < availability) to occur when the observed use was less than the 2.5 percentile of simulated random use. Habitats with nonsignificant selection (i.e., observed use $\geq$2.5 and $\leq$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 two-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

We conducted nest searches on the ground in the CD North study using the same techniques used in the Colville wildlife studies in 1996–1998 and in the Alpine project area in 1999 (Johnson et al. 1997, 1998, 1999a, 1999b, 2000). The ground-search area in 2000 was restricted to the area of proposed oil development, henceforth the CD North ground-search area (12.2 km^2) (Figure 2). We searched on foot within 10 m of the shorelines of all waterbodies, and in all intervening habitat we searched with ~10-m spacing between observers walking zig-zag paths. Using five to nine observers, we searched for nests of all ducks, geese, Tundra Swans, loons, gulls, terns, and other large birds. For each nest, we recorded the species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. In 2000, we conducted our nest search between 24–30 June.

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

We revisited nest sites of waterbirds in the ground-search area after hatch (between 13 and 16 July for waterfowl) to determine their fate. Nests were classified as successful if we found egg membranes 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 our revisits to nests, we opportunistically recorded broods in the area on 1:18,000-scale color aerial photographs. On 26 August, we searched all waterbodies ≥25 m long, primarily for loon broods, and recorded all brood locations on aerial photographs.

EIDERS

In 2000, we flew aerial surveys during the pre-nesting period (Table 2), and conducted ground-based surveys in the area of proposed oil development to search for eider nests and broods. For the pre-nesting survey, we used the same methods as in previous years (1992–1998), although the survey areas differed in extent. In 2000, we flew surveys over the CD North and CD South study areas (Appendix B2) but did not survey east of the Elaktoveach Channel. We flew the pre-nesting survey with two 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 areas. The strip width for this and other transect surveys was delimited visually by tape marks on the windows and wing struts or skids of the aircraft (Pennycuick and Western 1972). We recorded the locations of eiders on 1:63,360-scale USGS maps and used audio tapes to record numbers, species, and sex of eiders and their perpendicular distance from the flight line. The locations of eiders were entered manually into a GIS database for mapping and analysis.

From the data collected during the pre-nesting survey, we calculated the observed number of birds, the observed number of pairs, the indicated number of birds, the indicated number of pairs, and densities (number/km²) for each survey area. Following the USFWS (1987a) protocol, the total indicated number of birds was calculated by first doubling the number of males not in groups (a group is defined for this calculation as >4 birds of mixed sex that cannot be separated into singles or pairs), then adding this product to the number of birds in groups. The indicated number of pairs was the number of males. Density estimates were not adjusted with a visibility correction factor.

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

TUNDRA SWANS

In 2000, we flew aerial surveys for Tundra Swans during the nesting, brood-rearing, and fall-staging seasons (Table 2). During nesting and brood-rearing, we conducted aerial surveys over the entire Colville Delta, including the CD North study area, in accordance with USFWS protocols (USFWS 1987b, 1991). We flew east–west transects spaced 1.6-km apart in a fixed-wing airplane that was navigated with the aid of a GPS. The two observers (one on each side of the plane) each visually searched 800-m-wide transects while the pilot navigated and scanned for swans ahead of the aircraft. Locations and counts of swans were marked on 1:63,360-scale USGS maps. The same methods were used for nesting and brood-rearing surveys on the delta in 1993, 1995–1998, and 2000 (Smith et al. 1994, Johnson et al. 1998). Beginning in 1995, we photographed each nest with a 35-mm camera for site verification. During nesting in 1992, the survey on the delta differed from those of other years, in that year 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.

We used a Cessna 185 aircraft to fly a fall-staging survey in mid September for Tundra Swans. In addition to flying transects as described above, we flew non-transect paths over areas immediately adjacent to the delta that have been previously identified as fall-staging grounds for Tundra Swans (Seaman et al. 1981, Johnson et al. 1999a). A pilot and one observer looking out of opposite sides of the aircraft scanned the ground for swans. Locations and counts of swans were marked on 1:63,360-scale USGS maps.

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

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

LOONS

In 2000, we used a helicopter to conduct aerial surveys for nesting and brood-rearing Yellow-billed Loons (Table 2). In 1995–1998 (Johnson et al. 1996, 1997, 1998, 1999a), we used a fixed-wing aircraft to survey for nesting loons and a helicopter to survey for brood-rearing loons, whereas we used a fixed-wing aircraft for both surveys in 1993 (Smith et al. 1994). In 1993 and 1995–1998, we flew surveys over the entire delta, whereas in 2000 we surveyed the delta only on the west side of the Elaktoveach Channel. We flew all surveys in a lake-to-lake pattern, concentrating on lakes ~10 ha or larger in size and adjacent smaller lakes; we excluded coastal lakes and tapped lakes with low-water connections to river channels, where Yellow-billed Loons have not been observed to nest (North 1986, Johnson et al. 1999a). We used the 10-ha-size criterion in 1995–1998 and 2000 to concentrate our efforts on Yellow-billed Loons, which typically nest and rear their broods on lakes ≥10 ha (Sjolander and Agren 1976, North and Ryan 1989). During the nesting season in 1996–1998 and 2000, we revisited with a helicopter those lakes in the CD North study area where Yellow-billed Loons had been seen on the initial nest survey, but where nests were not found, to determine whether nesting was occurring. We also recorded locations of nesting and brood-rearing Pacific and Red-throated loons during all surveys. However, surveys for these two species were not thorough, because we did not systematically search small lakes (<10 ha), which frequently are used by these species for nesting and brood-rearing (Bergman and Derksen 1977). We recorded all loon locations on 1:63,630-scale USGS maps.

We calculated the total number of adults, nests, broods, and young by season for all three species of loons. We calculated density (number/km²) only for Yellow-billed Loons because our survey coverage for Pacific and Red-throated loons was inadequate for estimating density. Habitat use and proximity to nearest waterbody were calculated for Yellow-billed Loon nests found in 2000. Habitat selection was calculated for Yellow-billed Loon nests and broods in the area surveyed each year. We calculated selection indices based on nests found in 1993, 1995–1998, and 2000, and on broods found in 1995–1998 and 2000.

GEESE

In 2000, we conducted systematic aerial surveys for geese during the brood-rearing (31 July) and fall-staging (20 August) seasons. These surveys were developed originally in 1996 to count White-fronted Geese, although we also counted Brant, and Canada and Snow geese. The surveys were flown at 90 m agl on east–west flight lines that were 1.6 km apart, between the Elaktoveach and Nechelik channels. Two observers (including the pilot) searched a 400-m-wide strip on either side of the plane, thereby achieving 50% coverage of the survey area. We recorded species, numbers, and locations on 1:63,360-scale USGS maps. Coverage during 1997 and 1998 surveys was also 50%, whereas in 1996 coverage was equivalent to 25% (one observer). However, these previous surveys covered the entire delta. We also collected information opportunistically on geese during surveys for swans and loons, and in previous years (1992–1998) we conducted coastal surveys specifically for Brant during nesting, brood-rearing, and fall staging.

FOXES

We used aerial and ground-based surveys to evaluate the distribution and status of arctic and red fox dens on the Colville River Delta in 2000, continuing the annual monitoring effort begun in 1992 across the entire delta and adjacent coastal plain. We assessed den status and pup presence at known dens on helicopter-supported ground visits during 28 June–2 July, and then returned to active dens during 10–13 July to count pups (Table 2). Most survey effort focused on checking dens found in previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a), although we also searched opportunistically for dens in suitable habitats while transiting between known dens. Soil disturbance 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, we evaluated evidence of use by foxes and confirmed the species using the den. We examined fox sign to assess den status (following Garrott 1980): presence or absence of adult or pup foxes; presence and appearance of droppings, diggings, tracks, trampled vegetation, shed fur, and prey remains; and signs of predation (e.g., pup remains). We classified dens into four categories (following Burgess et al. 1993), the first three of which are considered to be "occupied" dens:

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

Because foxes commonly move pups from natal dens to secondary dens, repeated observations are needed to classify den status with confidence. Since 1996, we have made a concerted effort annually to confirm den occupancy and to count pups. Based on our initial assessment of den activity, our observations during 10–13 July were devoted to counting pups at as many active dens as possible. Observers were dropped off by helicopter at suitable vantage points several hundred meters from den sites, from which they conducted observations with binoculars and spotting scopes over periods of 2.5–4 hours. Observations usually were conducted early and late in the day, when foxes tend to be more active.

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

RESULTS AND DISCUSSION

HABITAT AVAILABILITY

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

In the CD North study area, the most abundant habitats were Wet Sedge–Willow Meadow (20% of the total area), Barrens (11%), Nonpatterned Wet Meadow (10%), and Tapped Lake with Low-water Connection (9%; Table 3). The outer delta is subject to more extensive river flooding during spring break-up and marine flooding from storm surges than the rest of the delta, and, therefore, contains younger surfaces with more mineral deposition, higher salinity, and less organic accumulation than the rest of the delta (see Jorgenson et al. 1997). These geologic processes have shaped the outer delta into a region of low topographic relief, short and often depauperate vegetation cover, and many lakes that are mostly tapped or brackish from flooding. Because CD North is on the outer delta, it contains larger proportions of coastal habitats than the entire delta. Open Nearshore Water, Brackish Water, Tapped Lake with Low-water Connection, Salt Marsh, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons are more abundant in the CD North study area than on the entire delta. The CD North study area also comprises more lakes than does the entire delta, with 21% of the area in lake habitats compared to 15% on 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 (henceforth, the ground-search area; Figure 3) contained 14 habitats, of which 9 occupied >1% of the search area (Table 4). Salt-killed Tundra occurred over the most area (29%), followed by Wet Sedge–Willow Meadow

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

	CD North Study Area		Colville Delta	
Habitat	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Open Nearshore Water (marine)	7.12	3.4	10.02	1.8
Brackish Water	4.01	1.9	6.53	1.2
Tapped Lake w/ Low-water Connection	17.76	8.6	21.62	3.9
Tapped Lake w/ High-water Connection	5.88	2.8	20.77	3.8
Salt Marsh	7.79	3.8	16.55	3.0
Tidal Flat	12.95	6.3	56.01	10.2
Salt-killed Tundra	15.14	7.3	25.64	4.7
Deep Open Water w/out Islands	10.04	4.9	20.77	3.8
Deep Open Water w/ Islands or Polygonized Margins	4.21	2.0	7.76	1.4
Shallow Open Water w/out Islands	0.89	0.4	2.02	0.4
Shallow Open Water w/ Islands or Polygonized Margins	0.29	0.1	0.54	0.1
River or Stream	14.60	7.1	82.07	14.9
Aquatic Sedge Marsh	0	0	0.13	<0.1
Aquatic Sedge w/ Deep Polygons	8.57	4.1	13.22	2.4
Aquatic Grass Marsh	0.34	0.2	1.45	0.3
Young Basin Wetland Complex	0	0	<0.01	<0.1
Old Basin Wetland Complex	0	0	0.01	<0.1
Nonpatterned Wet Meadow	21.69	10.5	41.54	7.5
Wet Sedge–Willow Meadow	41.81	20.2	102.63	18.6
Moist Sedge–Shrub Meadow	4.34	2.1	13.20	2.4
Moist Tussock Tundra	1.69	0.8	2.55	0.5
Riverine or Upland Shrub	5.30	2.6	27.58	5.0
Barrens (riverine, eolian, lacustrine)	22.29	10.8	78.67	14.3
Artificial (water, fill, peat road)	0.15	0.1	0.39	<0.1
Total	206.87	100	551.67	100

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

	CD North Ground-search Area	
Habitat	Area (km^2)	Availability (%)
Brackish Water	0.76	6.2
Tapped Lake w/ Low-water Connection	0.01	0.1
Salt Marsh	0.86	7.0
Tidal Flat	<0.01	<0.1
Salt-killed Tundra	3.51	28.8
Deep Open Water w/out Islands	0.11	0.9
Deep Open Water w/ Islands or Polygonized Margins	1.19	9.7
Shallow Open Water w/out Islands	0.01	0.1
Shallow Open Water w/ Islands or Polygonized Margins	0.07	0.5
River or Stream	<0.01	<0.1
Aquatic Sedge w/ Deep Polygons	1.83	15.0
Nonpatterned Wet Meadow	1.09	8.9
Wet Sedge–Willow Meadow	2.08	17.1
Moist Sedge–Shrub Meadow	0.43	3.5
Barrens (riverine, eolian, lacustrine)	0.25	2.0
Total	12.20	100.0

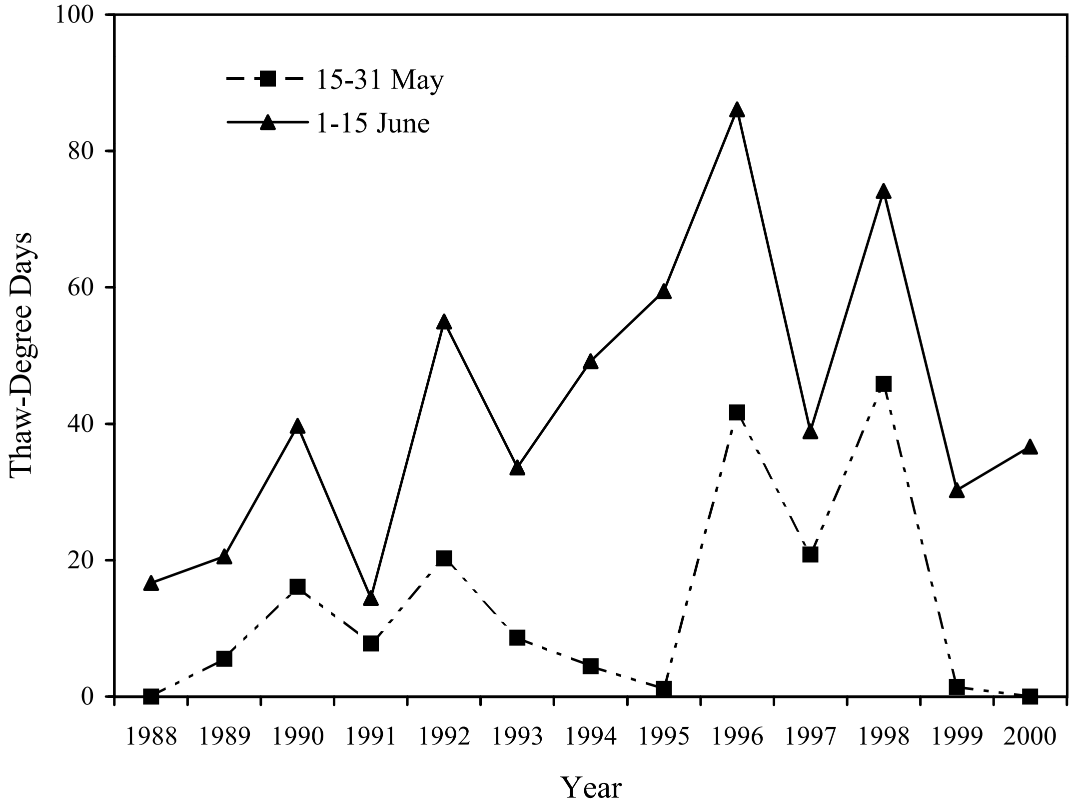


Figure 4. Number of thaw-degree days recorded for 15 May–15 June in the Kuparuk Oilfield, Alaska, 1988–2000. Thaw-degree days are calculated by summing the number of degrees above 0° C for daily mean temperature.

(17%), Aquatic Sedge with Deep Polygons (15%), and Nonpatterned Wet Meadow (9%).

CONDITIONS IN THE STUDY AREA

The 2000 breeding season was unusual among recent years because of the extent that weather and river conditions delayed the onset of nesting for birds in much of the study area. Spring temperatures were cold and snow melt in 2000 was late relative to other years we have worked on the delta, and more so than 1997 and 1999, 2 years that were marked by cool temperatures and late snow melt. Average daily temperatures in the Kuparuk Oilfield (~25 km east of the delta) did not get above freezing during 15–31 May 2000, making it the coldest year during this period since we began surveys on the delta in 1992 (Figure 4). During 11–15 June 2000, snow cover averaged 40% and 54% (range = 10–85%) in two areas west and south of the Kuparuk Oilfield and 14% (range = 3–30%) within the Kuparuk Oilfield survey area (Lawhead et al., in prep.), which is an area of accelerated thawing due to dust blown from gravel roads and pads. During the same period in 1999, the Kuparuk survey area had ~20% snow cover and the two other areas had <15% snow cover (Lawhead and Johnson 2000). In addition to late snow melt, the Colville River broke up relatively late on 8 June, and ice jams caused extensive flooding on the delta during the second week of June, which made some nesting areas inaccessible for several days. Another index to the lateness of the nesting season was the delayed development of Tundra Swan and loon young, which take longer than other species on the delta to become capable of flight. Young swans were judged to be unusually small during our brood-rearing survey on 17–19 August, and during the staging survey on 16 September,

Table 5. The number and density of nests and nest success of selected birds located during ground searches in the CD North ground-search area (12.2 km^2), Colville River Delta, Alaska, 2000.

Species	Number of Nests	Density (no./km^2)	Nest Success (%)
Red-throated Loon	9	0.7	67
Pacific Loon	9	0.7	44
Yellow-billed Loon	2	0.2	0
Greater White-fronted Goose	120	9.8	73
Brant	30	2.5	10
Tundra Swan	3	0.3	67
Northern Pintail[a]	3	0.3	0
Spectacled Eider[b]	14	1.2	43
King Eider	2	0.2	100
Long-tailed Duck[c]	18	1.5	39
Unidentified duck	1	0.1	0
Willow Ptarmigan	8	0.7	13
Parasitic Jaeger	1	0.1	100
Glaucous Gull	10	0.8	80
Sabine's Gull	5	0.4	20
Arctic Tern	9	0.7	89
Total	241	19.8	56

[a] Includes two probable Northern Pintail nests identified from down and feather characteristics.
[b] Includes one probable Spectacled Eider nest identified from down and feather characteristics.
[c] Includes three probable Long-tailed Duck nests identified from down and feather characteristics.

family groups were observed still to be on nesting territories. No young were observed in flocks, which usually form by mid-September prior to migration and freeze-up. During the same survey, loon adults were observed in flight, but none were observed on lakes attending young. These observations suggest that few swan or loon young survived to the beginning of migration, if freeze-up occurred during the second or third week of September, as it has in most years.

GROUND SEARCHES FOR NESTS AND BROODS

NESTS

In 2000, we recorded 241 nests of 15 species in the CD North ground-search area (Table 5). Overall nest success was 56%. Habitats with polygonal surface forms contained the highest numbers of nests: Wet Sedge–Willow Meadow contained 64 nests (27% of the total), Aquatic Sedge with Deep Polygons contained 59 nests (25%), and Salt-killed Tundra contained 41 nests (17%; Table 6). More than half of the nests belonged to geese and were composed of 120 Greater White-fronted Goose nests and 30 Brant nests (Figure 5). Duck nests were abundant in the ground-search area and were primarily Long-tailed Duck (formerly Oldsquaw) nests (18 nests, including 3 that were identified from feather and down samples) and Spectacled Eider nests (14, including 1 that was identified by color patterns on contour feathers in the nest; Anderson and Cooper 1994). Three Tundra Swan and two Yellow-billed Loon nests were found in the ground-search area. Eiders, swans, geese, and loons are discussed in more detail in later sections. Overall, the density of nests in the CD North ground-search area was

Table 6. Habitat use (%) by waterbirds for nesting and brood-rearing in the CD North ground-search area, Colville River Delta, Alaska, 2000.

Habitat	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Brant	Tundra Swan	Northern Pintail[a]	Spectacled Eider[a]	King Eider	Long-tailed Duck[a]	Unidentified duck	Willow Ptarmigan	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	Use (%)	Total Number
NESTING																		
Brackish Water	17	44	0	1	13	0	0	0	0	0	0	0	0	50	0	0	6	15
Salt-killed Tundra	17	11	0	17	10	33	33	64	50	0	0	25	0	0	40	0	17	41
Deep Open Water w/out Islands	0	0	0	2	0	0	0	0	0	11	0	0	0	0	0	22	2	4
Deep Open Water w/ Islands or Polygonized Margins	0	22	100	1	60	0	33	7	0	17	0	0	0	40	40	11	15	37
Shallow Open Water w/ Islands or Polygonized Margins	0	11	0	1	0	0	0	0	0	0	0	0	0	0	0	11	1	3
Aquatic Sedge w/ Deep Polygons	33	0	0	33	17	67	0	14	50	22	0	25	100	10	0	11	25	59
Nonpatterned Wet Meadow	0	11	0	8	0	0	33	0	0	11	0	25	0	0	20	11	7	17
Wet Sedge–Willow Meadow	33	0	0	39	0	0	0	14	0	33	100	25	0	0	0	33	27	64
Moist Sedge–Shrub Meadow	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	<1	1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Total Number of Nests	6	9	2	120	30	3	3	14	2	18	1	8	1	10	5	9		241
BROOD-REARING																		
Brackish Water	14	33		9	0		0	0		0			0	40	0	0	10	5
Tapped Lake w/ Low Water Connection	0	0		0	0		0	14		0			0	0	0	0	2	1
Salt Marsh	0	0		9	0		0	0		0			0	0	0	0	2	1
Salt-killed Tundra	14	0		46	100		0	0		0			100	0	33	0	18	9
Deep Open Water w/out Islands	0	0		9	0		50	0		100			0	0	33	0	10	5
Deep Open Water w/ Islands or Polygonized Margins	0	33		9	0		50	57		0			0	40	33	43	28	14
Shallow Open Water w/ Islands or Polygonized Margins	14	33		0	0		0	0		0			0	0	0	14	6	3
Aquatic Sedge w/ Deep Polygons	57	0		18	0		0	14		0			0	20	0	14	18	9
Nonpatterned Wet Meadow	0	0		0	0		0	0		0			0	0	0	14	2	1
Wet Sedge–Willow Meadow	0	0		0	0		0	14		0			0	0	0	14	4	2
Total	100	100		100	100		100	100		100			100	100	100	100	100	
Total Number of Broods	7	3	0	11	1	0	2	7	0	3	0	0	1	5	3	7		50

[a] Includes nests identified from feather and down samples

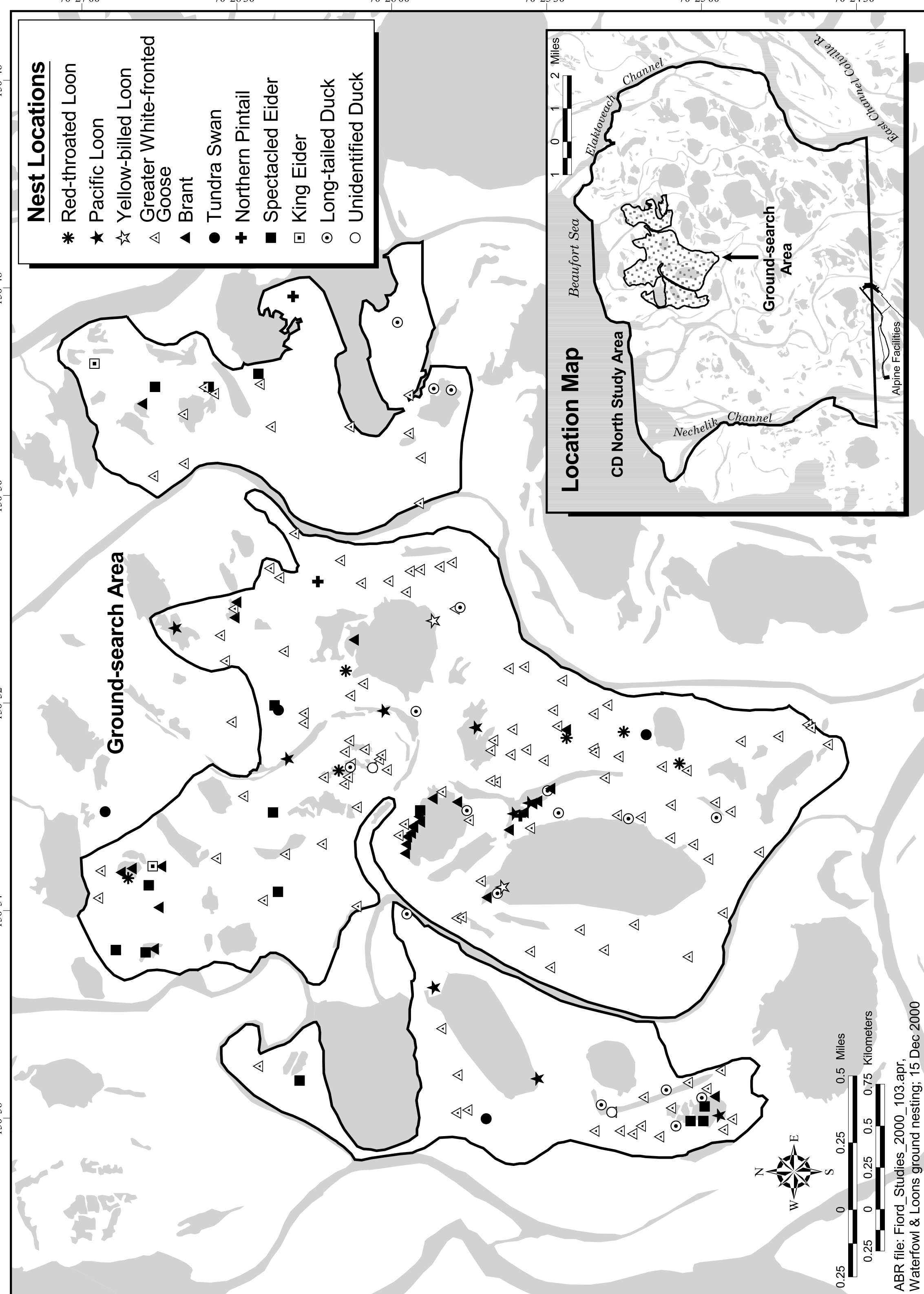


Figure 5. Distribution of waterfowl and loon nests located on ground searches in the CD North study area, Colville River Delta, Alaska, 2000.

Table 7. Densities (nests/km²) of nests in the Alpine, CD South, and CD North ground-search areas, Colville River Delta, Alaska, 1996–2000. Pre-2000 data are from Johnson et al. (2000); CD South data are from Burgess et al. (2000).

	Alpine				CD South	CD North
Species	1996	1997	1998	1999	2000	2000
Red-throated Loon	0.1	0.5	0.1	0	0	0.5
Pacific Loon	0.2	0.6	0.1	0.5	0.5	0.7
Yellow-billed Loon	0.1	0.1	0	0.1	0	0.2
Red-necked Grebe	0	0.2	0.1	0.1	0	0
Greater White-fronted Goose	2.0	3.1	3.2	5.0	6.2	9.8
Canada Goose	0	0	0.1	0.1	0	0
Brant	0.1	0.5	0.1	0.3[a]	0	2.5
Tundra Swan	0.2	0.4	0.3	0.4	0.2	0.3
Northern Shoveler	0.1	0	0.3[b]	0	0	0
Northern Pintail	0.1[b]	0.3	0.6[b]	0.6[b]	2.1[b]	0.3[b]
Green-winged Teal	0.1	0	0.1	0.3[b]	0	0
Greater Scaup	0	0.1	0.1	0.4	0	0
Lesser Scaup	0	0	0.1	0	0	0
Unidentified scaup	0	0	0.1	0.1[b]	0	0
Spectacled Eider	0	0	0.1	0.1	0.2	1.1[a]
King Eider	0.1	0	0	0	0	0.2
Long-tailed Duck	0.4[b]	0.6	0.4[b]	0.2[b]	0.2	1.5[b]
Unidentified duck	0	0	0.3	0.1	0	0.1
Willow Ptarmigan	0.1	0.8	nd	1.3	2.9	0.7
Rock Ptarmigan	0	0.1	nd	0	0.2	0
Unidentified ptarmigan	0	0	0	0.2	0	0
Sandhill Crane	0	0	0	0.1	0	0
Bar-tailed Godwit	0.1	0	0.1	0.2	0	0
Common Snipe	0	0.1	0	0	0	0
Parasitic Jaeger	0.1	0.1	0.1	0.1	0	0.1
Long-tailed Jaeger	0.1	0	0.1	0.1	0.3	0
Glaucous Gull	0	0.1	0	0.1	0.2	0.8
Sabine's Gull	0.1	0	0	0	0	0.4
Arctic Tern	0	0.3	0.3	1.0	0.7	0.7
Short-eared Owl	0.1	0	0	0	0	0
Area searched (km^2)	17.2	14.3	14.8	15.7	5.8	12.2
Total nest[c]	63	102	99	154	62	233
Total densities[c]	3.7	7.1	6.7	9.8	10.7	19.1
Total species[c]	16	14	18	18	10	16

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

about twice the densities found in the CD South and the Alpine ground-search areas (Table 7).

Nests of Long-tailed Ducks were 2–6 times more abundant in the CD North ground-search area than in the CD South and Alpine ground-search areas (Table 7). Seven of the 18 nests (39%) hatched successfully. Long-tailed Duck nests occurred most frequently in Wet Sedge–Willow Meadow (33% of all nests) and Aquatic Sedge with Deep Polygons (22%; Table 6). Most nests were found either on islands (4 nests), shorelines (4 nests), or polygon rims (8 nests). We found three Northern Pintail nests (including two identified from feather and down samples); all three failed to hatch. The density of Northern Pintail nests was dramatically lower in the CD North ground-search area than in either the CD South or Alpine ground-search areas, where they were generally the

Table 8. The number of broods of selected waterbirds located during ground searches in the CD North ground-search area (12.2 km²), Colville River Delta, Alaska, 2000.

Species	Number of Adults	Number of Young	Total Birds	Total Broods
Red-throated Loon	8	9	17	7
Pacific Loon	5	4	9	3
Greater White-fronted Goose	25	41	64	11
Brant	1	8	9	1
Northern Pintail	2	10	12	2
Spectacled Eider[a]	7	26	33	7
Long-tailed Duck	3	8	11	3
Parasitic Jaeger	1	2	3	1
Glaucous Gull	7	10	19	5
Sabine's Gull	5	4	9	3
Arctic Tern	14	10	24	7
Total	78	132	210	50

[a] One brood found during helicopter survey.

most abundant duck nests (Table 7). Both Long-tailed Ducks and Northern Pintails were the most abundant large birds on the Colville Delta during agency surveys in the 1980s; densities of both species (7.5 birds/km² and 16.6 birds/km²) in June were higher than that recorded for any other location on the Arctic Coastal Plain (Rothe et al. 1983).

We found 24 gull and tern nests during the ground search in the CD North study area (Figure 6, Table 5). Glaucous Gulls and Arctic Terns had 10 and 9 nests, respectively. Eighty percent of the Glaucous Gull nests and 89% of the Arctic Tern nests hatched. Five Sabine's Gull nests were found, of which only one hatched successfully. Glaucous and Sabine's gull nests were more abundant in the CD North ground-search area than in either the CD South or Alpine ground-search areas, but tern nest densities were comparable in the three areas (Table 7). The Glaucous Gull nests were located primarily on islands in aquatic habitats; whereas the Sabine's Gull and Arctic Tern nests were located in both terrestrial and aquatic habitats (Table 6).

We found one Parasitic Jaeger nest in the ground-search area, which hatched successfully (Figure 6, Table 5). We located eight nests of Willow Ptarmigan, but we did not check ptarmigan nests for hatch success because it is difficult to relocate nest bowls consistently. The density of ptarmigan nests (0.7 nests/km²) was comparable to densities in the Alpine ground-search area (0.1–1.3 nests/km²), but about a third of the density in the CD South ground-search area (2.9 nests/km²; Table 7).

BROODS

During ground searches for broods in 2000, we recorded 50 broods of 11 species (Table 8, Figure 7). Greater White-Fronted Geese (11 broods), Red-throated Loons (7 broods), Spectacled Eiders (7 broods), and Arctic Terns (7 broods) had more broods in the ground-search area than other species. The numbers of broods were undoubtedly undercounted, because young of many species are cryptic and use vegetation to hide, so numbers reported here are minimal counts. Broods were recorded most often in Deep Open Water with Islands or Polygonized Margins (14 broods or 28% of all broods) and Aquatic Sedge with Deep Polygons (9 broods, 18%) (Table 6).

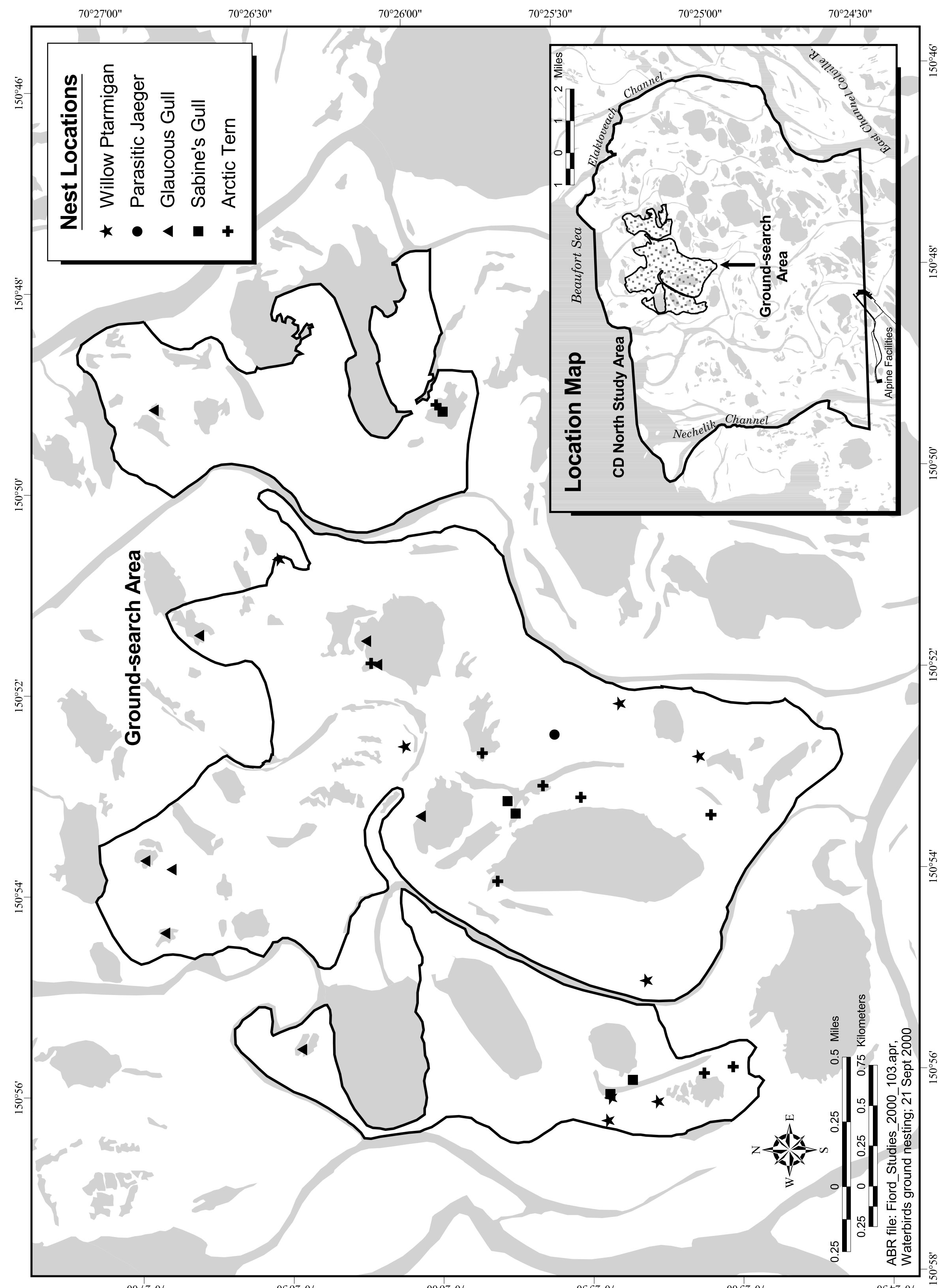


Figure 6. Distribution of selected bird nests located on ground searches in the CD North study area, Colville River Delta, Alaska, 2000.

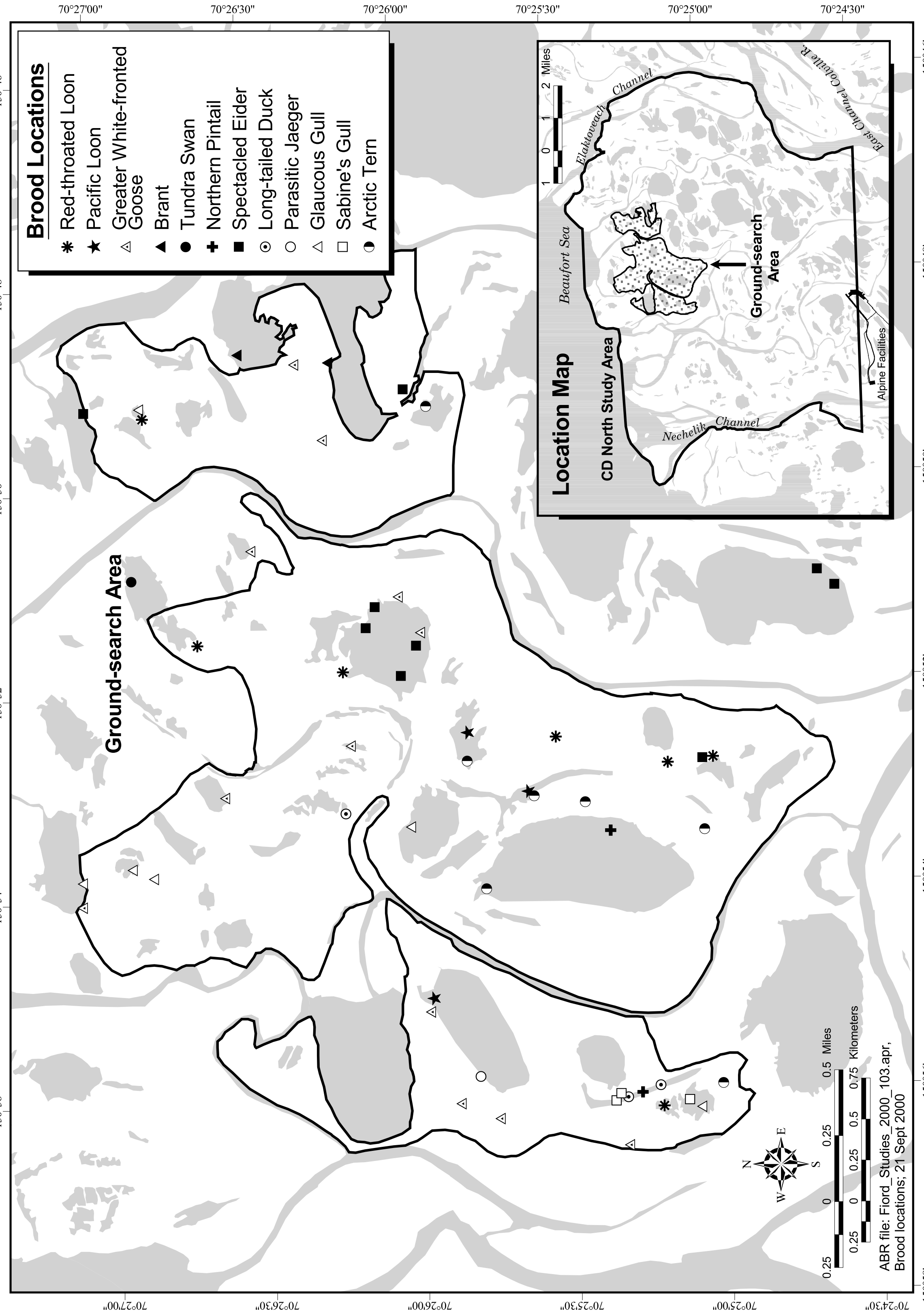


Figure 7. Distribution of broods recorded during nest-fate checks and ground searches in the CD North study area, Colville River Delta, Alaska, July and August 2000.

EIDERS

BACKGROUND

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

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

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

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

DISTRIBUTION AND ABUNDANCE

Pre-nesting

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

The distribution of both Spectacled and King eiders in 2000 was similar to that recorded on surveys flown in 1993–1998 (Figure 8, Appendices C1 and C2). Spectacled and King eiders on the Colville Delta were closely associated with coastal areas in all years. During pre-nesting in 2000, Spectacled Eiders were found as far as 14.3 km

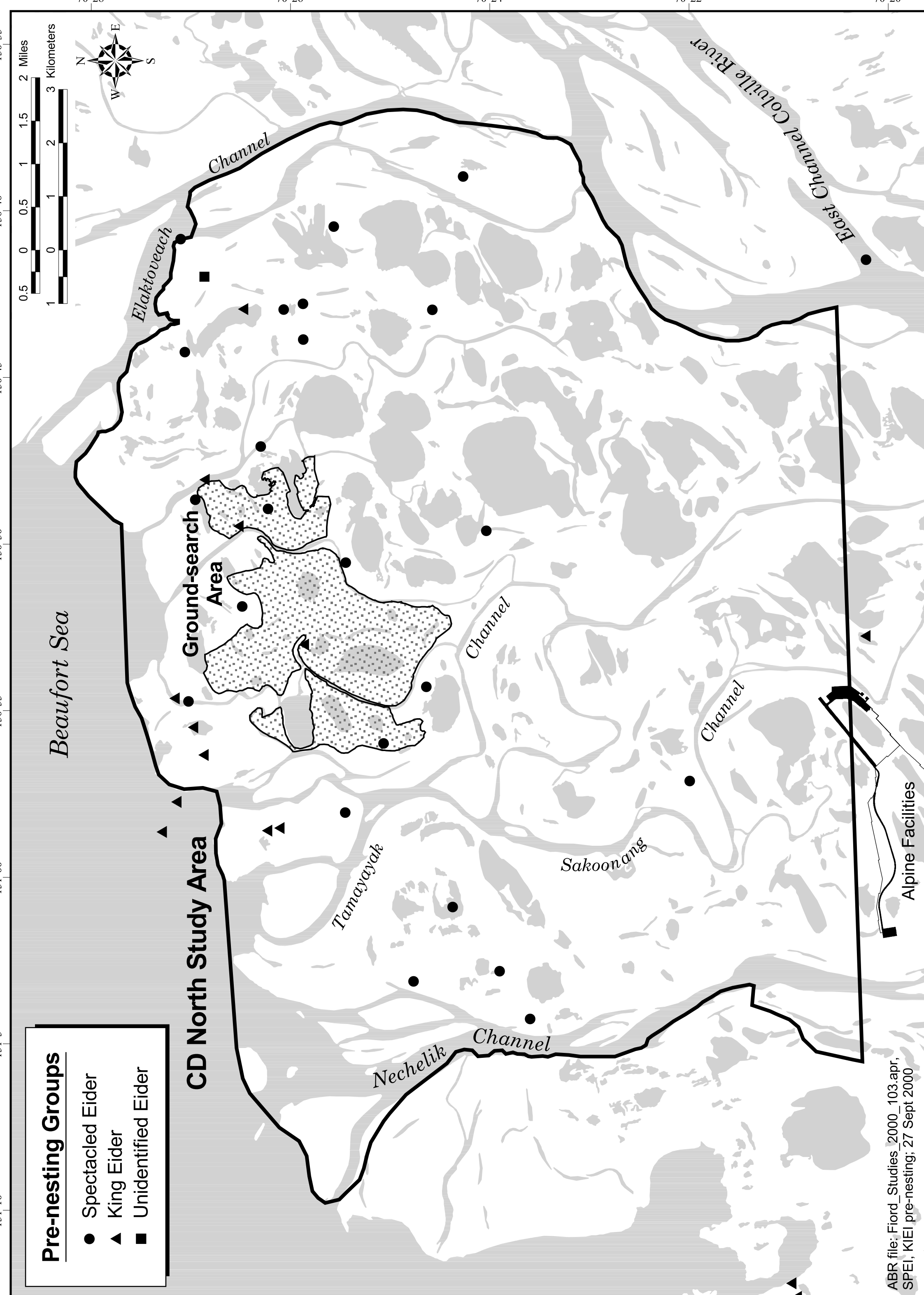


Figure 8. Distribution of Spectacled, King, and unidentified eider groups recorded during pre-nesting aerial surveys in the CD North study area, Colville River Delta, Alaska, 2000.

Table 9. Numbers and densities (uncorrected for sightability) of eiders seen during aerial surveys (100% coverage) of the CD North study area (206.9 km²), Colville River Delta, Alaska, 16 June 2000.

	Numbers of Eiders					Density (birds or pairs/km^2)		
	Observed			Indicated		Observed	Indicated	
Species	Males	Females	Total	Total[a]	Pairs[b]	Total	Total[a]	Pairs[b]
NON-FLYING BIRDS								
Spectacled Eider	18	12	30	36	18	0.14	0.17	0.09
King Eider	9	5	14	18	9	0.07	0.09	0.04
Unidentified Eider	0	1	1	0	0	<0.01	0	0
FLYING BIRDS								
Spectacled Eider	4	2	6	8	4	0.03	0.04	0.02
King Eider	1	1	2	2	1	0.01	0.01	<0.01
Unidentified Eider	0	0	0	0	0	0	0	0
NON-FLYING + FLYING BIRDS								
Spectacled Eider	22	14	36	44	22	0.17	0.21	0.11
King Eider	10	6	16	20	6	0.08	0.10	0.05
Unidentified Eider	0	1	1	0	0	<0.01	0	0

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

from the coastline, a small increase over the furthest inland sighting recorded between 1993 and 1998 (14 km). The mean distance from the coast of Spectacled Eiders in 2000 was 4.3 km (n = 24 sightings), slightly farther from the coast than the mean of all sightings since 1993 ($\bar{x}$ = 4.0 km, n = 199 sightings). Derksen et al. (1981) reported that Spectacled Eiders in the NPR–A were attracted to coastal areas and Kistchinski and Flint (1974) found the highest numbers of Spectacled Eiders in the maritime area on the Indigirka delta, although they estimated that area extended inland 40–50 km from the sea. King Eiders on the Colville Delta had a similar affinity for the coast: the maximal distance a group was found from the coast between 1993 and 2000 was 14.2 km, and the mean was 5.2 km (n = 112 sightings).

In 2000, Spectacled Eiders were the numerically dominant eider species during the pre-nesting survey in the CD North study area, as they have been during 5 of the 7 years the study area was entirely surveyed. We counted 36 Spectacled Eiders (68%), 16 King Eiders (30%), and 1 unidentified eider (2%) (Table 9). We calculated the same number of "indicated" birds (i.e., the number of single and paired males × 2 + the number birds in mixed sex groups ≥ 4; USFWS 1987a) for Spectacled Eiders (36) and slightly more for King Eiders (18).

The density of Spectacled Eiders in 2000 was the second lowest on record since delta-wide surveys began in 1993 (Table 10). In 2000, the unadjusted density (i.e., raw counts of birds that were uncorrected for sightability) of flying and non-flying Spectacled Eiders in the CD North study area was 0.17 birds/km² (Table 9). Because of changes in study area boundaries over the years, that density is not strictly comparable to the densities reported for 1993–1998 (Smith et al. 1994, Johnson et al. 1999a). We recalculated these densities for the CD North study area and found densities varied from highs in 1994 and 1998 to lows in 1996 and 2000 (Table 10).

The lowest density on the delta (0.16 birds/km²) was observed in 1996, but that year's survey was affected by the relatively early departure of males from the breeding grounds (Johnson et al. 1997). In 2000, frozen lakes and ponds with ice made survey conditions difficult and, along with extensive flooding, may have discouraged Spectacled Eiders from using the delta during the survey period.

Pre-nesting Spectacled Eiders in the CD North study area occur in densities comparable to

Table 10. Numbers and densities of eiders (flying and non-flying combined) during pre-nesting in the CD North study area (206.9 km²), Colville River Delta, Alaska, 1993–1998 and 2000. Counts were made from fixed-wing aircraft in early June. Pre-2000 data from Johnson et al. (1999a).

	2000		1998		1997		1996		1995		1994		1993[a]	
Species	No.	Birds /km²	No.	Birds /km²	No.	Birds /km²	No.	Birds /km²	No.	Birds /km²	No.	Birds /km²	No.	Birds /km²
Spectacled Eider	36	0.17	57	0.28	47	0.23	33	0.16	44	0.21	69	0.33	21	0.20
King Eider	16	0.08	16	0.08	7	0.03	13	0.06	5	0.02	12	0.06	11	0.11
Common Eider	0	0	2	0.01	0	0	0	0	0	0	0	0	0	0
Unident. eider	1	<0.01	0	0	0	0	0	0	10	0.05	0	0	2	0.02
Total	53	0.26	75	0.36	54	0.26	46	0.22	59	0.29	81	0.39	34	0.33

[a] Coverage of survey area in 1993 was 50%

those recorded across the entire Arctic Coastal Plain (Figure 9). The density of Spectacled Eiders in CD North in 1998 (0.28 indicated birds/km²) was similar to the density measured on the Arctic Coastal Plain (0.31 indicated birds/km²; Larned et al. 1999), and the trends over the years surveyed are somewhat similar. The CD North study area supports a higher density of Spectacled Eiders than does the more inland CD South study area (Appendix C1), probably because of its coastal location and brackish habitats, which the CD South area lacks. One pair of Spectacled Eiders (0.01 birds/km²) was seen on the aerial survey of the CD South study area in 2000, and similarly low numbers have been recorded there in the past (Burgess et al. 2000). The CD North study area also supported higher densities of Spectacled Eiders than the Kuparuk Oilfield immediately to the east (Figure 9); however, the Kuparuk survey area was much larger (525 km²) and included areas of low density eider habitat that were far from the coast (Anderson et al. 2000).

The density of King Eiders in 2000 (0.08 birds/km²) in the CD North study area was one of the two highest densities recorded since 1993 (Table 10). The annual trend has varied since 1993, but the fluctuation in actual numbers is relatively small. Most of the King Eiders using the

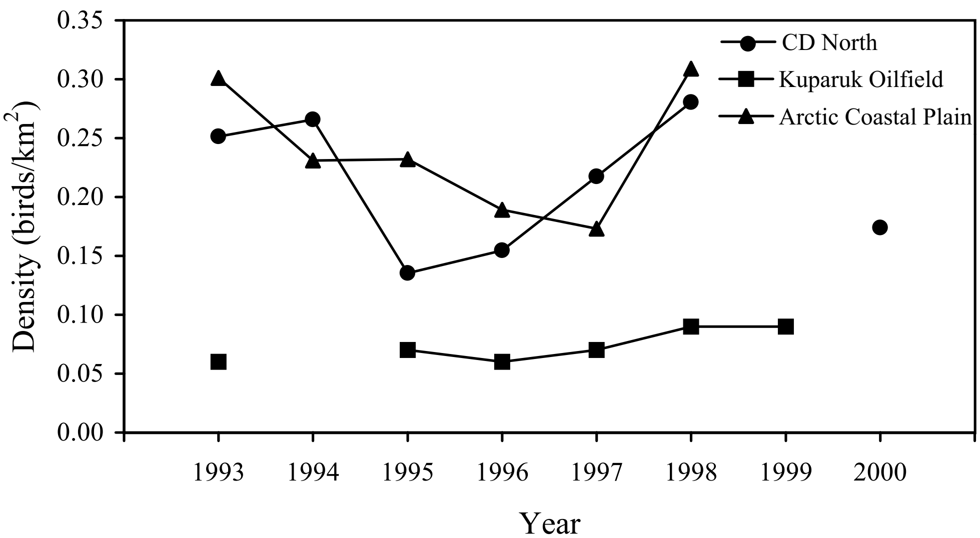


Figure 9. Trend in density of Spectacled Eiders (indicated birds; USFWS 1987a) counted on aerial surveys during pre-nesting in the CD North study area, the Kuparuk Oilfield, and the Arctic Coastal Plain, Alaska, 1993–2000. Data are from Anderson et al. (1999), Larned et al. (1999), and this study.

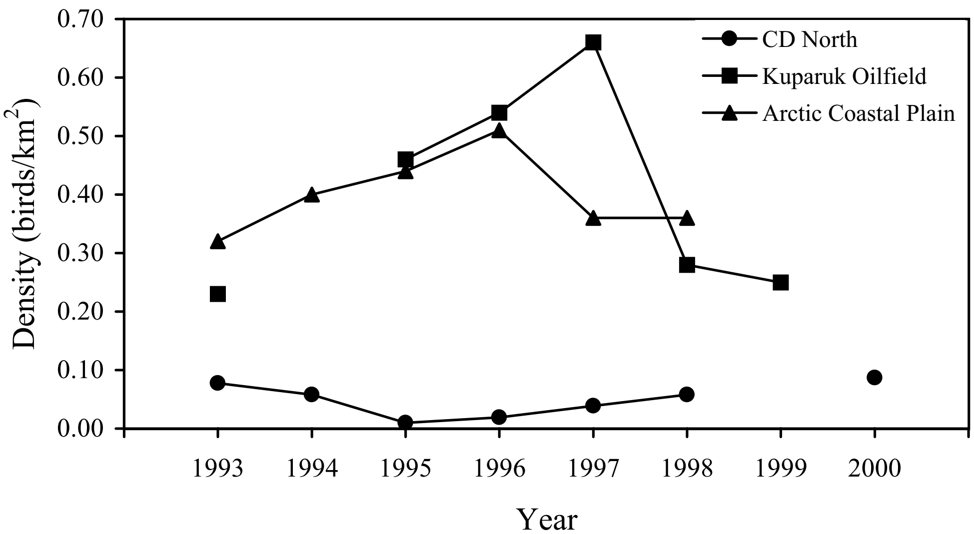


Figure 10. Trend in density of King Eiders (indicated birds, USFWS 1987a) counted on aerial surveys during pre-nesting in the CD North study area, the Kuparuk Oilfield, and the Arctic Coastal Plain, Alaska, 1993–2000. Data are from Anderson et al. (1999), Larned et al. (1999), and this study.

delta during pre-nesting occur in the large river channels on the delta's east side (Johnson et al. 1999a), outside the CD North study area boundaries (Appendix C2). The CD North study area supports less than one fourth of the density of King Eiders that occur in the adjacent Kuparuk Oilfield and the entire Arctic Coastal Plain (Figure 10). Only the CD South study area upstream on the delta from CD North supported lower densities of King Eiders; in 2000, three pairs of King Eiders (0.04 birds/km²) were sighted in the CD South study area (Burgess et al. 2000).

Nesting

The coastal portion of the delta, where eiders concentrate during pre-nesting (Figure 8, Appendices C1 and C2), also is where Spectacled Eiders nest most commonly. We have not found any documented nest locations that were farther than 13 km from the coast (Appendices C3 and C4), although we must note that coverage on the delta during nest searching has never been complete. The mean distances from the coast of all eider nests on the delta for which we have records are 3.6 km (n = 49) for Spectacled Eider, 3.9 km (n = 6) for King Eider, 1.4 km (n = 1) for Common Eider, and 2.4 km (n = 3) for unidentified eider.

In the CD North ground-search area (12.2 km²) during 2000, we located 14 Spectacled Eider nests (including one that was identified by color patterns on contour feathers in the nest; Anderson and Cooper 1994) for a density of 1.2 nests/km², and 2 King Eider nests for a density of 0.16 nests/km² (Figure 11). Average clutch size was 4 eggs (n = 7 nests) for Spectacled Eider nests and unknown for King Eider nests; clutch sizes were counted only for those nests where the hens were flushed unintentionally. Spectacled Eiders flushed 4–20 m from searchers and the average flushing distance was 13 m (n = 7). Six of 14 (43%) Spectacled Eider nests hatched successfully, and both King Eider nests were successful. Of the eight Spectacled Eider nests that failed to hatch, one had failed before it was found, and three had their hens flushed during our nest search. It is not clear whether nests flushed during our search were more prone to failure; of six successful Spectacled Eider nests, four (67%) were flushed, and of eight failed nests, three (38%) were flushed.

In 4 previous years—1992, 1993, 1994, and 1997—we searched portions of the CD North ground-search area for eider nests (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1998). Ten Spectacled Eider nests (one was identified by

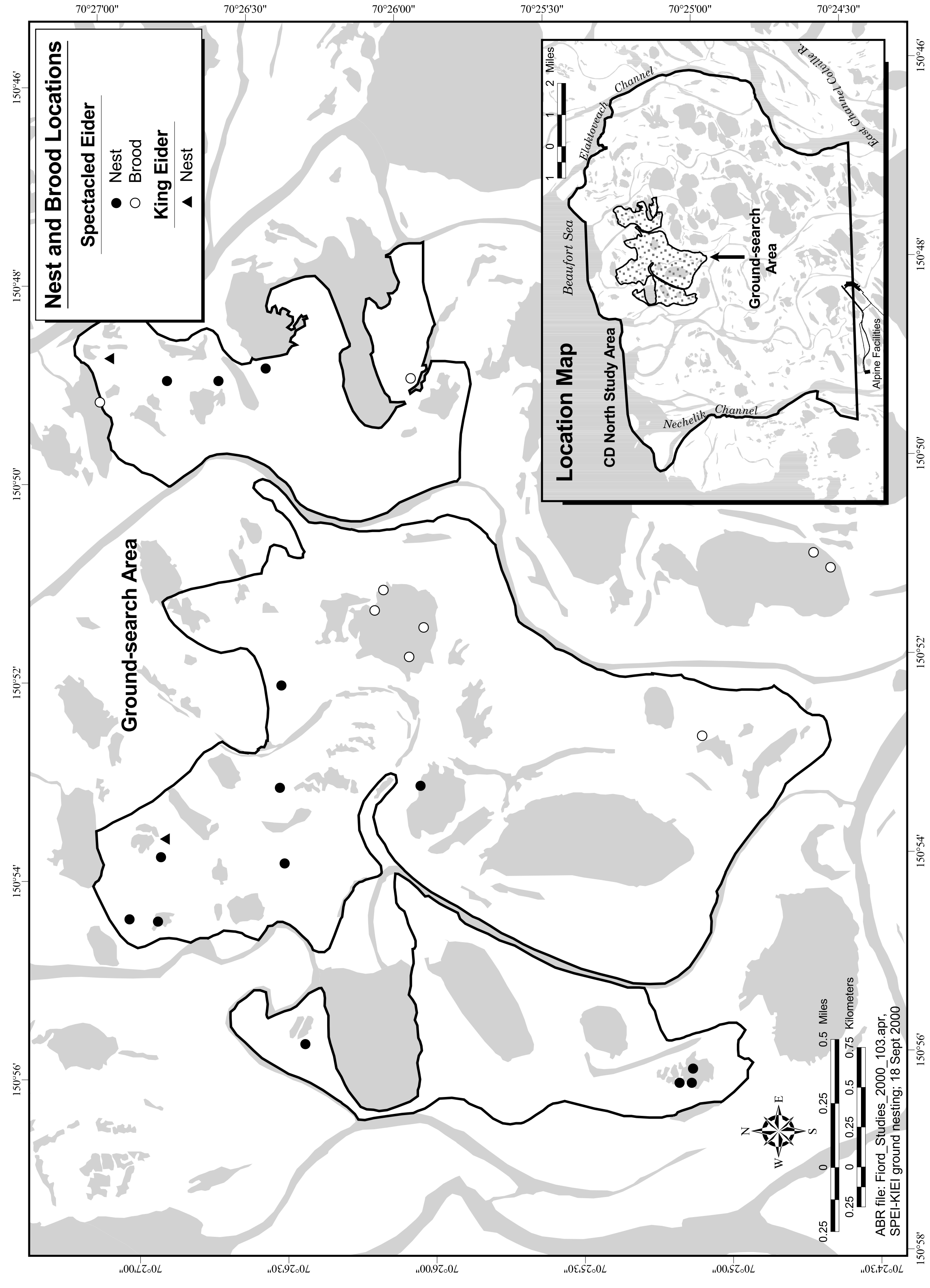


Figure 11. Distribution of Spectacled and King eider nests and broods located during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000.

contour feathers in the nest) and 1 King Eider nest were found in locations similar to nests found in 2000 (Appendices C3 and C4). During nest searches in various portions of the delta from 1992 to 2000, we have found 45 Spectacled Eider nests, 6 King Eider nests, 1 Common Eider nest, and 3 nests that were not identified to species. Eleven Spectacled Eider nests were recorded on the Colville Delta during bird studies conducted from 1981 to 1987 (Renken et al. 1983, Rothe et al. 1983, North et al. 1984, Nickles et al. 1987, Gerhardt et al. 1988); however, we were able to obtain the locations of only four of these nests (M. North, unpubl. data). The earliest records we have found for nests are of two Spectacled Eider nests on the outer delta in 1958 and four in 1959 (T. Myres, unpubl. data). Four of the nests found in 1993 and 1994 were on the same lakes as the nests from these earliest records (near the Nechelik Channel, Appendix C3). By comparison, we have searched the vicinity of the Alpine project area (10.6–17.2 km²) in 6 consecutive years (1995–2000), and have found only two Spectacled Eider nests (one in 1998 and one in 1999) and one probable King Eider nest (in 1996; identification based on contour feathers in the nest)(Johnson et al. in prep.). These nests near Alpine were 9.7–9.9 km from the coast. Another Spectacled Eider nest 9.6 km from the coast was found in the CD South ground-search area (5.8 km²) during 2000 (Burgess et al. 2000). The low densities of nests in the Alpine and CD South areas contrast sharply with the concentration of Spectacled Eider nests in the CD North ground-search area and are indicative of the quality of eider nesting habitat available in the coastal areas of the delta.

We have found few nests of other eider species on the delta, possibly because we focused our nest searches before 1996 on Spectacled Eiders. More probable, however, is that the delta does not support much nesting by other eider species. Similar search techniques were used in the Kuparuk Oilfield, and 53% of the 178 nests found in 6 years belonged to King Eiders (Anderson et al. 1999). In 9 years of nest searching on the delta, only 10 of 55 nests (18%) belonged to species other than Spectacled Eiders: 1 Common Eider nest, 6 King Eider nests (2 identified by contour feathers), and 3 nests of unidentified eiders.

Brood-rearing

The distribution of eider broods seen on the delta opportunistically and during eider surveys was similar to the distribution of eiders during pre-nesting and nesting surveys (Appendices C1, C3, C5); no broods were observed >13 km from the coast. In 2000, we recorded nine Spectacled Eider broods on 25–27 August (during loon brood surveys) containing a mean of 3.4 young/brood (Figure 11). Two of these broods were located just outside the ground-search area. For the entire delta we have records of 25 Spectacled Eider broods and 2 King Eider broods (Appendix C5). From 1996 to 1998, we saw no broods of Spectacled or King eiders during helicopter or foot surveys of the Alpine project area; during those years, no other areas were searched specifically for eider broods on the delta. One brood of unidentified eiders was seen at the southern end of the CD North study area during an aerial survey for loon broods in 1997 (Appendix C5). In 1995, only one Spectacled Eider brood and one King Eider brood were seen during a systematic helicopter survey of the entire delta. 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 their detection. During ground searches for broods in 1993, 11 Spectacled Eider broods with 3.8 young/brood (42 young total) were found (Smith et al. 1994). One brood with 3 young occurred in the Alpine project area, and the remaining 10 broods all occurred on the coastal portion of the delta.

HABITAT USE

Pre-nesting

During the pre-nesting season in 2000, Spectacled Eiders were found in 9 of the 21 habitats available (Tables 3 and 11). Groups of Spectacled Eiders seen during the aerial survey were recorded most often in Aquatic Sedge with Deep Polygons (33% of all sightings), Wet Sedge–Willow Meadow (22%), and Deep Open Water without Islands (11%). One of these habitats—Aquatic Sedge with Deep Polygons—was significantly preferred (i.e., habitat use was greater than availability) according to the analysis of 7 years of sightings for the entire delta (Appendix D1). Deep Open Water without Islands was used in proportion to its availability (i.e.,

Table 11. Habitat use by Spectacled Eiders and King Eiders during pre-nesting on the CD North study area, Colville River Delta, Alaska, 2000.

Species/Habitat	No. of Groups	No. of Adults	Use (%)
SPECTACLED EIDER			
Brackish Water	1	2	5.6
Tapped Lake w/ Low-water Connection	1	2	5.6
Salt Marsh	1	2	5.6
Salt-killed Tundra	1	2	5.6
Deep Open Water w/out Islands	2	2	11.1
Shallow Open Water w/out Islands	1	2	5.6
River or Stream	1	2	5.6
Aquatic Sedge w/ Deep Polygons	6	10	33.3
Wet Sedge–Willow Meadow	4	6	22.2
Total	18	30	100
KING EIDER			
Brackish Water	2	3	25.0
Salt Marsh	1	2	12.5
Salt-killed Tundra	2	3	25.0
Deep Open Water w/ Islands or Polygonized Margins	1	2	12.5
River or Stream	1	2	12.5
Aquatic Sedge w/ Deep Polygons	1	2	12.5
Total	8	14	100

selection for or against this habitat was not significant). Wet Sedge–Willow Meadow was avoided (i.e., use was significantly lower than availability) on the entire delta despite 10% of the Spectacled Eider sightings occurring there, because its availability (19% of the delta area) was so large. Wet Sedge–Willow Meadow is clearly a well-used habitat, but it is not a habitat that is likely to be limiting. Two other habitats preferred on the entire delta, Brackish Water and Salt Marsh, were also used in the CD North study area.

Elsewhere, studies have emphasized the importance of emergent vegetation for eiders using waterbodies. West of the Colville Delta in the NPR–A, Spectacled Eiders were found in shallow *Arctophila* ponds and deep open lakes in June, with shallow *Carex* ponds becoming more important through the summer (Derksen et al. 1981). East of the Colville River in the Kuparuk Oilfield, most of the pre-nesting Spectacled Eiders were found in basin wetland complexes, aquatic grass (*Arctophila*), and aquatic sedge (*Carex*) habitats (Anderson et al. 2000). Bergman et al. (1977) found most Spectacled Eiders at Storkersen Point in deep *Arctophila* wetlands. In Prudhoe Bay, pre-nesting Spectacled Eiders used flooded terrestrial habitats, but preferred ponds with emergent vegetation (both *Arctophila* and *Carex*) and impoundments (Warnock and Troy 1992). Lakes with emergents are not abundant on the Colville Delta; however, Aquatic Sedge with Deep Polygons and Aquatic Grass Marsh are probably analogous to the *Carex* and *Arctophila* ponds described elsewhere. Of these two habitats, only Aquatic Sedge with Deep Polygons occupies a significant proportion of the CD North study area (4% of the total area), and it was the most frequently used habitat (Table 11).

King Eiders used a set of habitats similar to those used by Spectacled Eiders during the 2000 pre-nesting period in the CD North study area. The greatest number of sightings of King Eiders occurred in Brackish Water (2 groups, 25% of the total) and Salt-killed Tundra (2 groups) (Table 11). Salt Marsh, Deep Open Water with Islands and Polygonized Margins, River or Stream, and Aquatic Sedge with Deep Polygons all were used by one group each. Brackish Water and River or

Table 12. Habitat use by Spectacled Eiders and King Eiders during nesting in the CD North ground-search area, Colville River Delta, Alaska, 2000

Species/Habitat	No. of Nests	Use (%)
SPECTACLED EIDER		
Brackish Water	1	7.1
Salt-killed Tundra	8	57.1
Deep Open Water w/ Islands or Polygonized Margins	3	21.4
Aquatic Sedge w/ Deep Polygons	2	14.3
Total	14	100
KING EIDER		
Salt-killed Tundra	1	50.0
Aquatic Sedge w/ Deep Polygons	1	50.0
Total	2	100

Stream were the only habitats preferred by pre-nesting King Eiders on the delta over 7 years of surveys; the remaining habitats used by King Eiders in the CD North study area were used in proportion to their availability on the entire delta (Appendix D1). The preference for River or Stream, low use of typical nesting habitat (i.e., lakes and wet meadows), and the prevalence of flocks rather than pairs on the entire delta suggests that most King Eiders had not yet dispersed into breeding areas during the pre-nesting surveys (Johnson et al. 1999a). Furthermore, the low number of nests found later on nest searches indicates that the Colville 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).

Nesting

We conducted nesting surveys on the ground because of the difficulty in finding eider nests during aerial surveys. Consequently, complete surveys of extensive habitats on the Colville Delta were not feasible. We chose to search areas that either maximized our chances of finding nests (1993, 1994, and 1997) or that included proposed development sites (1995–2000). Thus, we have not searched a representative sample of habitats from which selection can be calculated; instead, we used the nesting data to summarize habitat associations.

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, most nests (8 or 57% of all nests) were found in Salt-killed Tundra. The remaining habitats contained one to three nests each. Two of the four habitats used during nesting in 2000—Brackish Water and Aquatic Sedge with Deep Polygons—were preferred habitats during pre-nesting (Appendix D1). In 9 years of nest searching in various locations on the delta, 45 nests of Spectacled Eiders have been found in 9 habitats; in 2 of those years, no nests were found (Appendix D2). The highest number of nests occupied Salt-killed Tundra (12 nests), Aquatic Sedge with Deep Polygons (9 nests), Brackish Water (6 nests on islands), and Nonpatterned Wet Meadow (7 nests). All three habitats preferred during pre-nesting were used for nesting on the delta. The results of pre-nesting and nesting habitat analyses emphasize the importance to breeding Spectacled Eiders of habitats that are more prevalent on the outer delta: Brackish Water, Salt-killed Tundra, Salt Marsh, and Aquatic Sedge with Deep Polygons.

Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 2.9 m (range = 0.1–80 m, *n* = 45) from permanent water (Smith et al. 1994, Johnson et al. 1998, Burgess et al. 2000, this study). Brackish Water was the nearest waterbody to 47% of the nests, and Deep Open Water with Islands or Polygonized Margins was the nearest to 27% 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 7 years, and the waterbodies closest to nests were primarily basin wetland complexes, shallow and deep open lakes, and water with emergents (both *Carex* and *Arctophila*) (Anderson et al. 1999). Spectacled Eiders at Storkersen Point preferred the same habitat (deep *Arctophila*) for nesting as they did during pre-nesting (Bergman et al. 1977). In the NPR–A, Spectacled Eiders used shallow *Carex* ponds during summer (Derksen et al. 1981). In the Kuparuk Oilfield, the most common nesting habitats were basin wetland complexes, aquatic grass with islands, low-relief wet meadows, and nonpatterned wet meadows (Anderson et al. 1999). In Prudhoe Bay, nests were found in *Carex* ponds and wet, nonpatterned tundra (Warnock and Troy 1992). Waterbodies with emergent vegetation (e.g., Aquatic Grass Marsh and Aquatic Sedge Marsh) are scarce in the CD North study area and on the Colville Delta, with the exception of Aquatic Sedge with Deep Polygons (Table 3); therefore, nesting habitat on the delta differs somewhat from areas with abundant *Carex* and *Arctophila* waterbodies.

Two King Eider nests were found in 2000, and they occurred in Salt-killed Tundra and Aquatic Sedge with Deep Polygons (Table 12). We have found only four other King Eider nests (two were identified by contour feathers) during 9 years of nest searches on the delta. Two of these nests were in Aquatic Sedge with Deep Polygons, and the other two nests were in Salt-killed Tundra and Wet Sedge–Willow Meadow. The distance of nests from permanent water was greater ($\bar{x}$ = 14 m, *n* = 6, range = 0.2–80 m) than that for Spectacled Eider nests. The nearest waterbodies were both types of Tapped Lakes, Brackish Water, Deep Open Water without Islands, and Shallow Open Water without Islands. Anderson et al. (1999) found King Eiders in the Kuparuk Oilfield nesting near basin wetland complexes, aquatic grass, shallow open water, and aquatic sedge. At Storkersen Point, nesting King Eiders preferred shallow and deep *Arctophila* and coastal wetlands (Bergman et al. 1977). Farther east, in Prudhoe Bay, King Eiders used a wider array of non-aquatic habitats than did Spectacled Eiders and preferred moist, wet low-centered polygons and wet strangmoor (Warnock and Troy 1992).

Brood-rearing

We saw nine Spectacled Eider brood-rearing groups while conducting loon surveys in the CD North study area. Six groups (66% of all groups) were using the two types of Deep Open Water, and one group each was using Tapped Lake with Low-water Connection, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow (Table 13). We conducted aerial surveys for eider broods only during 1995, so the majority of sightings have been opportunistic. Only 20 Spectacled Eider brood-rearing groups have been seen since 1992 (Appendix D3). Most groups were found in Salt-killed Tundra (20% of all locations), Deep Open Water with Islands or Polygonized Margins (20%), Deep Open Water without Islands (15%), Brackish Water (15%), and Wet Sedge–Willow Meadow (15%). Brood-rearing groups appear to be attracted to coastal lakes; most groups (35%) were seen nearest to Brackish Water ($\bar{x}$ = 0.03 km, *n* = 7), and the mean distance to the coast was 3.3 km (*n* = 20). In the NPR–A, Spectacled Eider broods primarily used shallow *Carex* ponds, deep open lakes, and deep *Arctophila* (Derksen et al. 1981). Post-nesting adults without broods at Storkersen Point also preferred deep *Arctophila* (Bergman et al. 1977).

Only two King Eider broods have been seen on the delta since studies began in 1992. One King Eider brood was seen in 1995 in Aquatic Sedge with Deep Polygons approximately 0.02 km from Brackish Water (Appendix D3). The other King Eider brood was found in 1992 in Wet Sedge–Willow Meadow approximately 0.07 km from Deep Open Water without Islands.

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

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

TUNDRA SWANS

BACKGROUND

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

Table 14. Numbers of Tundra Swans and swan nests recorded on aerial surveys during nesting in the CD North study area, Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).

	Birds		Nests	
Year	No.	Percent Nesting	No.	Density (no./km^2)
2000	96	27	16	0.08
1998	292	8	14	0.07
1997	264	9	15	0.07
1996	146	21	19	0.09
1995	74	51	21	0.10
1993	92	22	14	0.07
1992	63	21	9	0.04

DISTRIBUTION AND ABUNDANCE

Nesting

In 2000, we counted 16 Tundra Swan nests during standardized aerial surveys in the CD North study area, exactly half the number counted on the entire delta (Figure 12, Table 14, Appendix D4). Two additional nests not recorded during the aerial survey were found during ground searches within the CD North study area. More nests were located in the CD North study area during aerial surveys in 1995 and 1996, reflecting increased nesting that was observed in these 2 years in the area from the Kuparuk River to the Colville Delta, which likely were region-wide events (Anderson et al 1996, Johnson et al 1997). In 2000, nest density in the CD North study area (0.08 nests/km²) calculated from the aerial survey was within the range of values we have observed over the previous 6 years of surveys (0.04–0.10 nests/km²). Swan nest densities on the entire Colville Delta were slightly lower (0.03–0.8 nests/km²) than in the CD North study area (Appendix D4, Appendix C6). Of the swans nesting on the delta, 42–70% were located within the CD North study area.

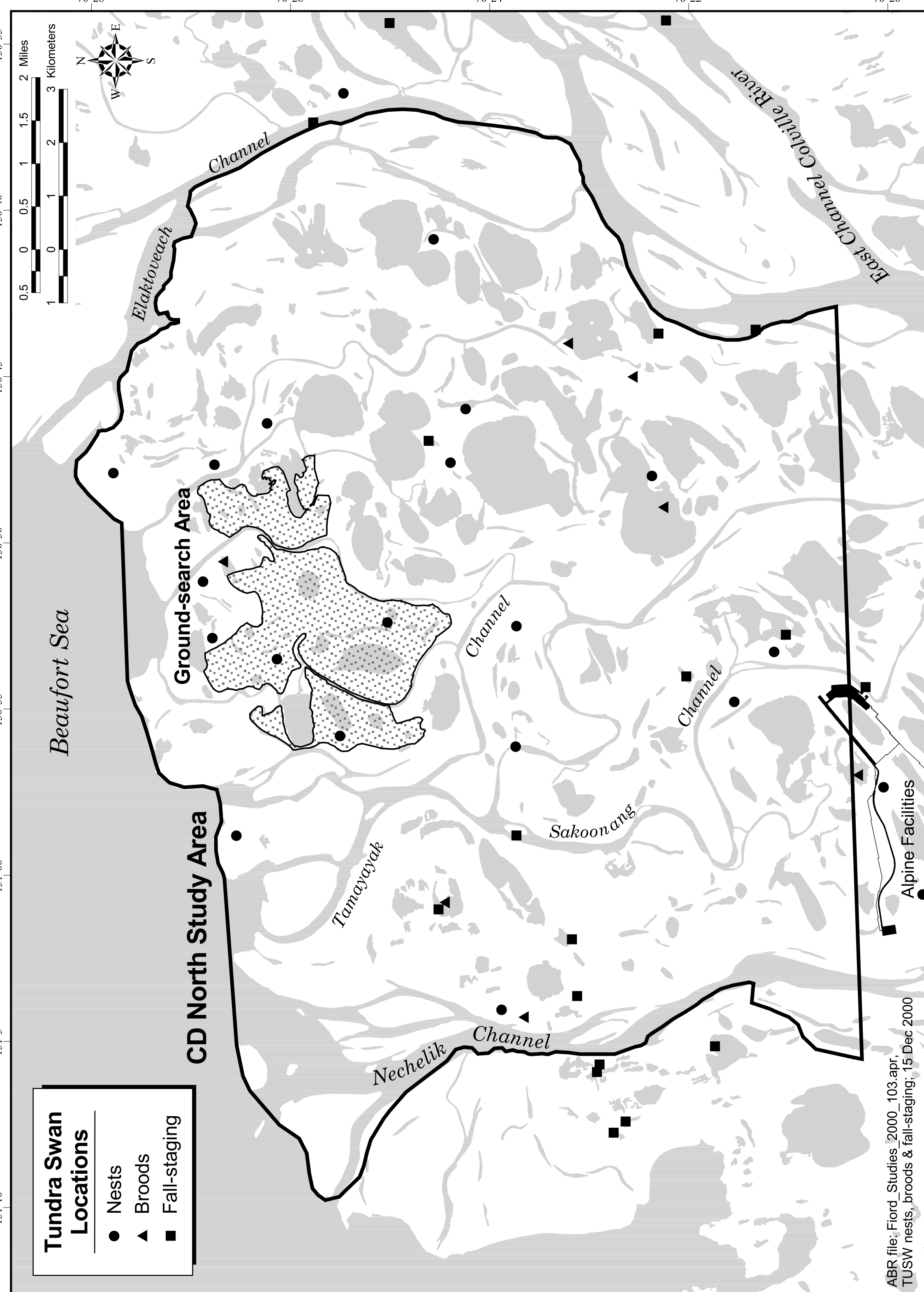


Figure 12. Distribution of Tundra Swan nests, broods, and fall-staging groups recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000.

Table 15. Numbers of Tundra Swans and broods recorded during brood-rearing and fall staging on aerial surveys in the CD North study area, Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).

	Brood-rearing								Fall Staging
Year	Adults	Young	Total Birds	Percent with Broods	Percent Young	Mean Brood Size	No. of Broods	Brood Density (no./km^2)	Total Birds
2000	202	11	213	6	5	1.8	6	0.03	21
1998	213	24	237	9	10	2.4	10	0.05	19
1997	164	32	196	15	16	2.7	12	0.06	10
1996	133	49	182	21	27	3.5	14	0.07	19
1995	87	41	128	28	32	3.4	12	0.06	40
1993	111	16	127	7	13	3.2	5	0.02	35
1992	99	17	116	15	15	2.1	8	0.04	no data

Higher densities of nests have been found on the delta during intensive ground searches. In 1982, 48 nests (~0.11 nests/km²) were found on the northern 80% of the delta (Simpson et al. 1982). Nest densities recorded during aerial surveys of other areas on the coastal plain were similar to those for the Colville Delta: 0.04–0.06 nests/km² on the eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km² in the Kuparuk Oilfield and adjacent areas (Anderson et al. 1999).

Brood-rearing

Six swan broods were counted in the CD North study area in mid-August 2000 (Figure 12). The distribution of broods across the entire delta has been relatively uniform during the years surveyed (Appendix C7). Nest success in the CD North study area, estimated by dividing numbers of broods by the number of nests, was only 38% in 2000 (Tables 14 and 15). Nest success rates estimated for the previous 6 survey years were 36–89% (Appendix D4). The density of broods for the study area in 2000 was 0.03 broods/km², which was low relative to densities from past years (Table 15). The estimated nest success for the entire delta in 2000 was 66% (21 of 32 nests), and the density of broods was 0.04 broods/km² (Appendix D4). Mean brood size for the CD North study area was 1.8 young/brood (n = 6), which was similar to the mean brood size for the entire delta (2.0 young/brood, n = 21). Brood size in 2000 was the lowest we have recorded on the Colville Delta in 7 years of surveys (Appendix D4). Low nest success (63%) and small brood sizes ($\bar{x}$ = 2.0 young/brood, n = 52) also were recorded in the Kuparuk Oilfield and vicinity during 2000 and were some of the lowest estimates on record there since 1988 (Anderson et al. in prep.). The low nest success and small brood sizes over a broad area from the Colville Delta to the Kuparuk River are indicative of a regional cause for poor nesting; we suspect the cool temperatures and late snow melt during May and June (see CONDITIONS IN THE STUDY AREA) delayed nest initiation and depressed swan productivity. In 1981, Rothe et al. (1983), using intensive ground surveys, measured 91% nest success (n = 32 nests) and 2.1 young/brood on the Colville Delta. In 1982, nest success was 71% (n = 48 nests), and mean brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). In a 3-year study (1988–1990) of swans nesting on the Canning and Kongakut river deltas, the overall nest success was 76% (n = 110 nests) (Monda et al. 1994).

Productivity (as indicated by nest success, brood density, and brood size) on the delta during the 7 years that we conducted aerial surveys was similar to or greater than values reported in other studies of swans on the Arctic Coastal Plain. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995–2000) recorded mean brood sizes of 2.0–2.8 young/brood and densities of 0.02–0.04 broods/km² (Anderson et al. in prep.).

Platte and Brackney (1987) estimated 63–85% nest success, 0.04 broods/km², and 2.5 young/brood on portions of the Arctic National Wildlife Refuge (ANWR) during 1982–1985.

Fall Staging

In 2000, we flew a fall-staging survey on 16 September that covered the Colville River delta and the documented staging areas adjacent to the delta (Seaman et al. 1981, Johnson et al. 1999a). Of the 106 swans counted, the largest flock encountered was 8 individuals; the majority of the swans (84) were pairs, singles, or individual family groups. On the CD North study area, we counted 21 swans (Table 15). We suspect the small number and size of flocks was the result of young swans being unable to fly to sites where pre-migratory aggregations form; the late spring and resulting late hatch of swan nests probably delayed their development.

During swan staging surveys, most swans generally occur in several large flocks that occupy river channels on the outer delta. Wetlands immediately east of the delta, lying between the Miluveach River and Kalubik Creek, have had the largest aggregations of Tundra Swans on the Arctic Coastal Plain of Alaska during fall staging (Seaman et al. 1981), and we have observed large numbers there as well (Appendix C8). In 1996, we counted 355 swans on the delta (Appendix D6) and 415 on several lakes just east of the delta. In 1997, 286 swans were recorded, and in 1998, 411 swans were recorded, primarily in the East Channel of the Colville Delta (e.g., near the mouth of the Miluveach River). We expanded our fall-staging survey area in 1998, flying over the wetlands at the mouths of the Tingmeachsiovik River and Fish Creek, west of the mouth of the Nechelik Channel, where we counted 229 swans, most within a single group. We had not surveyed this area during previous years, so we do not know whether it is used regularly during fall staging. On 16 September 2000, we flew over the same area but found few swans (17) there.

Swans beginning fall migration appear to have varying departure times from the delta. On 19 September 1995, we counted only 64 swans (Appendix D6), most of which were in discrete family groups, distributed throughout the delta. Three days of subzero temperatures two weeks earlier had caused lakes to freeze (J. Helmericks, Golden Plover, Prudhoe Bay, AK, pers. comm.) and may have induced most swans to leave. Similarly, in 1992, subzero temperatures after 8 September caused an early freeze, and swans vacated the delta by the time of our fall-staging survey (17 September; Smith et al. 1993). In contrast, temperatures in 1993 remained above freezing until after a staging survey on 15 September when we saw 295 swans. In 1996, we also saw large numbers of swans (355) on the staging survey, but because the survey was conducted on 6 September before the first freezing temperatures of the month, we have no data on when the swans departed. These few observations suggest that the departure of most swans from the delta can be triggered before the middle of September by cold temperatures and freeze-up of waterbodies, but large numbers of swans can remain on the delta later when temperatures remain above freezing. Surveys in 4 of the 6 years considered here documented large numbers of swans staging on or near the Colville Delta prior to migration (Johnson et al. 1999a), an event also reported by Campbell et al. (1988).

HABITAT USE

Nesting

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. In the CD North study area, we found 16 nests in 8 habitat types (Table 16). Nine nests were found in preferred habitats based on the delta-wide multi-year analysis: Salt-killed Tundra, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow (Appendix D5). Wet Sedge–Willow Meadow was used by the largest percentage of the swans nesting in the CD North study area (25%), and was the most available habitat (20%) (Table 3). The habitats used by swans nesting in the CD North study area were similar to those used on the entire delta over all years surveyed (Appendix D5). During 7 years of surveys on the delta, swan nests (n = 212) were located in 16 of 24 available habitats. Five habitat types were preferred, and eight were avoided.

Tundra Swans breeding on the Canning and Kongakut river deltas in northeastern Alaska selected marsh habitats and nested near large lakes

Table 16. Habitat use by nesting and brood-rearing Tundra Swans in the CD North study area, Colville River Delta, Alaska, 2000.

Habitat Type	Nests No.	Nests Use (%)	Broods No.	Broods Use (%)
Brackish Water	0	0	1	16.7
Tapped Lake w/ Low-water Connection	0	0	1	16.7
Salt Marsh	2	12.5	1	16.7
Tidal Flat	1	6.3	0	0
Deep Open Water w/out Islands	0	0	1	16.7
Salt-killed Tundra	3	18.8	0	0
River or Stream	0	0	0	0
Aquatic Sedge w/ Deep Polygons	2	12.5	0	0
Wet Sedge–Willow Meadow	4	25.0	2	33.3
Moist Tussock Tundra	1	6.3	0	0
Riverine or Upland Shrub	2	12.5	0	0
Barrens (riverine, eolian, lacustrine)	1	6.3	0	0
Total	16	100	6	100

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

Brood-rearing

In the CD North study area, four of the six broods were observed in habitats that were preferred—Brackish Water, Salt Marsh, Tapped Lake with Low-water Connection, and Deep Open Water without Islands—based on a selection analysis of 7 years of surveys on the entire delta (Table 16; Appendix D5). Tundra Swans with broods used 18 of 24 available habitats (Appendix D5). Five habitats were preferred and four were avoided. Wet Sedge–Willow Meadow was used by the highest percentage of broods in both the CD North study area and on the delta, but was used in proportion to its availability (Appendix D5).

The preference for salt-affected habitats (Brackish Water, Salt Marsh, and Tapped Lake with Low-water Connection) by brood-rearing swans may reflect a seasonal change in distribution or habitat preference, in that 36% of all swan broods on the delta were in salt-affected habitats, compared with only 19% of all nests (Appendix D5). Swan broods in northeast Alaska used different habitats as the brood-rearing season progressed (Monda et al. 1994). Early in the brood-rearing season on the Kongakut River delta, grazing in saline graminoid marsh and aquatic-marsh habitats predominated. Later in the season, surface and sub-surface foraging concentrated more in aquatic-marsh habitat. Changes in habitat and foraging methods may be related to nutritive quality of different plants or the increasing ability of older, larger cygnets to feed on submerged vegetation (e.g., pondweed [*Potamogeton* spp.]) in deeper water. Spindler and Hall (1991) found swans feeding on various species of submergent pondweed in late August and September in brackish water on river deltas of the Kobuk-Selawik Lowlands. On the Colville Delta, swans are also reported to favor pondweed during the brood-rearing and molting periods (Johnson and Herter 1989). Wilk (1988) described spring-staging swans feeding on abundant pondweed in tidally influenced habitat in the Naknek River. Monda et al. (1994) also found that pondweed was an important component of the diet of swans of the Kongakut and Canning river deltas; pondweed, along with another important food,

Table 17. Numbers and densities of loons and their nests and broods counted on aerial surveys in the CD North study area, Colville River Delta, Alaska, 1993, 1995–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).

		Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
		Number			Density (no./km^2)		Number			Number		
Area	Year	Adults	Nests/ Broods	Young	Birds	Nests/ Broods	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
Nesting (207 km^2)												
	2000	32	9 (9)[b]		0.15	0.04 (0.04)	67	10		9	0	
	1998	17	7 (11)[b]		0.08	0.03 (0.05)	47	9		3	0	
	1997	30	7 (10)[b]		0.15	0.03 (0.05)	59	20		2	1	
	1996	22	5 (7)[b]		0.11	0.02 (0.03)	41	18		5	2	
	1995	21	6		0.10	0.03	20	3		4	0	
	1993	34	8		0.16	0.04	69	20		34	0	
Brood-rearing (207 km^2)												
	2000	8	0	0	0.04	0	41	2	2	3	2	2
	1998	39	7	8	0.19	0.03	85	13	15	5	3	3
	1997	38	3	4	0.18	0.01	103	12	13	15	4	4
	1996	42	5	5	0.20	0.02	61	12	13	11	0	0
	1995	31	6	6	0.15	0.03	83	21	26	30	5	5
	1993	20	5	5	0.10	0.02	25	1	1	0	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and survey intensity varied among years.

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

alkali grass (*Puccinellia phryganodes*), grows well in salt-affected environments. Although we did not collect data on the feeding habits of swans, the use of salt-affected and aquatic marsh habitats by broods and fall-staging flocks on the Colville Delta suggests that some of the same plants are being sought there.

LOONS

BACKGROUND

On the Arctic Coastal Plain of Alaska, Yellow-billed Loons nest primarily between the Colville and Meade rivers, with the highest densities found south of Smith Bay (Brackney and King 1992). The Colville Delta also is an important nesting area for Yellow-billed Loons (North and Ryan 1988). Yellow-billed Loons arrive on the delta just after the first spring meltwater accumulates on the river channels, usually during the last week of May (Rothe et al. 1983), and use openings in rivers, tapped lakes, and in the sea ice before nesting lakes are available in early June (North and Ryan 1988). Nest initiation begins the second week of June, hatching occurs in mid-July, and broods usually are raised in the nesting lake (Rothe et al. 1983); however, broods occasionally move to different lakes (North 1986).

DISTRIBUTION AND ABUNDANCE

Nesting

In 2000, we counted 32 Yellow-billed Loons and 9 nests in the CD North study area during the aerial survey. The number of loons was similar to counts made in 1993 and 1997, and greater than the numbers recorded in 1995, 1996, and 1998 (Table 17). Densities of Yellow-billed loons ranged from 0.08 to 0.16 birds/km^2 during our 6 years of study. Densities similar to that found in 2000 (0.15 birds/km^2) have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska: Square Lake in the NPR–A (0.14 birds/km^2; Derkson et al. 1981) and the Alaktak region south of Smith Bay (0.16 birds/km^2; McIntyre 1990). The distribution of Yellow-billed Loons in the CD North study area in 2000 was similar to that recorded on aerial surveys in 1993 and 1995–1998 (Smith et al. 1994;

Johnson et al. 1999a), and during ground studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

In 1996–1998 and 2000, we revisited lakes where we had seen Yellow-billed Loon pairs but did not find nests during the initial aerial survey. During these second visits in 1996–1998, we found an additional two to four nests in the CD North study area that either had been missed or were initiated after the first survey. In 2000, we found no additional nests during revisit surveys or during ground searches within the CD North ground-search area. Our count of nine nests in 2000 was within the range of nests (6–11) we have recorded in the previous 5 years of surveys (Table 17). During intensive ground surveys of the delta in 1983 and 1984, North (1986) found 11 and 13 nests, respectively, in the CD North study area. All nine nests found in 2000 were on lakes where we have recorded nesting by Yellow-billed Loons in previous years (Figure 13, Appendix C9). Two of the nine nests were within the CD North ground-search area; nesting also occurred within this area in 1995–1998. With the additional nests found in some years during revisit surveys, densities in the CD North study area ranged from 0.03–0.05 nests/km² in our 6 years of surveys.

Our aerial surveys for loons focused on Yellow-billed Loons, which tend to nest on large lakes (>10 ha). Consequently, the survey route flown did not provide complete coverage of smaller waterbodies, which are frequented by Pacific and Red-throated loons. Opportunistic counts of Pacific and Red-throated loons reflect their general distribution in the CD North study area but are not indicative of the relative abundance of these species (due to biases in species detectability) or annual changes in abundance (because of annual variation in survey intensity) (Figure 14, Appendix C10). Therefore, we have not calculated densities for these two species. Although our counts are not adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon in the CD North study area during each year of study (Table 17). 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 in 1981 were 1.5 birds/km² for Pacific Loons and 0.6 birds/km² for Red-throated Loon (Rothe et al. 1983).

Within the CD North ground-search area, we found nine Pacific and six Red-throated loon nests in 2000 during a ground search (Figure 5, Table 5). We assumed from the number and location of Red-throated Loon broods found during the brood search that three additional Red-throated Loon nests were in the area, but not found initially (Figure 7). Densities of birds (based on the number of nesting birds) and nests in the ground-search area was the same for each species: 1.5 birds/km² and 0.73 nests/km², respectively. Nest success was 44% for Pacific Loons and 78% for Red-throated Loons.

Brood-rearing

Production of Yellow-billed Loons was poor in 2000. We counted eight adult Yellow-billed Loons and saw no broods during the brood-rearing aerial survey in the CD North study area. In each of our previous 5 years of surveys, we counted ≥20 loons and ≥3 broods in the same area (Table 17, Appendix C11). However, three loon broods were seen during 2000 in the CD South area and one was seen near Nuiqsut (Burgess et al. 2000). The density of Yellow-billed Loons during brood-rearing in 2000 was 0.04 birds/km². In comparison, densities ranged from 0.10 to 0.20 birds/km² in 1993 and 1995–1998. In 2000, survey conditions were fair on the day of the brood survey, which may have reduced our detection rate; however, we circled some nest lakes twice in the helicopter and still did not see loons. 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. During the brood search on the ground, which occurred the day before the aerial survey, we observed Yellow-billed Loons flying from the delta towards the ocean. We conducted the aerial survey in 2000 at the same time as previous years, and the small number of loons seen may have resulted from pairs vacating their territories earlier than in previous years. In 1993 and 1995–1998, we counted between three and seven loon broods and densities ranged from 0.01 to 0.03 broods/km² (Table 17). The highest number of Yellow-billed

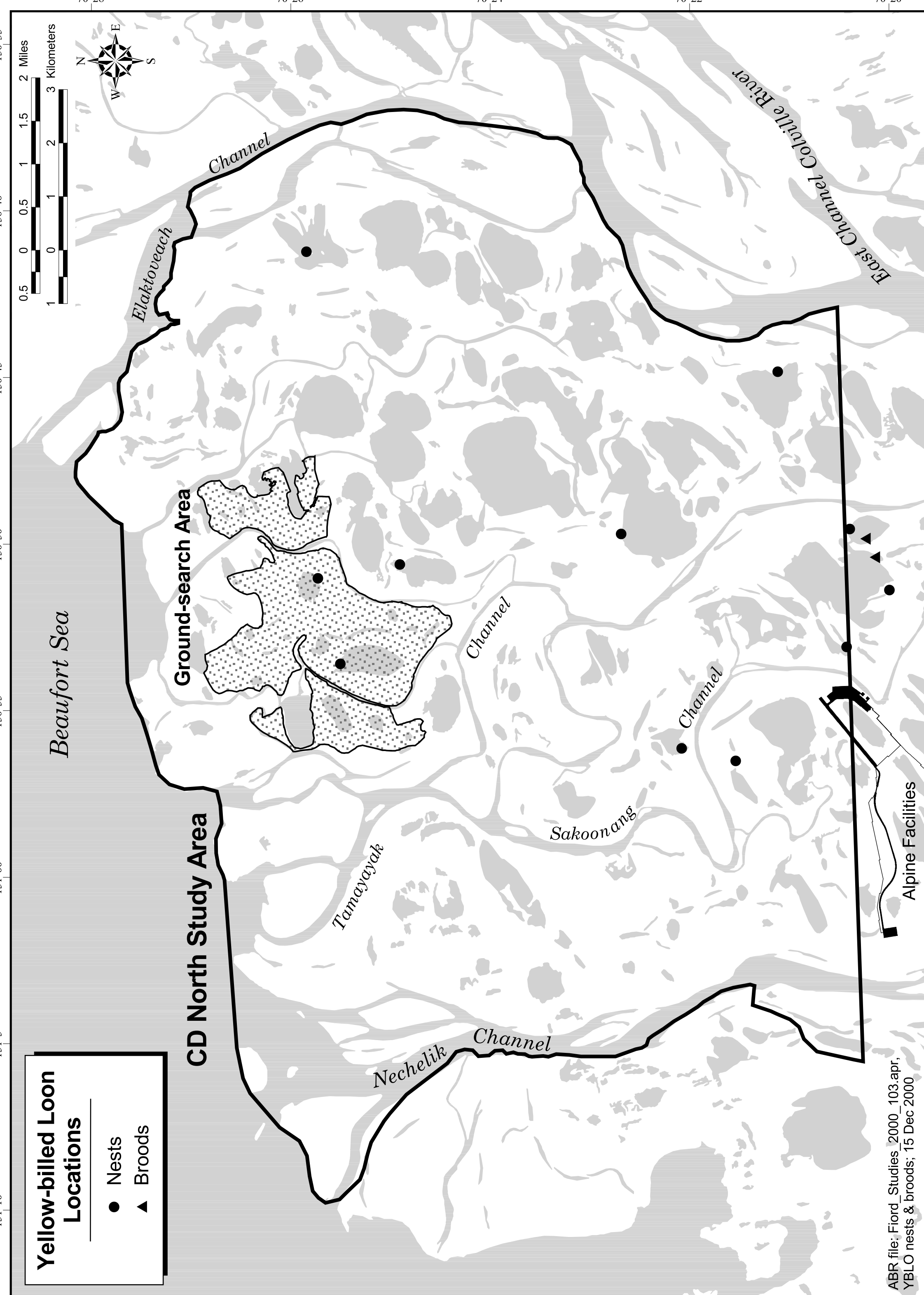


Figure 13. Distribution of Yellow-billed Loon nests and broods recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000. No broods were seen in CD North during 2000.

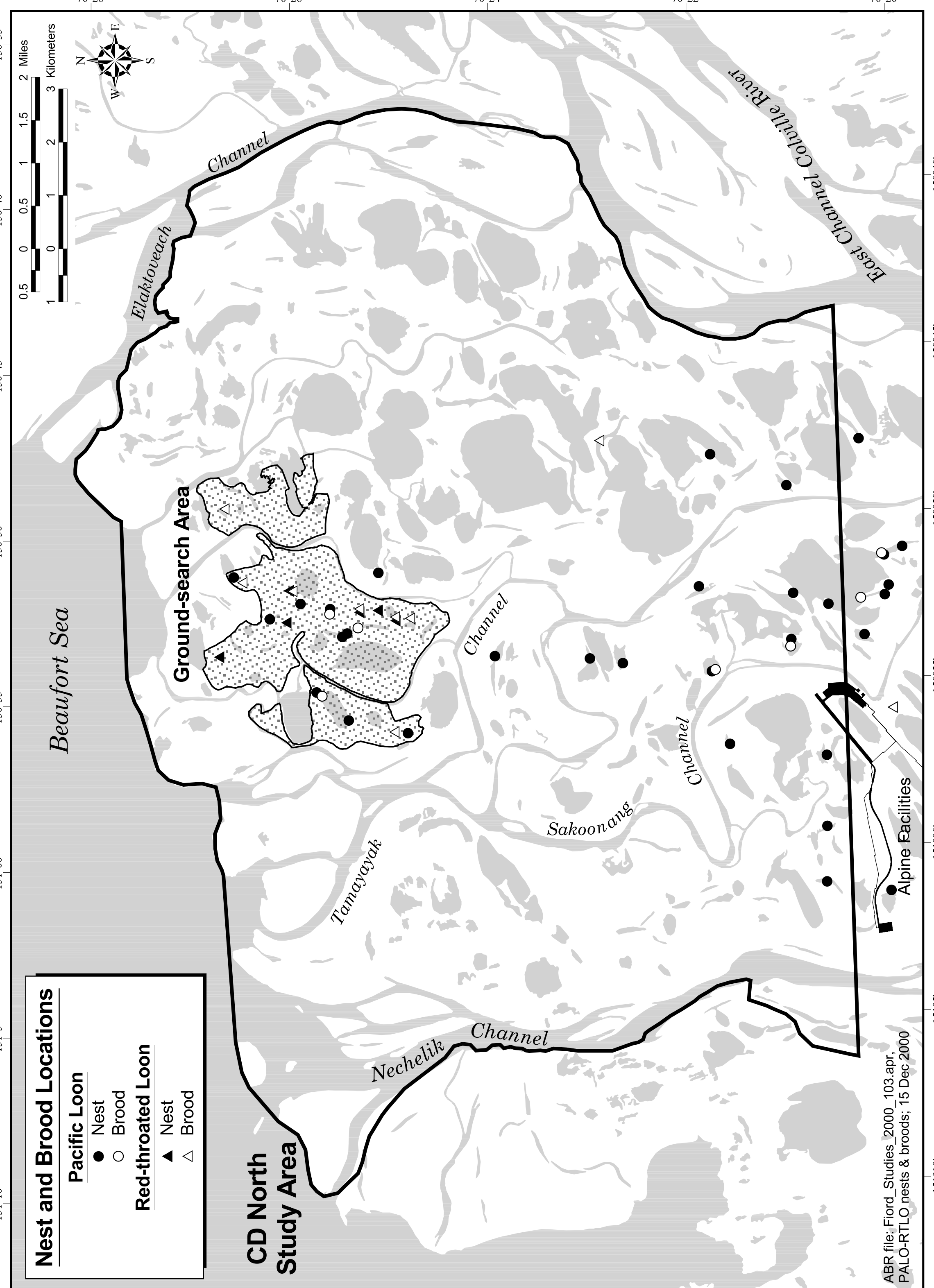


Figure 14. Distribution of Pacific and Red-throated loon nests and broods recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000.

Table 18. Habitat use by nesting Yellow-billed Loons recorded during aerial surveys in the CD North study area, Colville River Delta, Alaska, 2000.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Tapped Lake w/ High-water Connection	1	11.1
Deep Open Water w/out Islands	2	22.2
Deep Open Water w/ Islands or Polygonized Margins	2	22.2
Nonpatterned Wet Meadow	1	11.1
Wet Sedge–Willow Meadow	3	33.3
Total	9	100
NEAREST WATERBODY HABITAT		
Tapped Lake w/ High-water Connection	2	22.2
Deep Open Water w/out Islands	4	44.4
Deep Open Water w/ Islands or Polygonized Margins	3	33.3
Total	9	100

Loon broods recorded in the CD North study area during our 6 years of surveys was in 1998 when we counted seven broods and eight young.

Two factors may have caused Yellow-billed Loon production to fail in 2000. The late thaw and cool spring temperatures in 2000 (Figure 4) may have delayed nest initiation and reduced nest success. Another factor that may have contributed to brood failure was the effects of a severe storm with high westerly winds that occurred on 11 August.

In 2000, we also recorded fewer Pacific and Red-throated loons and their broods in the CD North study area than during all previous years except 1993 (Table 17, Figure 14). As mentioned above, those numbers underestimated the actual number of Pacific and Red-throated loons with broods. Both these loon species can rear their young on smaller waterbodies than Yellow-billed Loons; thus, because our aerial survey did not include all waterbodies, some broods were missed. Moreover, because our survey intensity for these smaller waterbodies varied among years and survey coverage was never complete, we cannot compare annual abundance or calculate densities for these two species (Appendix C12).

Within the CD North ground-search area, we saw three Pacific and seven Red-throated loon broods in 2000 during an intensive foot survey (Figure 7). Based on the number of birds seen during the brood search, the density for adults was 1.3 and 1.1 birds/km^2, respectively, for Pacific and Red-throated loons. Brood density was 0.25 broods/km^2 for Pacific Loons and 0.57 broods/km^2 for Red-throated Loons.

HABITAT USE

Nesting

In 2000, the habitats most frequently used for nesting (78% of all nests) by Yellow-billed Loons in the CD North study area were Wet Sedge–Willow Meadow (3 nests) and the 2 types of Deep Open Water (2 nests each) (Table 18). We found one nest in each of two other habitats, Tapped Lake with High-water Connection and Nonpatterned Wet Meadow. Nests were built on peninsulas, shorelines, islands, or in emergent vegetation; the latter two types could be classified as part of a waterbody at the scale of our habitat map.

During 6 years (1993, 1995–1998, 2000) of aerial surveys on the Colville Delta, 85 Yellow-billed Loon nests were found in 8 of 24 available habitats (Appendix D7). Four preferred habitats accounted for 62 (73%) of the 85 nests: Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, and Wet Sedge–Willow Meadow. Wet Sedge–Willow Meadow was the habitat most frequently used for nesting (40% of all nests), and it was the most abundant habitat on the delta (25% of total area). Nesting Yellow-billed Loons avoided five habitats: Tapped Lake with

Low-water Connection, Salt-killed Tundra, River or Stream, Riverine or Upland Shrub, and Barrens.

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 occurred most commonly near Deep Open Water without Islands (44% of all nests), Deep Open Water with Islands or Polygonized Margins (33%), and Tapped Lake with High-water Connection (22%) (Table 18). Measurements of the distance from the nest to the nearest waterbody were not recorded during aerial surveys, but all nests were close (≤1m) to water. 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 two Deep Open Water types and Tapped Lakes with High-water Connections that we have described. Although North and Ryan (1988) reported that Yellow-billed Loons did not nest on tapped lakes, they did not discriminate Tapped Lakes with High-water Connections, which may appear to be untapped because they commonly are connected to channels by low, vegetated areas that do not flood every year. The small waterbodies where North (1986) found nests probably correspond to our Aquatic Sedge with Deep Polygons, Shallow Open Water without Islands, and Aquatic Grass Marsh. Consistent with our observations, North (1986) found that nests on small waterbodies (<10 ha) always were near (<70 m) larger waterbodies.

Brood-rearing

In the CD North study area in 2000, we found no Yellow-billed Loon broods, but surveys of the Colville Delta from previous years show the importance of large, deep waterbodies for brood-rearing. During aerial surveys in 1995–1998 and 2000, we found 34 Yellow-billed Loon broods in three habitats on the delta—Tapped Lake with High-water Connection and both types of Deep Open Water—all of which were preferred (Appendix D7). Deep Open Water without Islands was used by most broods (62%), followed by Tapped Lake with High-water Connection (24%) and Deep Open Water with Islands or Polygonized Margins (14%). No shallow-water habitats were used during brood-rearing. Wet Sedge–Willow Meadow, and Barrens, the two most abundant habitats in the survey area, were the only habitats avoided by loons during brood-rearing on the delta. The concurrence of 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 two broods (North 1986).

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 nine islands centered around Anachlik Island near the mouth of the East Channel (Simpson et al. 1982, Renken et al. 1983, Martin and Nelson 1996). Brant began nesting at the Anachlik Colony-complex in the 1960s, nesting first on Anachlik Island, then expanding to Char, Brant, and Eskimo islands by the late 1970s–early 1980s (Martin and Nelson 1996). These four islands remain the core of the colony-complex, but Brant now nest in limited numbers on at least five other islands. Additional locations for small numbers of Brant nests are scattered across the delta, primarily in the northern half (Johnson et al. 1999a).

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

The fall migration of Brant along the arctic coast of Alaska usually begins in mid- to late August (Johnson and Herter 1989), and major river deltas, such as the Colville Delta, provide important resting and feeding areas for Brant at that time (Johnson and Richardson 1981). These fall-staging Brant tend to use areas along the coast that are similar, but not limited, to those used by brood-rearing groups (Smith et al. 1994).

DISTRIBUTION AND ABUNDANCE

Nesting

In 2000, we located 30 Brant nests in the CD North ground-search area (12.2 km²) (Figure 15, Table 5). Brant were the second most numerous nesting species at a density of 2.5 nests/km². In 1992, 1994, and 1997, we conducted ground searches for nesting eiders in portions of the CD North study area, but Brant nests were not recorded consistently. In 2000, nest success was only 10% in the CD North ground-search area.

Between 1992 and 1998, we conducted aerial surveys for nesting Brant that included the entire outer delta. During these surveys, we recorded ≥14 colonies (locations with ≥2 nests) in the CD North study area that had 1–5 years of occupation and 2–18 nests, as well as 6 locations of solitary nests with only 1 year of use (Appendix C13). During these nesting aerial surveys, we recorded three colonies/nesting locations that occurred in the CD North ground-search area, each containing 1–10 nests; the largest colony was occupied for at least 5 years. During our ground search in 2000, we recorded three colonies containing 2–20 nests, and three solitary nesting locations. The largest colony found in 2000 was in the same location as the largest colony recorded in the CD North ground-search area during previous aerial surveys.

Brood-rearing

Data from both a multi-year banding study in the neighboring oilfields and our aerial surveys indicate that brood-rearing groups of Brant from the Colville Delta disperse as far east as the Kuparuk River delta (Anderson et al. 1996, Martin and Nelson 1996, Martin et al. 1997), and as far west as the Tingmeachsiovik River (Smith et al. 1994). The predominant pattern for most Brant is to rear their broods along the coast (Stickney and Ritchie 1996). In the CD North study area, we recorded 364 Brant (148 adults and 216 goslings) at three locations during the goose aerial survey (Figure 15). The size of the brood-rearing groups ranged from 44 to 200 birds, and the mean percentage of goslings was 59% (range = 55–67%, $n = 3$), which was comparable to the percentages in previous years (46–60% goslings).

The number of Brant observed in the CD North study area during brood-rearing in 2000 was slightly above average for the numbers recorded since surveys were started by USFWS in 1988 ($\bar{x}$ = 286 birds, range = 35–934; Table 19). The distribution of Brant in this area was highly variable; in most years larger numbers of Brant were recorded between the East and Elaktoveach channels (Appendix C14). In 2000, one of the three brood-rearing groups observed was within the CD North ground-search area.

Fall Staging

During fall-staging aerial surveys in 2000, we saw 189 Brant in 7 locations in the CD North study area (Figure 16), and group sizes ranged from 2 to 80 birds ($\bar{x}$ = 27 birds). In previous years (1992–1993, 1995–1998), we observed 2–6 groups with total numbers of Brant ranging from 64 to 314 (Appendix C15). Average group size ranged between 21 and 70 birds.

HABITAT USE

Nesting

We collected detailed information on the habitat occupied by 30 individual nests found on

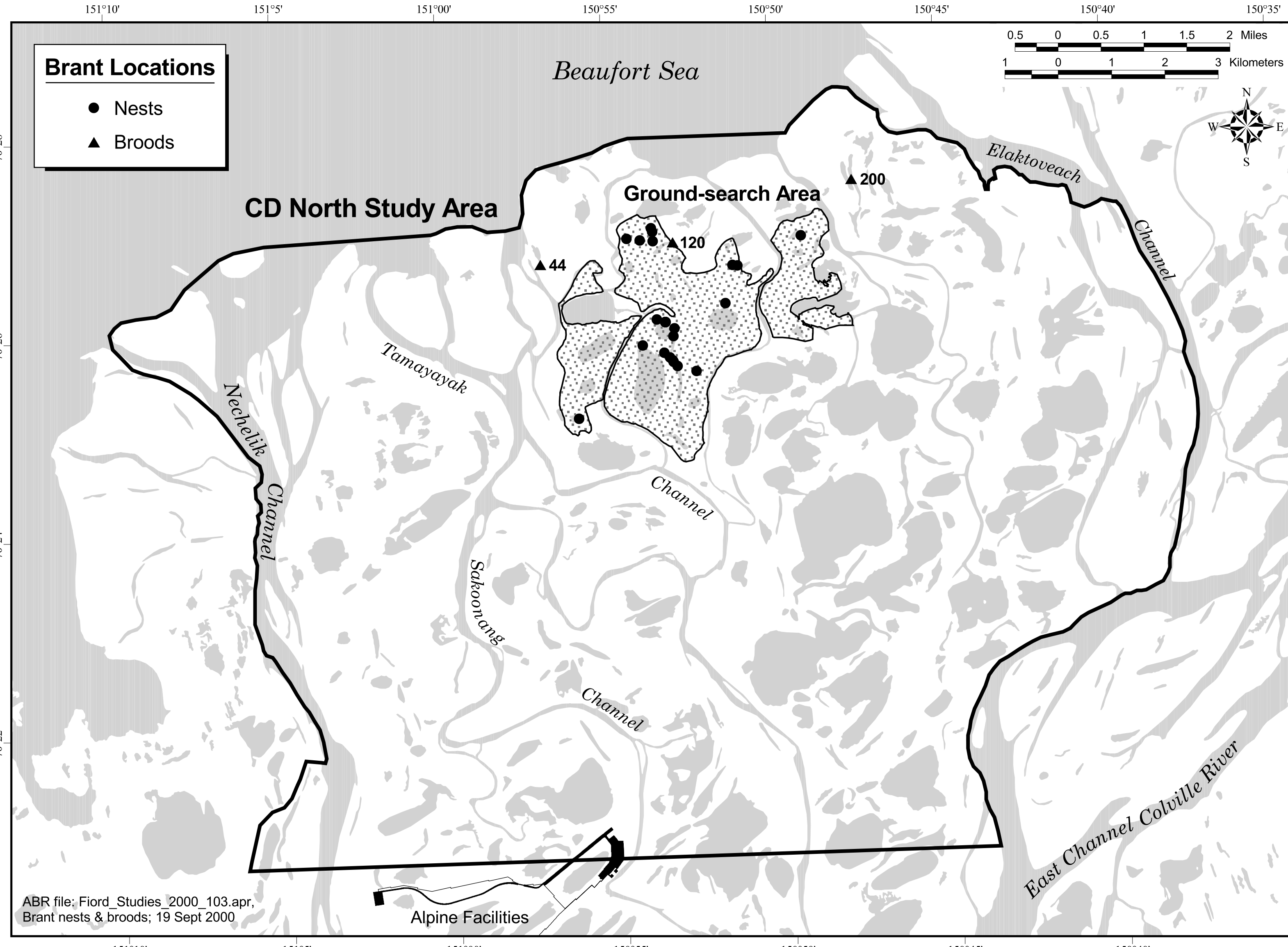


Figure 15. Distribution of Brant nests and brood-rearing groups recorded during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000. Total number of birds is listed for brood locations.

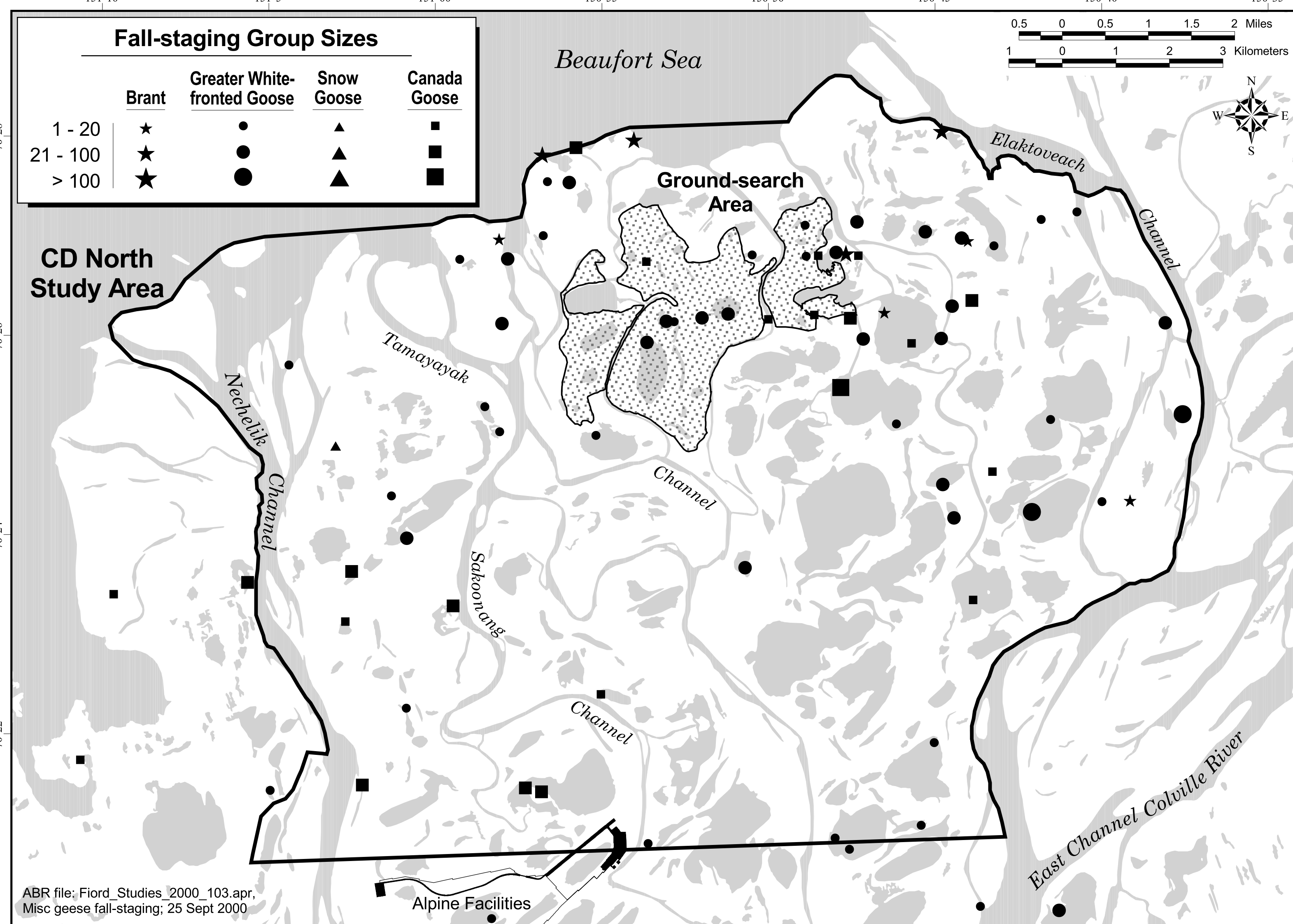


Figure 16. Distribution of fall-staging groups of Brant, Greater White-fronted, Snow, and Canada geese recorded during aerial surveys in the CD North study area, Colville River Delta, Alaska, August 2000.

Table 19. Abundance, distribution, and percentage of goslings in brood-rearing groups of Brant between the Elaktoveach and Nechelik Channels on the Colville River Delta, Alaska, during late July-early August. Data for years prior to 1992 are from Bayha et al. (1992); data for 1992, 1993, 1995–1998 are from ABR (unpubl. data).

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

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

ground surveys in the CD North ground-search area in 2000 (Table 20). Over 70% of the nests were in aquatic habitats with 60% in Deep Open Water with Islands or Polygonized Margins. Nests were most often on islands (24 nests, 80%), polygon rims (4 nests, 13%), or along shorelines (2 nests, 7%). The largest colony (20 nests) straddled a complex of different habitat types (Deep Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons). Brant nests averaged 20.8 m from permanent water with 24 nests located <1 m from permanent water, and the remaining 6 nests ranged from 4 to 265 m from water.

During aerial nesting surveys in 1993 and 1995–1998, we found 19 colonies of Brant nesting in 6 of 21 available habitats, with Salt-killed Tundra and Aquatic Sedge with Deep Polygons being preferred in an analysis of habitat selection (Appendix D8). These two habitats were occupied by nine nests in the CD North study area in 2000 (Table 20) and contained the most colonies and the

Table 20. Habitat use and nearest waterbody habitat of individual Brant nests located during ground-based surveys in the CD North ground-search area, Colville River Delta, Alaska, 2000.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Brackish Water	4	13.3
Salt-killed Tundra	3	10.0
Deep Open Water w/ Islands or Polygonized Margins	18	60.0
Aquatic Sedge w/ Deep Polygons	5	16.7
Total	30	100
NEAREST WATERBODY HABITAT[a]		
Brackish Water	8	26.7
Deep Open Water w/ Islands or Polygonized Margins	22	73.3
Total	30	100

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

most nests of all habitats during 5 years of surveys on the delta.

Brood-rearing

In the CD North study area during 2000, we saw three groups of brood-rearing Brant in three different habitats: Salt Marsh, Salt-killed Tundra, and Barrens. All groups were within 0.05 km of water (Brackish Water and Shallow Open Water without Islands) and between 0.8 and 1.2 km from the coast. In previous years (1993, 1995, 1996, and 1998) during coastal brood-rearing surveys, we saw 40 groups of Brant in 10 different habitats, with salt-affected habitats receiving the greatest use (Appendix D8). During those years, Brackish Water was used by the most Brant brood groups (38%) and was the only preferred habitat on the delta. Brood-rearing groups frequently moved into nearby water when disturbed by our survey aircraft, so the high use of waterbodies probably was the result of some broods moving from adjacent foraging habitat (most likely Salt Marsh) as our aircraft approached. More than half of the brood-rearing groups were close to Brackish Water. The mean distance of brood-rearing groups to the nearest waterbody was 0.02 km.

OTHER GEESE

BACKGROUND

The Colville Delta is a regionally important nesting area for White-fronted Geese (Rothe et al. 1983). In the early 1980s, the USFWS recorded mean densities during June of 6.28 birds/km² and 1.8 nests/km² in scattered plots across the delta, and 6.6 nests/ km² at one site on the western delta, which were among the highest densities recorded for these geese and their nests on the Arctic Coastal Plain of Alaska (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). More recently, we have recorded nest densities of 2.0–5.0 nests/km² on the delta in the Alpine project area (Johnson et. al. 1999b, 2000).

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

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

DISTRIBUTION AND ABUNDANCE

Nesting

During the nest search in 2000, we found 120 nests of Greater White-fronted Geese in the CD North ground-search area, which was almost half of all nests found (Figure 5, Table 5). The number of nests of these geese was four times greater than that of Brant, the second most numerous nesting species. The density of nests (9.8 nests/km²) found in the CD North ground-search area was greater than densities found in the Alpine project area or CD South ground-search area (Table 7), and greater than any density previously reported for the delta (Simpson et al. 1982, Rothe et al. 1983,

Table 21. Numbers of Greater White-fronted Geese counted during brood-rearing aerial surveys in the CD North study area, Colville River Delta, Alaska, 1996–1998 and 2000. Pre-2000 data are from Johnson et al. (1999a). In 1996, survey coverage was 25% of the study area; in all other years coverage was 50%

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

Johnson et al. 1999b, 2000). Eighty-eight (73%) of the nests found in the ground-search area hatched.

We did not find any nests of Snow or Canada geese during our foot survey in the CD North ground-search area in 2000. However, in 1994, two Snow Goose nests were found during ground searches in this same area and additional nests were located on the outer delta either during ground surveys or aerial surveys in 1993, 1995, and 1997 (1 or 2 each year). All Snow Goose nests were <5 km from the coast. In 1997, we found a Canada Goose nest near the Nechelik Channel, which was the first record of Canada Geese nesting on the delta, and we found two nests just west of the delta in the NPR–A during aerial surveys (Appendix C13) (Johnson et al. 1998). At one of these locations in the NPR–A, we counted 10 Canada Goose nests 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. 1999b, 2000).

Brood-rearing

In the CD North ground-search area in 2000, we observed 11 broods of Greater White-fronted Geese with at least 41 young (Figure 7, Table 8). The average brood size was 3.7 young.

During the systematic aerial survey (50% coverage) of the CD North study area in 2000, we saw 1,304 Greater White-fronted Geese in 17 groups (Figure 17). Group sizes ranged from 14 to 360 birds ($\bar{x}$ = 77) and goslings composed 51% of the total number of geese (Table 21). The number of Greater White-fronted Geese seen in 2000 was about the same as in 1998 (1,354 birds) and 1997 (1,224) and more than the number in 1996 (331) (Table 21, Appendix C16). In 1996–1998, goslings were 35–58% of the groups seen during the systematic surveys. Prior to 1996, brood counts of Greater White-fronted Geese were collected opportunistically during aerial surveys conducted for Brant and eiders.

Small groups of Snow Geese have been seen in most years during brood-rearing surveys and most of these groups were in the CD North study area (Figure 17). In 2000, we recorded two groups of brood-rearing Snow Geese totaling 45 birds (16 adults and 29 goslings) during the systematic aerial survey. The number of Snow Geese seen during this survey was less than that seen during two surveys (72 and 52 geese) in 1998, but was greater than the number of Snow Geese recorded during surveys in 1995, 1996, and 1997(Appendix C16); no Snow Geese were recorded in the CD North study area during surveys in 1992 and 1993.

During the aerial brood-rearing survey in 2000, we recorded a group of 8 adult and 14 gosling Canada Geese in the CD North study area (Figure 17). Similarly in 1998, we saw a group of 8 adults and 16 goslings in this area, which was only the third record of these geese on the delta during the brood-rearing/molting period (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 2000, large numbers of Greater White-fronted Geese, in groups that averaged <30 birds, were distributed throughout

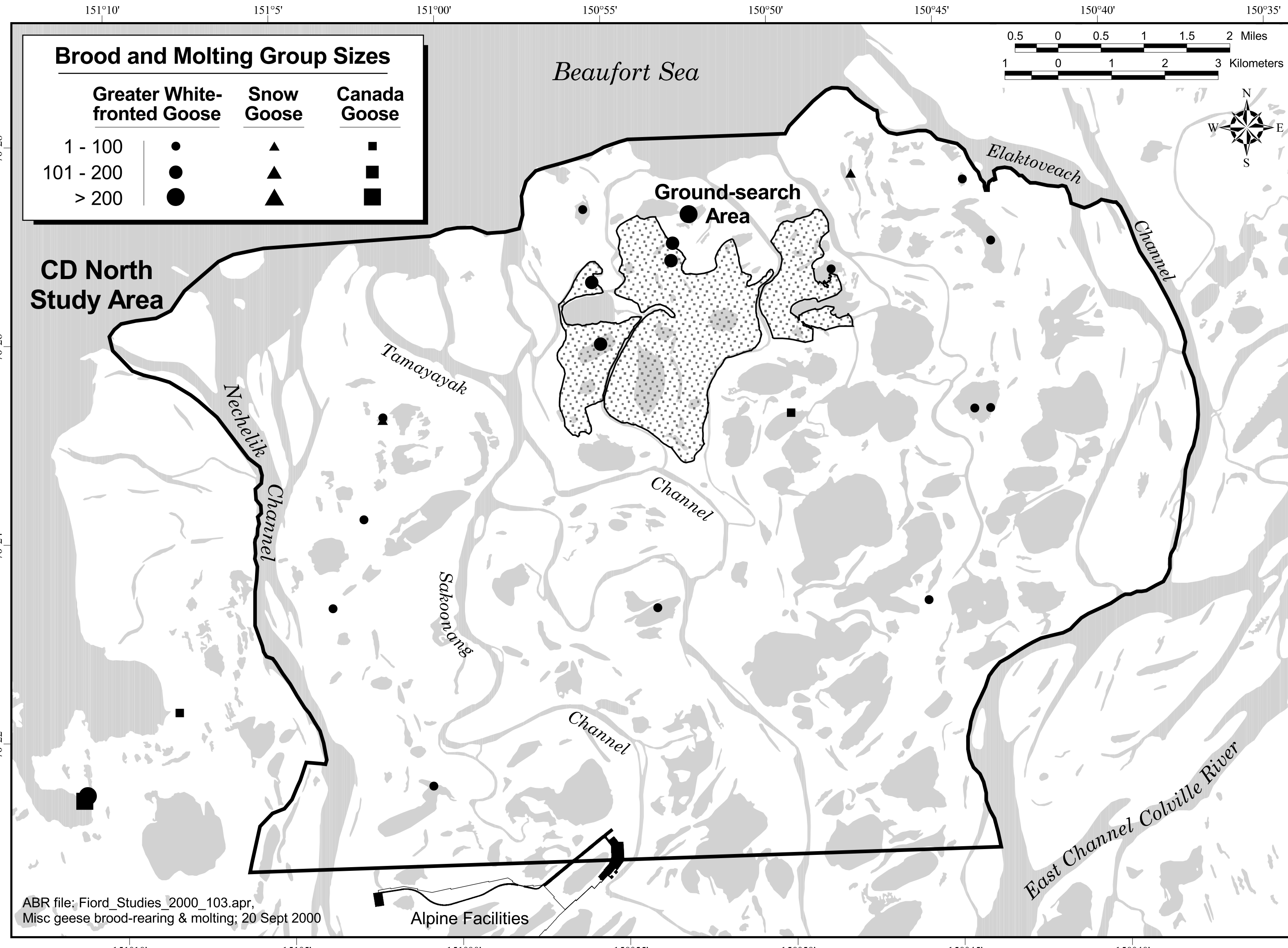


Figure 17. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese recorded during aerial surveys in the CD North study area, Colville River Delta, Alaska, July 2000.

Table 22. Numbers of Greater White-fronted Geese and Canada Geese counted during fall-staging aerial surveys in the CD North study area, Colville River Delta, Alaska, 1996–1998 and 2000. Pre-2000 data are from Johnson et al. (1999a). In 1996, survey coverage was 25%; in all other years, coverage was 50% of the study area.

	Greater White-fronted Goose				Canada Goose			
Year	No. of Birds	No. of Groups	Mean Group Size	Range	No. of Birds	No. of Groups	Mean Group Size	Range
2000	1,227	44	27.9	2–150	558	19	29.4	5–115
1998	687	22	31.2	6–150	678	20	33.9	6–75
1997	893	34	26.3	4–80	996	33	30.2	3–175
1996	765	13	58.9	5–350	1,021	8	127.6	10–500

the CD North study area in a variety of aquatic and terrestrial habitats (Figure 16, Table 22). This also was the pattern of distribution in both 1997 and 1998, but in 1996, the geese were concentrated around river channels and large lakes in fewer, but larger groups. On the systematic survey in 2000, we counted 1,227 geese, which was substantially greater than the count in 1998 (687 geese) and in 1997 (893 geese) (Table 22).

In 1996, we recorded 765 geese in the CD North study area, but the survey coverage was half that in subsequent years. Prior to 1996, we made observations opportunistically during surveys for focal species. Counts of fall-staging Greater White-fronted Geese seen on the delta during 1991, 1992, and 1995, were 213, 602, and 400 geese, respectively.

During the 2000 fall-staging survey, we saw one group of 18 Snow Geese (Figure 16). In 1997, we saw one group (6 birds) of Snow Geese and three groups (36 birds) during two surveys (Appendix C17). We saw three Snow Geese in one group in 1996, and 20 in 2 groups in 1995 (Johnson et al. 1998). As during brood-rearing, all Snow Geese were seen on the outer delta during fall staging.

Canada Geese occurred in large numbers during fall staging, and used coastal areas of the outer delta more than other areas on the delta (Figure 16). In 2000, we observed 558 Canada Geese in 19 groups in the CD North study area during the systematic survey for geese (Table 22). In 1996–1998, we counted 678–1,021 Canada Geese, and the highest count was obtained with half the survey coverage (25%) used in the other years. The greatest numbers of Canada Geese were recorded in 1992, when we counted ~4,600 Canada Geese in the CD North study area (Smith et al. 1993). During 1991, 1993, and 1995, the numbers counted incidental to other surveys were lower: 182–792 birds. Both brood-rearing and fall-staging counts of geese have been highly variable annually. Our data are insufficient to determine whether this annual variation in numbers is due to differences in survey timing and survey intensity, or is due to actual changes in abundance.

HABITAT USE

In 2000, Greater White-fronted Geese in the CD North ground-search area nested in 8 of 14 available habitats (Table 6). Most nests were found in habitats with polygonal surfaces: Wet Sedge–Willow Meadow (39% of all nests), Aquatic Sedge with Deep Polygons (33%), and Salt-killed Tundra (17%). Eighty-nine percent of the Greater White-fronted Goose nests were on slightly elevated landforms—polygon rims, low ridges, or small hummocks—that were similar to the nesting sites reported for other areas of the delta (Simpson et al. 1982, Johnson et al. 2000). Nests ranged from <1 to 303 m ($\bar{x}$ = 79.7 m, n = 120) from the nearest permanent waterbody.

Brood-rearing groups of White-fronted Geese recorded during the aerial survey were generally distributed throughout the CD North study area in 2000, and typically occurred in or near lakes: 65% of all groups were observed in Deep Open Water (both types), Brackish Water, and Tapped Lake

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

Season/Habitat	Greater White-fronted Goose Groups	Greater White-fronted Goose Use (%)	Canada Goose Groups	Canada Goose Use (%)	Snow Goose Groups	Snow Goose Use (%)
BROOD-REARING/MOLTING						
Brackish Water	4	23.5	0	0	1	50.0
Tapped Lake w/ Low-water Connection	1	5.9	1	100	0	0
Salt Marsh	1	5.9	0	0	0	0
Salt-killed Tundra	2	11.8	0	0	0	0
Deep Open Water w/out Islands	4	23.5	0	0	1	50.0
Deep Open Water w/ Islands or Polygonized Margins	2	11.8	0	0	0	0
Aquatic Sedge with Deep Polygons	1	5.9	0	0	0	0
Wet Sedge–Willow Meadow	1	5.9	0	0	0	0
Moist Tussock Tundra	1	5.9	0	0	0	0
Total	17	100	1	100	2	100
FALL-STAGING						
Open Nearshore Water	0	0	1	9.1	0	0
Brackish Water	3	9.1	0	0	0	0
Tapped Lake w/ Low-water Connection	6	18.2	2	18.2	0	0
Tapped Lake w/ High-water Connection	1	3.0	0	0	0	0
Salt Marsh	1	3.0	1	9.1	0	0
Salt-killed Tundra	5	15.2	1	9.1	0	0
Deep Open Water w/out Islands	4	12.1	0	0	0	0
Deep Open Water w/ Islands or Polygonized Margins	7	21.2	0	0	0	0
River or Stream	4	12.1	0	0	0	0
Aquatic Sedge with Deep Polygons	0	0	0	0	0	0
Nonpatterned Wet Meadow	0	0	1	9.1	0	0
Wet Sedge–Willow Meadow	2	6.1	1	9.1	0	0
Moist Sedge–Shrub Meadow	0	0	0	0	1	100
Barrens (riverine, eolian, lacustrine)	0	0	4	36.4	0	0
Total	33	100	11	100	1	100

with Low-water Connection (Table 23). All the brood-rearing groups of Canada and Snow geese also were observed in lakes (Table 23).

During fall staging, Greater White-fronted Geese used habitats similar to those used during brood-rearing; 64% of all groups used water habitats (Table 23). Fall-staging Canada Geese used many of the same habitats, but were most prevalent (73% of all groups) in terrestrial types (Table 23). Only one group of Snow Geese was seen, and they were in Moist Sedge–Shrub Meadow.

FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are common on the coastal plain. Red foxes are common in the foothills and mountains of the Brooks Range, but are restricted largely to major drainages (such as the Colville and Sagavanirktok rivers) on the coastal plain, where they are much less common than the arctic fox (Eberhardt 1977). Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Schamel and Tracy 1986, Hersteinsson and Macdonald 1992).

Arctic foxes in northern Alaska breed in late March or April, and pups are born in late May or June after a gestation period of ~52 days (Chesemore 1975). Pups first emerge from dens at 3–4 weeks of age (Garrott et al. 1984), and dens are occupied from late spring until pups disperse in mid-August (Chesemore 1975). Throughout their circumpolar range, arctic fox litters average 4–8 pups but can range up to 15 pups (Chesemore 1975, Follmann and Fay 1981, Strand et al. 1995, Johnson et al. 1997). Survival of arctic fox pups to weaning is highest in years when microtine rodents (primarily lemmings) are abundant (Macpherson 1969). Causes of pup mortality include predation, starvation, and sibling aggression (Macpherson 1969, Garrott and Eberhardt 1982, Burgess et al. 1993). For both arctic and red foxes, lemmings and voles are the most important year-round prey, supplemented by carcasses of caribou and marine mammals and, in summer, by arctic ground squirrels and nesting birds and their eggs; garbage is eaten when available (Chesemore 1968, Eberhardt 1977, Garrott et al. 1983b). Foxes are potent predators of nesting birds, and the growth of local populations from artificial food sources has led to concerns about the effects of foxes on avian populations (Day 1998, Burgess 2000).

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

DISTRIBUTION AND ABUNDANCE

Number and Density of Dens

We have located 11 fox dens in the CD North study area since 1992, including active and inactive sites of both species (Figure 18, Table 24). Nine (82%) of the dens were arctic fox sites in 2000. Two red fox dens were located on an island in the Elaktoveach Channel (in the eastern portion of the study area), but only one denning pair used both dens in 2000. The newly discovered red fox den was a natal site located ~250 m east of the secondary den, which previously had been an inactive arctic fox den (judging from burrow dimensions) since we discovered it in 1998. The density of arctic fox dens active annually (3–8 dens; Table 25) ranged from 1 den/26 km² to 1 den/69 km², with a modal density (4 dens) of 1 den/52 km². The highest density of active dens occurred in 1996, a year of high microtine rodent populations when a large proportion of dens were occupied across the entire delta and adjacent coastal plain (Johnson et al. 1997). The annual density of active red fox dens cannot be calculated due to the absence of occupied sites before 2000.

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

In 8 years of surveys (1992, 1993, 1995–2000) and contacts with other observers, we have located 62 fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield (most are depicted in Appendix C18). In 2000, 53 dens (85%) were classified as arctic fox dens and the remaining 9 dens (15%) were occupied by red foxes; 3 of the dens used by red foxes were former arctic fox dens.

The total density (active and inactive) of fox dens in the CD North study area (207 km²) was 1 den/19 km². Arctic fox den density was 1 den/23 km² and red fox den density was 1 den/103 km², but because both red fox sites were 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/92 km²; comparative data are unavailable for this species from other arctic tundra areas. The density of arctic fox dens in the CD North study area is slightly higher than the density for the combined Colville Delta (551 km²) and Transportation Corridor (343 km²) survey areas, which was 1 den/26 km² (Johnson et al. 2000). The overall density also was higher than the 1 den/34 km² reported by Eberhardt et al. (1983)

Table 24. Landforms, activity status, and number of pups counted at arctic and red fox dens in the CD North study area during the 1993 and 1995–2000 denning seasons, Colville River delta, Alaska. Zeroes indicate that dens were observed but no pups were seen; dashes indicate no data. Pre-2000 data are from Johnson et al. (2000).

	2000		1999		1998		1997		1996		1995		1993	
Species / Landform	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups	Status	No. Pups
ARCTIC FOX														
old dune	inactive?		natal	8	natal	3	inactive	0	natal	6	inactive	--	natal	5
dune / lake bank	inactive		inactive	--	inactive	0	inactive?	0	natal	3	inactive	--	natal	3
lake bank	natal	3	inactive	--	natal?	0	natal?	0	natal	4	inactive	--	inactive	--
dune / lake bank	inactive?		inactive	--	inactive	--	inactive	0	natal	6	natal	--	inactive	--
dune / lake bank	natal?	0	active	0	active	0	natal	3	natal	5	secondary ?	--	adults only	--
dune ridge	natal	5	natal	0	natal	2	inactive?	0	natal	7	natal	3	--	--
dune / river bank	inactive		inactive	--	natal	1	natal	4	natal	5	secondary	3	--	--
dune / lake bank	inactive		inactive	--	*not checked*	--	*not checked*	--	inactive	--	inactive	--	--	--
low dune ridge	natal	5	natal	2	inactive	--	natal	5	secondary	6	--	--	--	--
RED FOX														
sand dune [a]	secondary	2	inactive	--	inactive	--	--	--	--	--	--	--	--	--
sand dune	natal	0	--	--	--	--	--	--	--	--	--	--	--	--

[a] Arctic fox den until 2000.

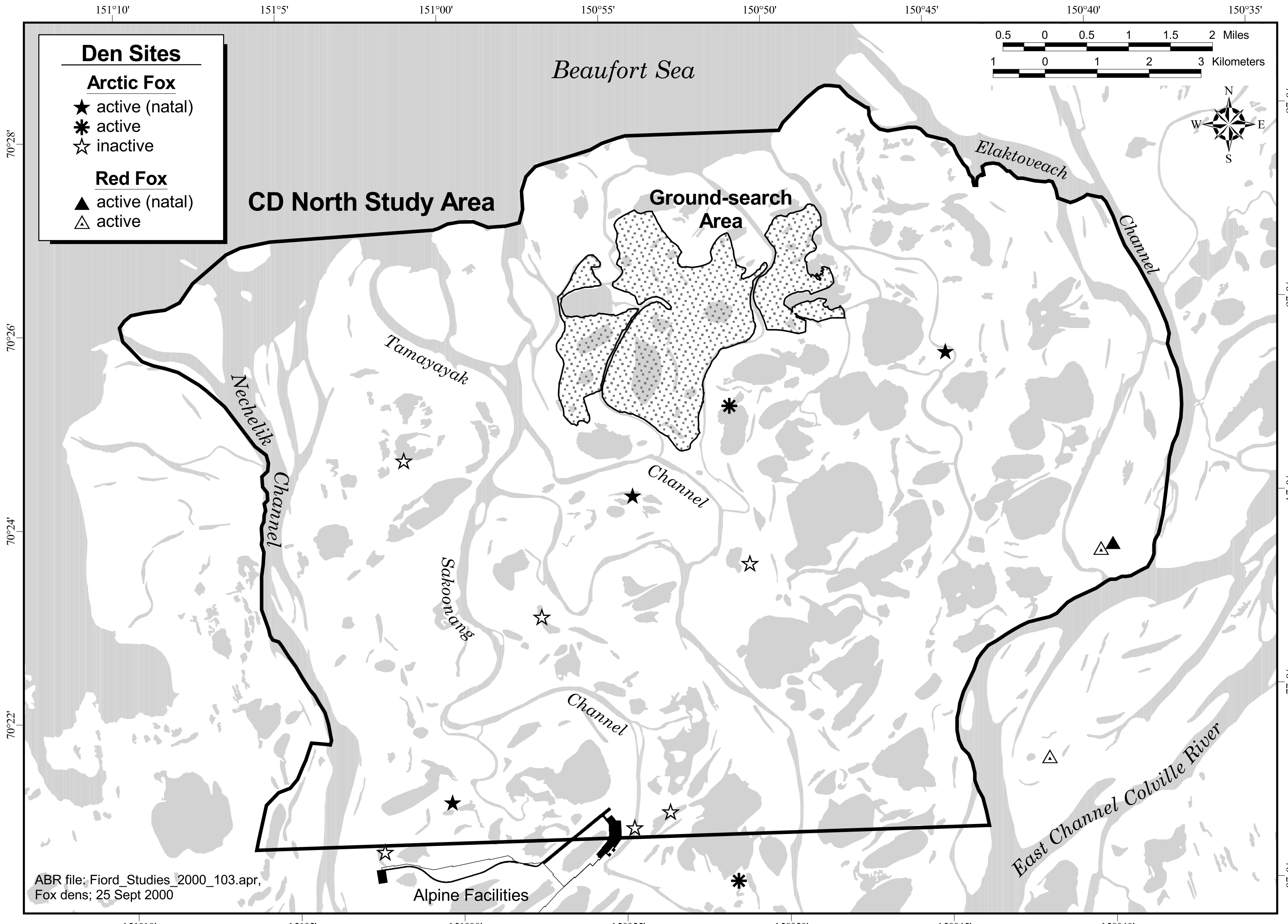


Figure 18. Distribution of arctic and red fox dens found during aerial and ground surveys in the CD North study area, Colville River Delta, Alaska, 2000. Survey coverage was not uniform over the area portrayed.

Table 25. Occupancy and status of fox dens during the 1993 and 1995–2000 denning seasons in the CD North study area, Colville River delta, Alaska. Pre-2000 data are from Johnson et al. (2000).

	2000		1999		1998		1997		1996		1995		1993	
Species / Status	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ARCTIC FOX														
Active natal	3	33	3	30	3	33	3	38	7	78	2	25	2	40
Active secondary	0	--	0	--	0	--	0	--	1	11	1	13	0	--
Active[a]	1	11	1	10	2	22	1	13	0	--	1	13	1	20
Inactive[b]	5	56	6	60	4	44	4	50	1	11	4	50	2	40
Total sample	9		10		9		8		9		8		5	
RED FOX														
Active natal	1	50	0	--	0	--	0	--	0	--	0	--	0	--
Active secondary	1	50	0	--	0	--	0	--	0	--	0	--	0	--
Total sample	2		0		0		0		0		0		0	

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

for their 1,700-km² Colville study area (which extended farther east–west than ours, but not as far inland). However, the overall density of arctic fox dens was lower than those reported for the 805-km² developed area of the Prudhoe Bay Oilfield (1 den/12–15 km²; Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues et al. 1994), but was near the range reported for undeveloped areas nearby the Prudhoe field (1 den/28–72 km²; Burgess et al. 1993, Rodrigues et al. 1994).

Den Occupancy and Production of Young

Based on brief visits at all nine arctic fox dens and longer observations at four of those dens, we concluded that pups were present at a minimum of three natal dens and suspected that pups were present at another active den (Table 24). We counted 13 arctic fox pups at the 3 confirmed natal dens, for a mean litter size of 4.3 pups. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to reliably obtain complete counts.

We counted two pups at the secondary den site used by the single denning pair of red foxes in the CD North study area, and it is possible that more were present; the litter had moved from the natal den by the time of our observations. Red fox dens are more difficult to observe than arctic fox dens because they tend to be located in sand dunes having high topographic relief and tall shrubs that obscure the den entrances and activity areas. Estimates of pup production can be confounded by the use of secondary dens, which may result in splitting of litters among several dens by one family (Garrott 1980, Eberhardt et al. 1983). Garrott (1980) noted that movements of arctic foxes from natal dens to secondary dens typically occurred after early to mid-July when the young were 5–7 weeks old, and that interchange of young between dens occurred after the initial move.

The estimated 44% den occupancy rate by arctic fox litters (natal, secondary, and active categories combined) in the CD North study area in 2000 was at the lower end of the range observed since 1993 (40–89% occupied; Table 25). The lowest occupancy rate we have observed for this species in the study area was 40% in 1999; in contrast, the 89% den occupancy rate in 1996 (when microtine rodent populations peaked) was the highest on record for the Colville area. Eberhardt et al. (1983) reported that in their Colville study area the percentage of arctic fox dens containing pups ranged from 6% to 55% annually over a 5-year period, whereas 56–67% showed signs of activity by adults alone. Burgess et al. (1993) estimated that between 45% and 58% of the arctic fox dens in the Prudhoe Bay Oilfield produced litters in 1992. In 1993, the occupancy rate by arctic foxes at 49 natural den sites in the Prudhoe Bay Oilfield and surrounding area was 69%, and 53% of the sites were classified as natal dens (Rodrigues et al. 1994). On Herschel Island in the northern Yukon, only 3–19% of a sample of 32 arctic fox dens examined over 5 years were used as natal dens in any one year (Smits and Slough 1993).

Pup production by arctic foxes in the CD North study area was moderate in 2000; the count of 13 pups we observed was close to the mean annual total of 13.8 pups in the study area during 1993 and 1995–2000, although still well below the highest production of 42 pups in 1996. The mean litter size of 4.3 pups for arctic foxes in 2000 was near the upper end of the range observed since 1993 (2.0–5.3 pups/litter). Den occupancy and litter sizes increase in years when microtine rodents are abundant (Garrott 1980, Johnson et al. 1997, 1999a). In 1978, when small mammals were abundant on the Colville Delta, Garrott (1980) observed seven litters (from a total of 23 active dens), which averaged 6.1 pups (range = 2–8 pups/litter). In contrast, he observed only one litter the year before (from two active dens), when small mammals were scarce, and was unable to obtain a complete litter count. The number of pups produced and the mean litter size we recorded in 2000 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 11 dens, or 64%); 4 other habitat types were used to a lesser extent (one den each)—Barrens, Moist Sedge–Shrub Meadow, Wet Sedge–Willow Meadow, and Nonpatterned Wet Meadow. 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 (Appendix D9), updating the analysis by Johnson et al. (1999a). Fifteen dens (71% of the total) were located in Riverine or Upland Shrub, the only denning habitat that was preferred. Dens in the four other habitats used actually were located in small patches of higher microrelief that are smaller than the minimal mapping size of habitat areas. Foxes avoided denning in Barrens, the second most abundant terrestrial habitat on the delta (21% of the total area).

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). Low mounds are used most often for den sites in the Teshekpuk Lake area of NPR–A west of the Colville Delta (Chesemore 1969). These observations all confirm that the primary requirement for denning habitat is well-drained soil with a texture conducive to burrowing, conditions that occur on elevated microsites within a variety of larger habitat types.

LITERATURE CITED

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix A. Common and scientific names of birds and mammals seen during wildlife surveys on the Colville River Delta, 1992–2000.

BIRDS

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

MAMMALS

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

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

Habitat	Description
Open Nearshore Water (Marine)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced by winds may raise sea level as much as 2–3 m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. This habitat is important for some species of waterfowl during molting and during spring and fall staging, and for loons while foraging.
Brackish Water	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake with Low-water Connection	Waterbodies that have been partially drained through erosion of banks by adjacent river channels, but which are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lak generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common alon the shorelines. Deeper lakes in this habitat do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes provide important overwintering habitat for fi
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, an 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 *Sedu rosea.* Salt Marsh is an important habitat for brood-rearing and molting waterfowl.
Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flats occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flats frequently are associated with lagoons and estuaries and may vary widely in salinity levels. Tidal Flats are considered separately from other barren habitats because of their importance to estuarine and marine invertebrates and shorebirds.
Salt-killed Tundra	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and which are being colonized by salt-tolerant plants. Colonizing plants include *Puccinellia andersonii, Dupontia fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, Stellaria humifusa, Cerastium beeringianum,* and *Salix ovalifolia* This habitat typically occurs either on low-lying areas that formerly supported Wet Sedge–Willow Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that formerly supported Moist Sedge–Shrub Meadows and Upland Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizing plants. These areas are often polygonized, with the rims less salt-affected than the centers of the polygons.
Deep Open Water without Islands	Deep (≥1.5 m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes; most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. They do not freeze to the bottom during winter. Lakes usually are not connected to rivers. Sediments are fine-grained silt and clay. Deep Open Waters without Islands are differentiated from those with islands because of the importance of islands to nesting waterbirds.

Appendix B1. (Continued)

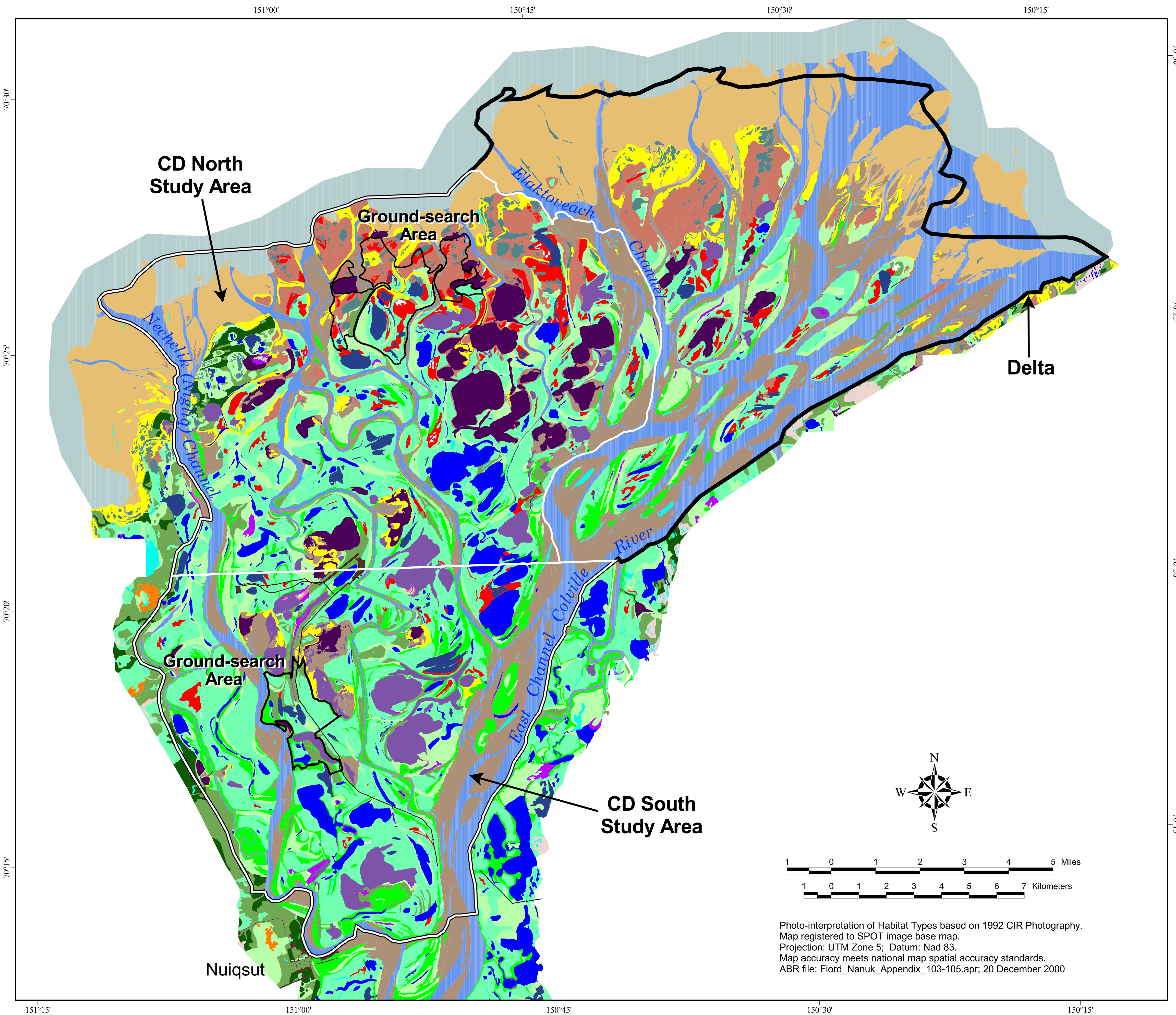
Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many species of waterbirds.
Shallow Open Water without Islands	Ponds and small lakes <1.5 m deep with emergent vegetation covering <5% of the waterbody surface. Due to the shallow depth, water freezes to the bottom during winter and thaws by early to mid-June. Maximal summer temperatures are higher than those in deep water. Although these ponds generally are surrounded by wet and moist tundra, ponds located in barren areas also are included in this category. Sediments are fine-grained silt and clay.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex shorelines characterized by low-center polygons. Distinguished from Shallow Open Water without Islands because shoreline complexity appears to be an important feature of nesting habitat for many species of waterbirds.
River or Stream	Permanently flooded channels of the Colville River and its tributaries and smaller stream channels in the Transportation Corridor. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of the Colville River Delta are slightly saline, whereas streams in the Transportation Corridor are non-saline. During winter unfrozen water in deeper channels can become hypersaline.
Aquatic Sedge Marsh	Permanently flooded waterbodies or margins of waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤0.3 m deep. Water and bottom sediments of this shallow habitat freeze completely during winter, but the ice melts in early June. The sediments generally consist of a peat layer (0.2–0.5 m deep) overlying fine-grained silt.
Aquatic Sedge with Deep Polygons	Primarily a coastal habitat in which thermokarst of ice-rich soil has produced deep (>1 m), permanently flooded polygon centers. Emergent vegetation, mostly *C. aquatilis,* usually is found around the margins of the polygon centers. Occasionally, centers will have the emergent grass *Arctophila fulva*. Polygon rims are moderately well drained and dominated by sedges and dwarf shrubs, including *Dryas integrifolia*, *Salix reticulata, S. phlebophylla,* and *S. ovalifolia.*
Aquatic Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva*. Due to shallow water depths (<1 m), the water freezes to the bottom in the winter, and thaws by early June. *Arctophila* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in the thaw lake cycle and is more productive than Aquatic Sedge Marsh. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (ice-poor)	Basin wetland complexes (both young and old) occur in drained lake basins and are characterized by a complex mosaic of open water, aquatic sedge and grass marshes, and wet and moist meadows in patches too small (<0.5 ha) to map individually. Deeper basins may be entirely inundated during spring breakup. Water levels gradually recede following breakup. Basins often have distinct upland rims marking the location of old shorelines, although boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw-lake stages. Soils generally are fine-grained, organic-rich, and ice-poor in the young type. The lack of ground ice results in poorly developed polygon rims in wetter areas and indistinct edges of waterbodies. Ecological communities within younger basins appear to be much more productive than are those in older basins, which is the reason for differentiating between the two types of basin wetland complexes.

Appendix B1. (Continued)

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

Appendix B1. (Continued)

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

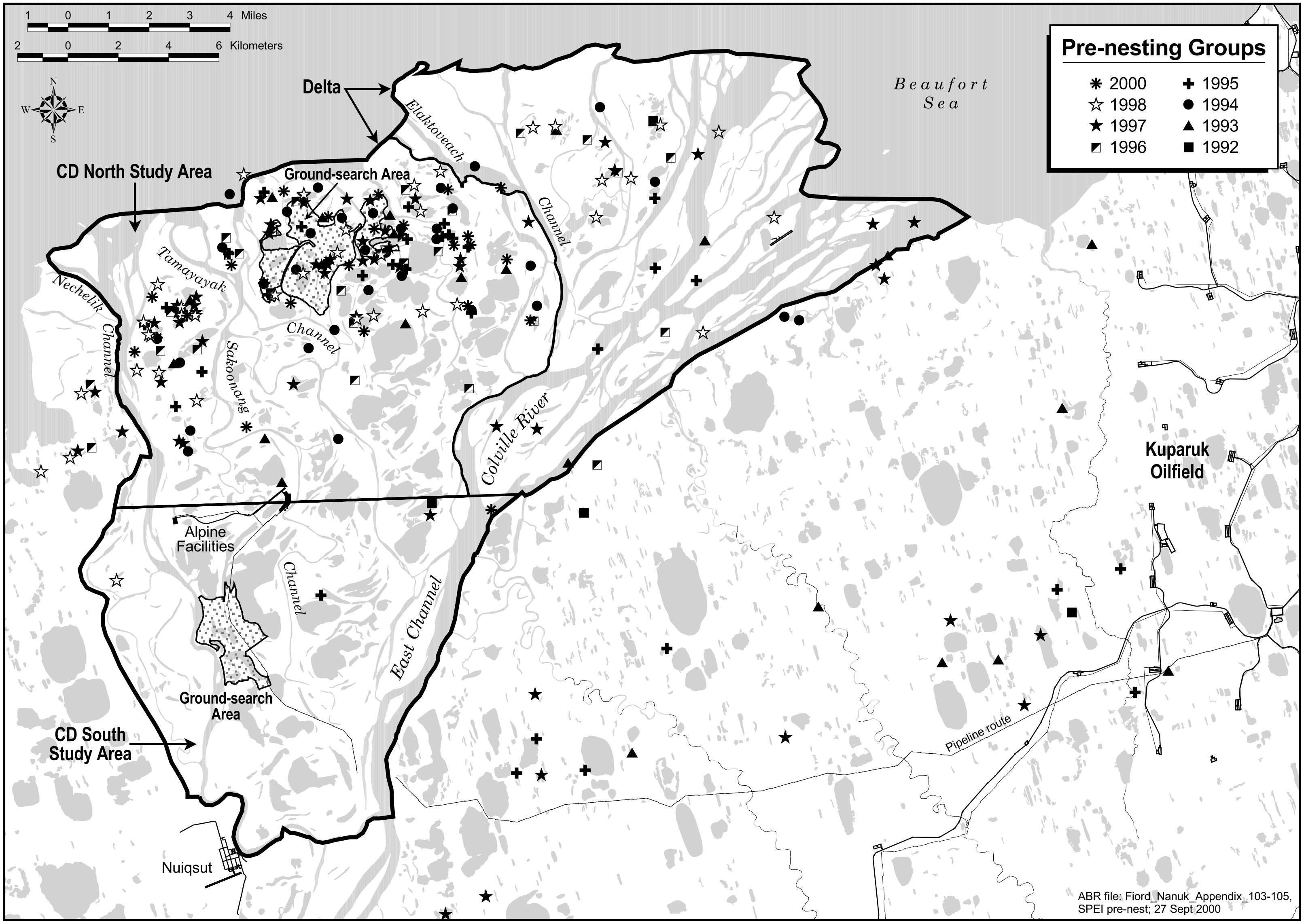


Wildlife Habitat Types

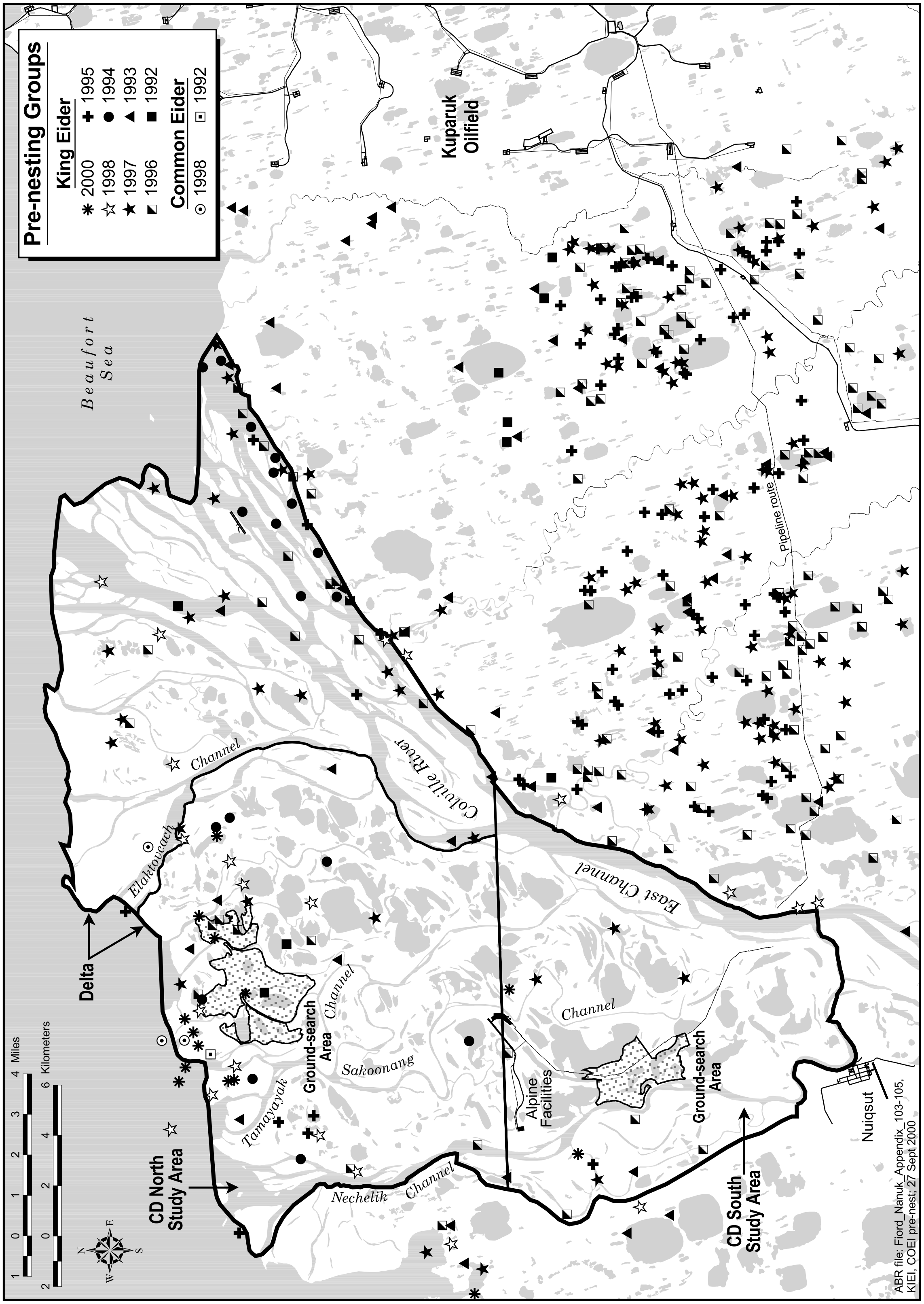
- Open Nearshore Water (marine)
- Brackish Water
- Tapped Lake w/ Low-water Connection
- Tapped Lake w/ High-water Connection
- Salt Marsh
- Tidal Flat
- Salt-killed Tundra
- Deep Open Water w/o Islands
- Deep Open Water w/ Islands or Polygonized Margins
- Shallow Open Water w/o Islands
- Shallow Open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

Pipeline Route

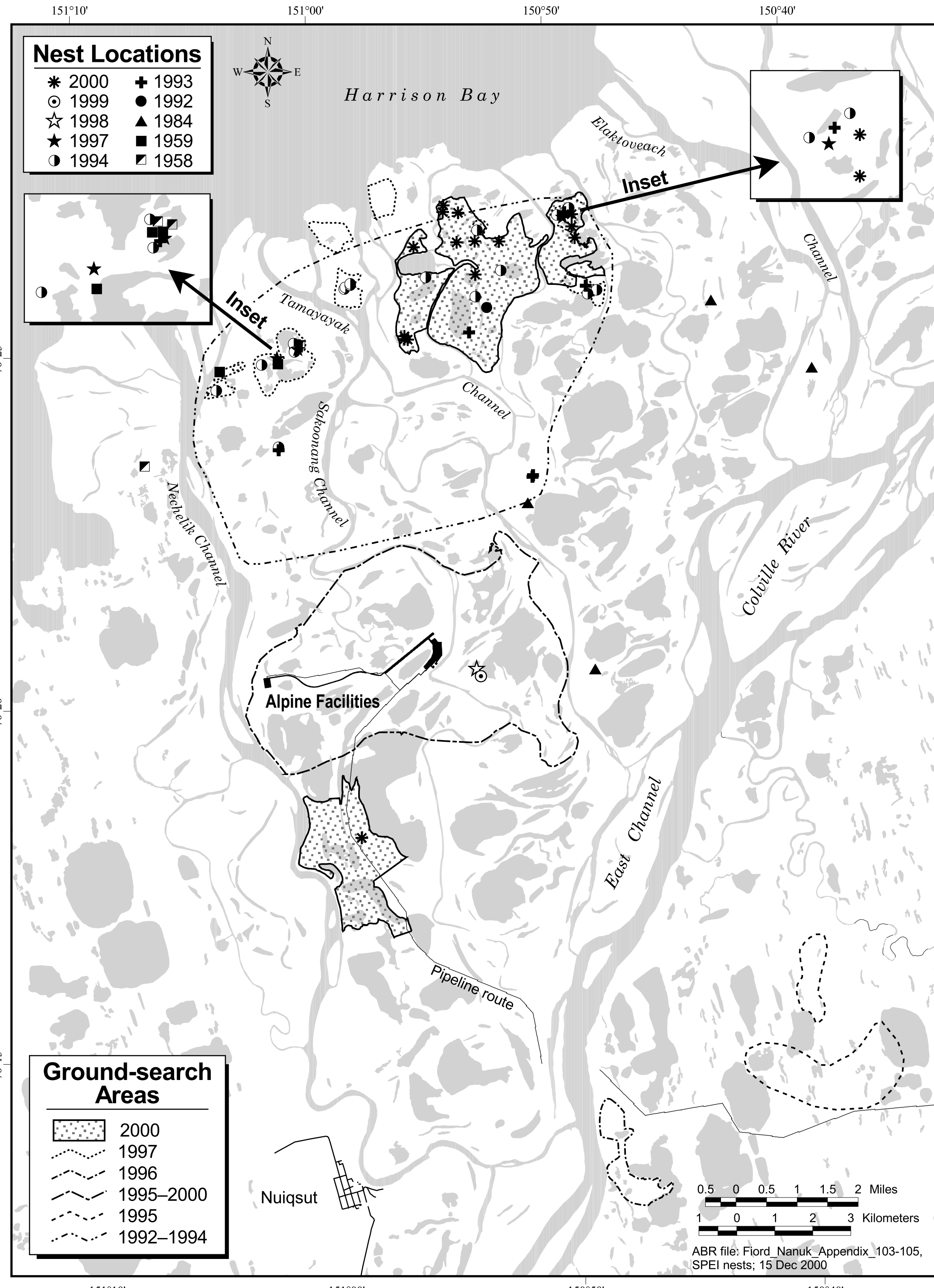
Appendix B2. Wildlife habitats on the Colville River Delta, Alaska.



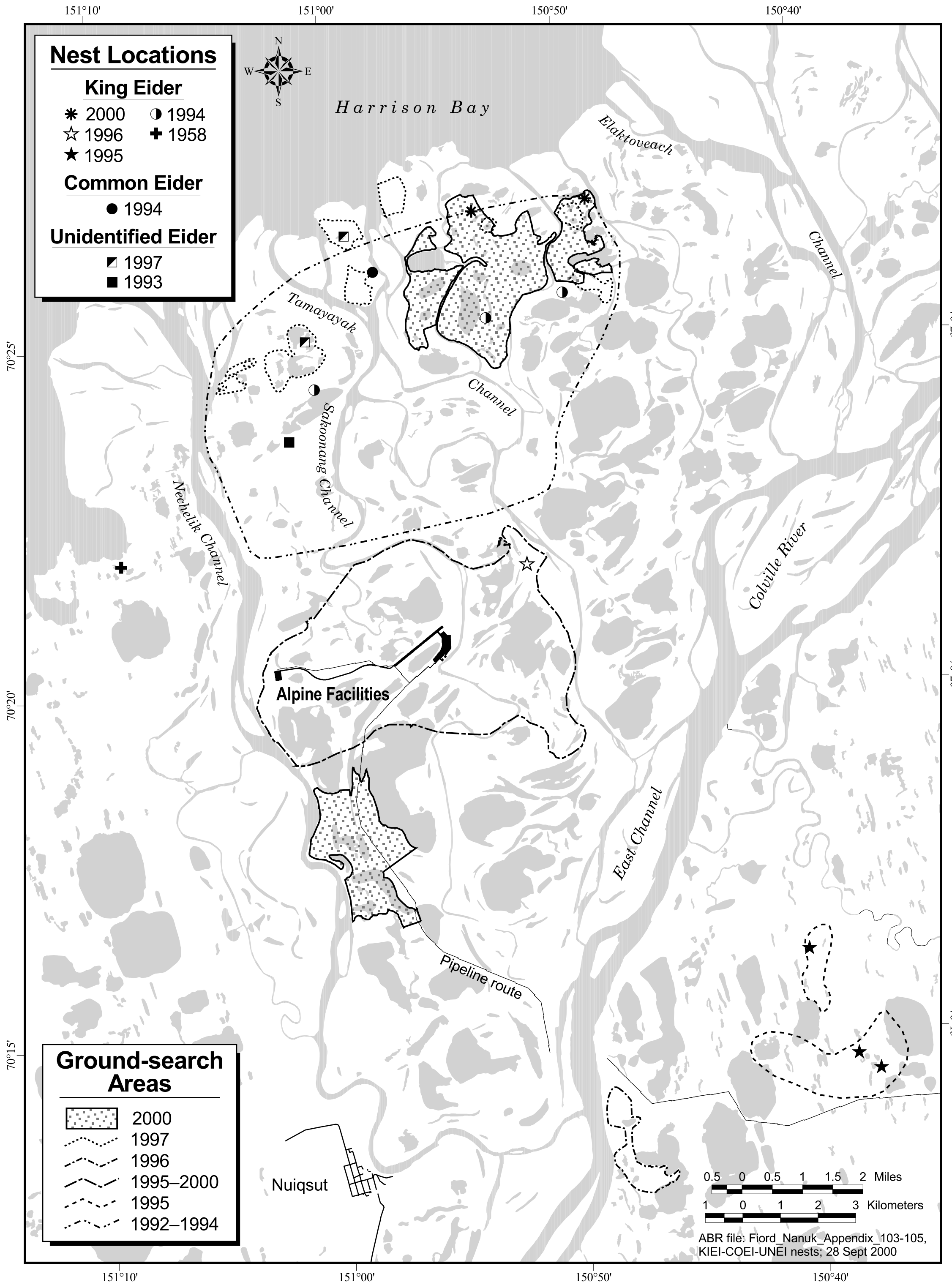
Appendix C1. Distribution of Spectacled Eider groups recorded during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).



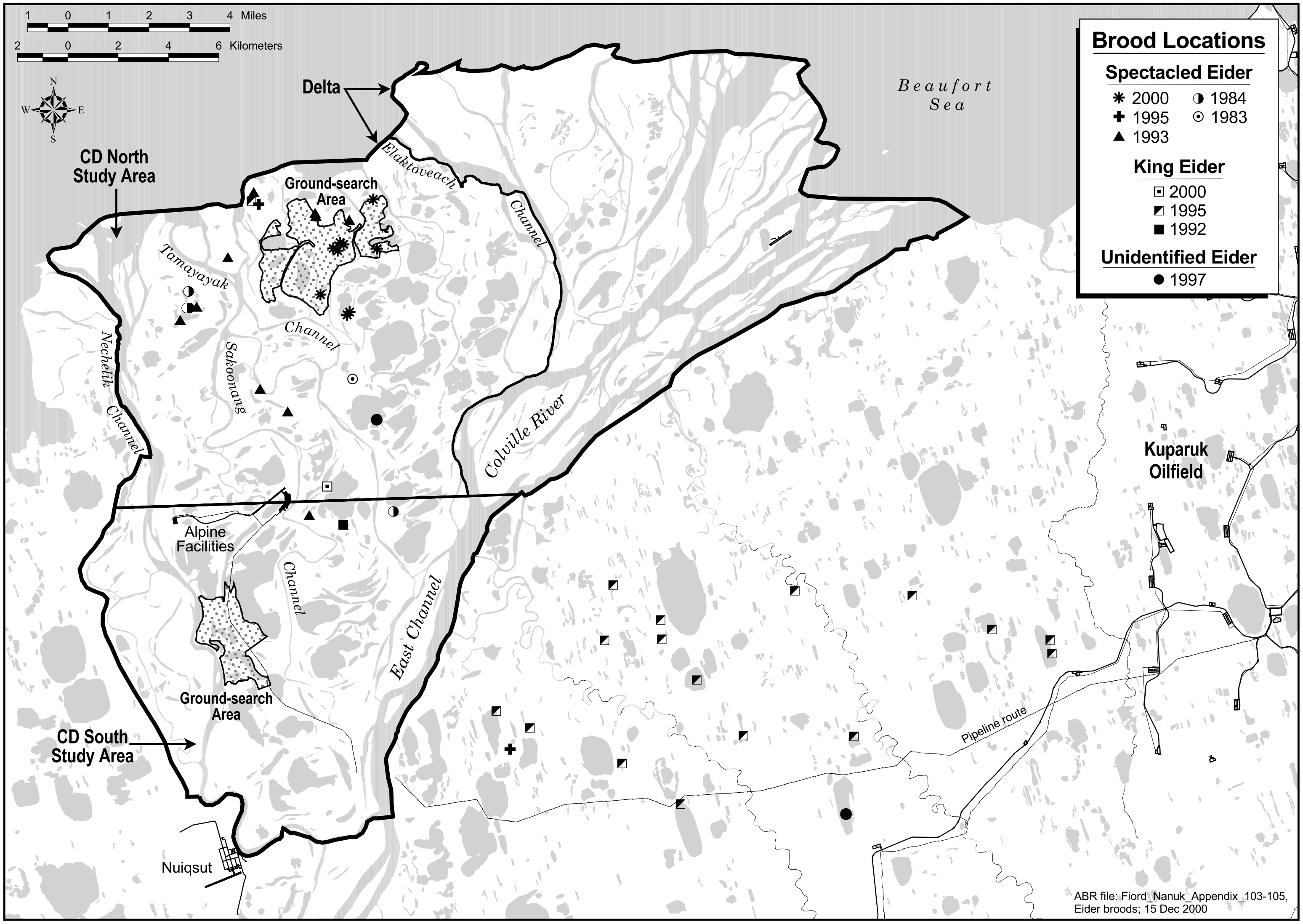
Appendix C2. Distribution of King and Common eider groups recorded during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).



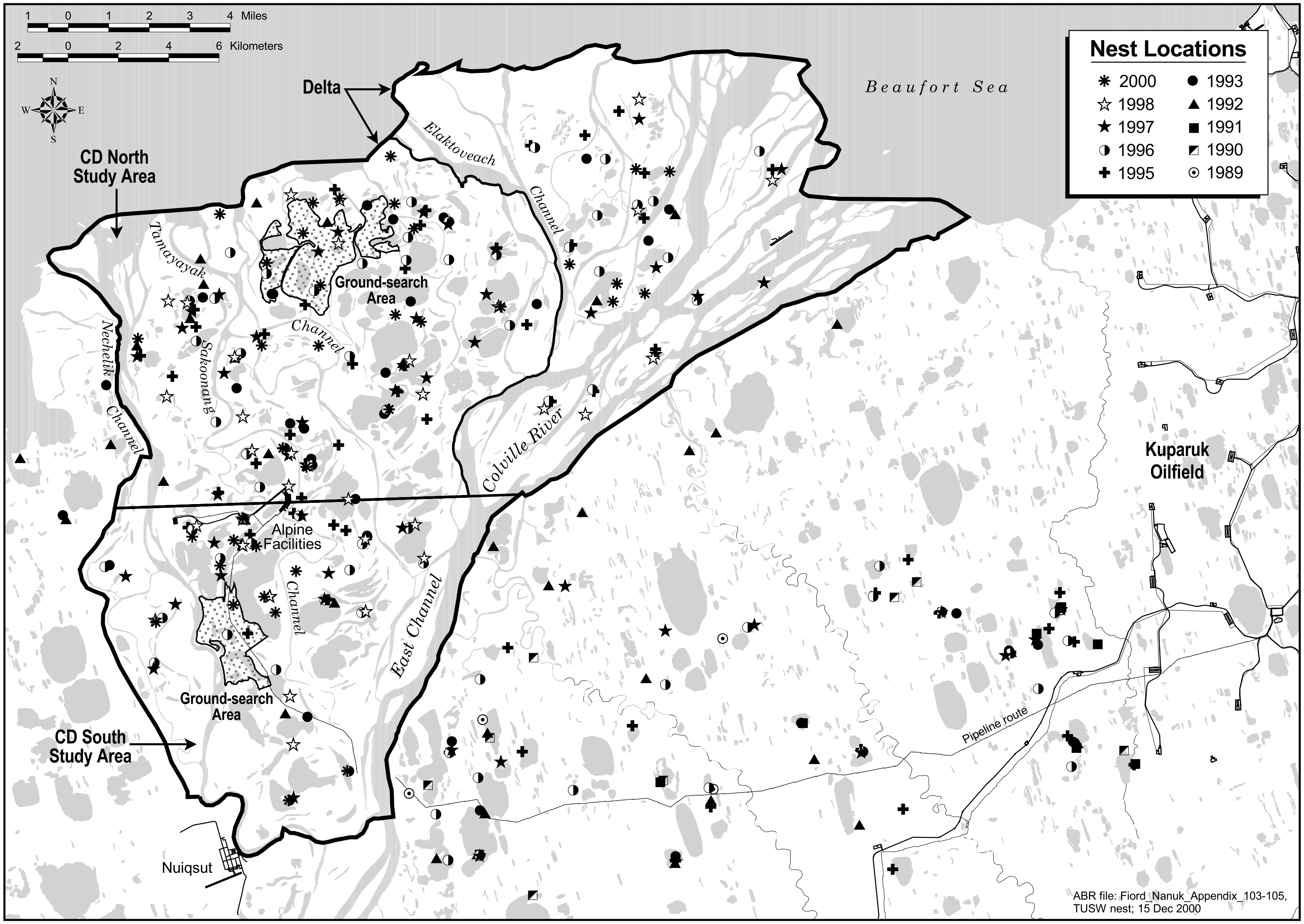
Appendix C3. Distribution of Spectacled Eider nests located during ground searches on the Colville River Delta, Alaska, 1958, 1959, 1984, 1992–1994, and 1997–2000. Pre-2000 data are from T. Myres (1958, 1959, unpubl. data), M. North (1984, unpubl. data), Smith et al. (1993, 1994), Johnson et al. (1999a) and Johnson et al. (2000). Survey coverage was not uniform over the areas portrayed.



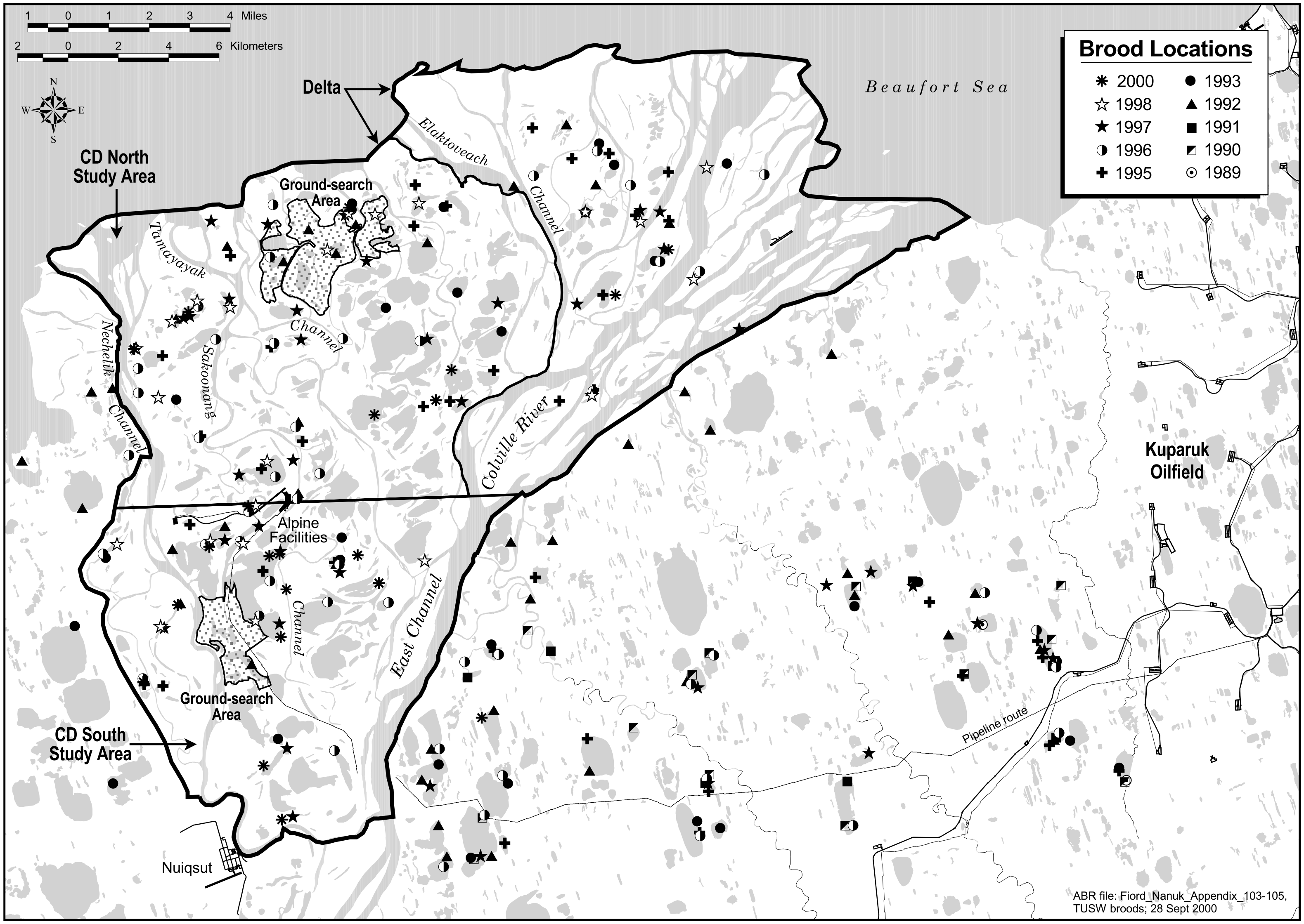
Appendix C4. Distribution of King, Common, and unidentified eider nests located during ground searches on the Colville River Delta, Alaska, 1958, 1993–1997, and 2000. Pre-2000 data are from T. Myres (1958, unpubl. data), Smith et al. (1993, 1994), Johnson et al. (1999a) and Johnson et al. (2000). Survey coverage was not uniform over the areas portrayed.



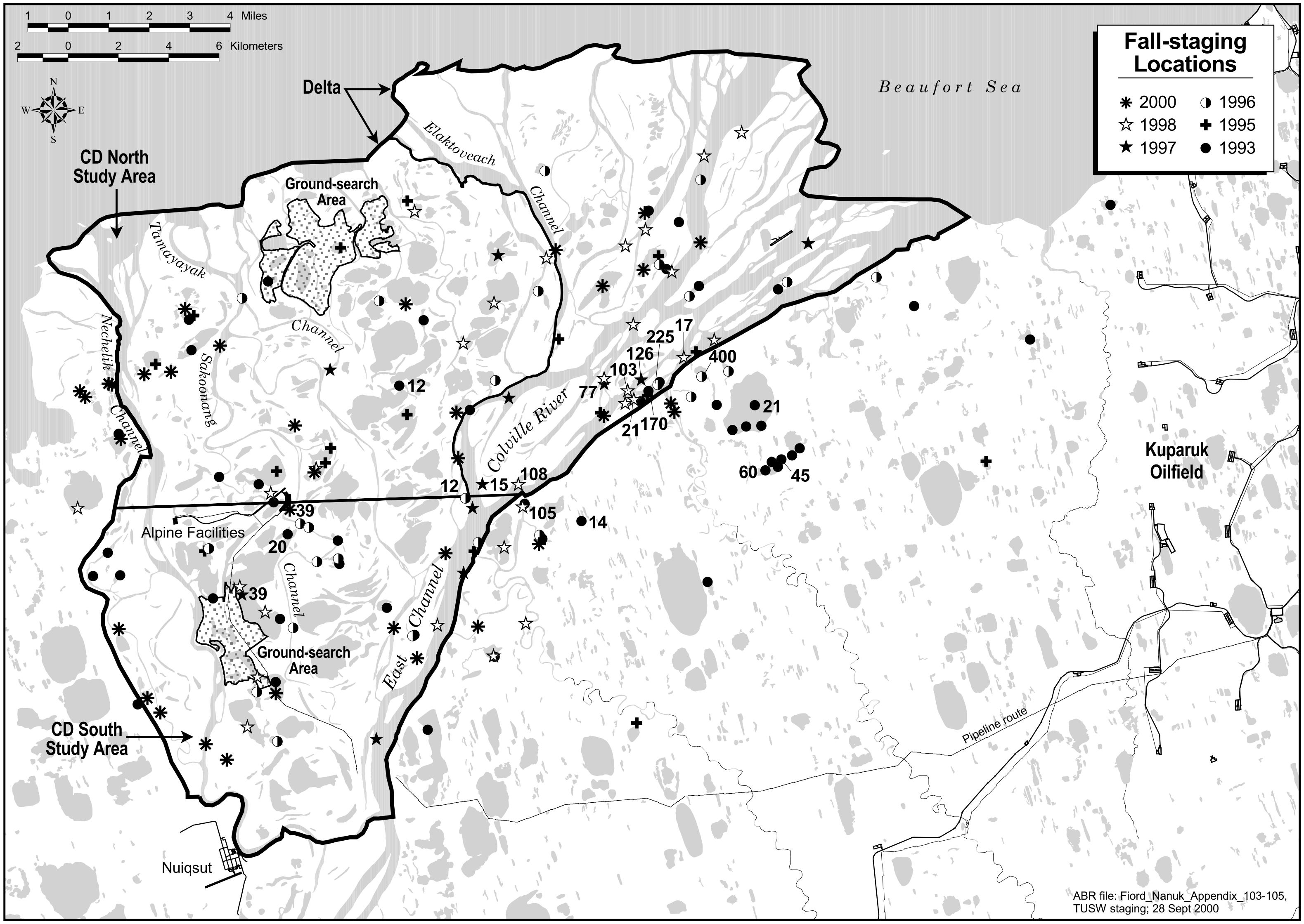
Appendix C5. Distribution of Spectacled, King, and unidentified eider broods recorded during aerial and ground surveys in the CD North and CD South study areas, Colville River Delta, Alaska, 1983, 1984, 1992, 1993, 1995, 1997, and 2000. Pre-2000 data are from M. North (1983, 1984, unpubl. data), Smith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



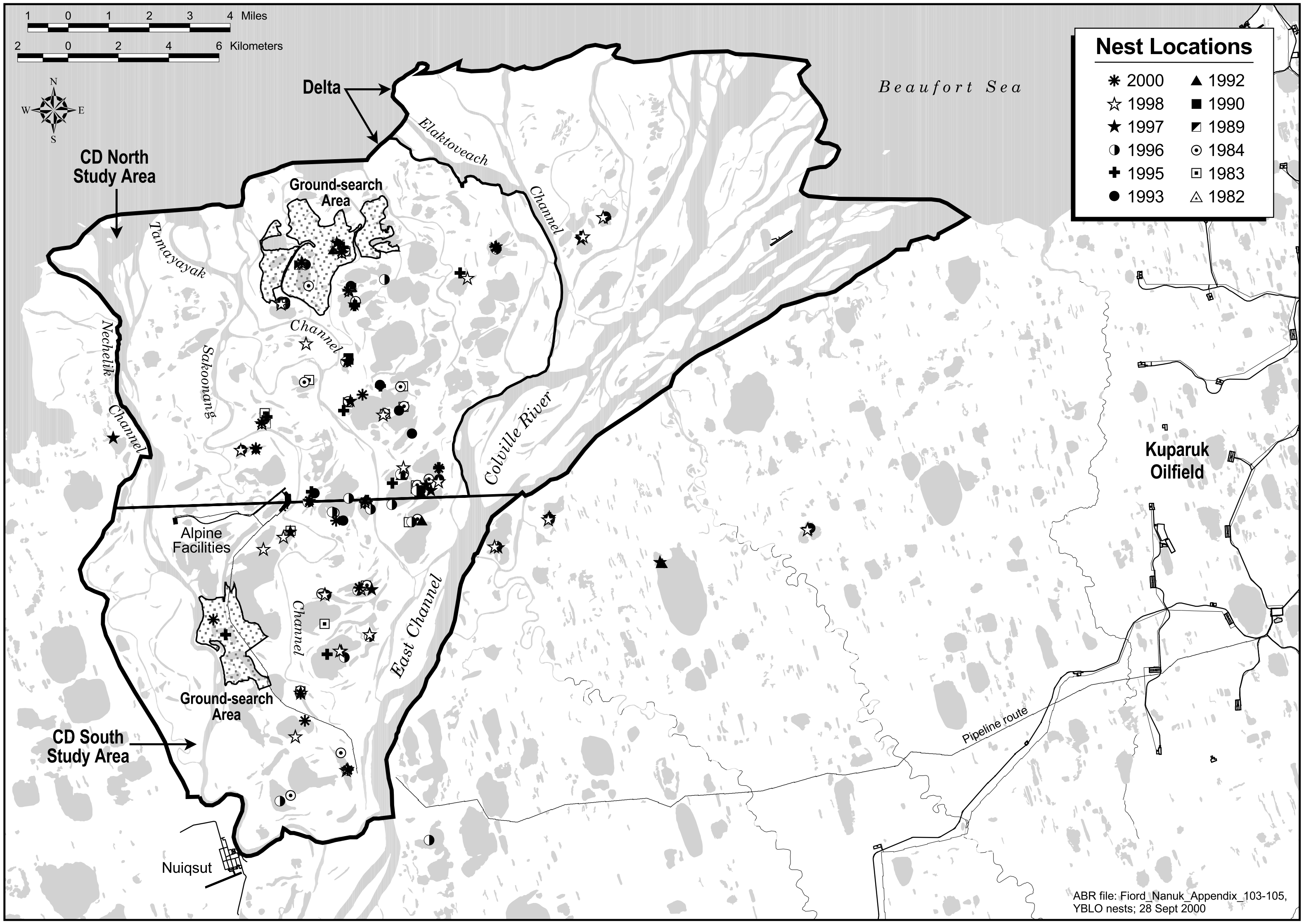
Appendix C6. Distribution of Tundra Swan nests recorded during aerial and ground surveys in the vicinity of the Colville River Delta, Alaska, 1989–1993, 1995–1998, and 2000. Pre-2000 data are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), Smith et al. (1993, 1994), and Johnson et al.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



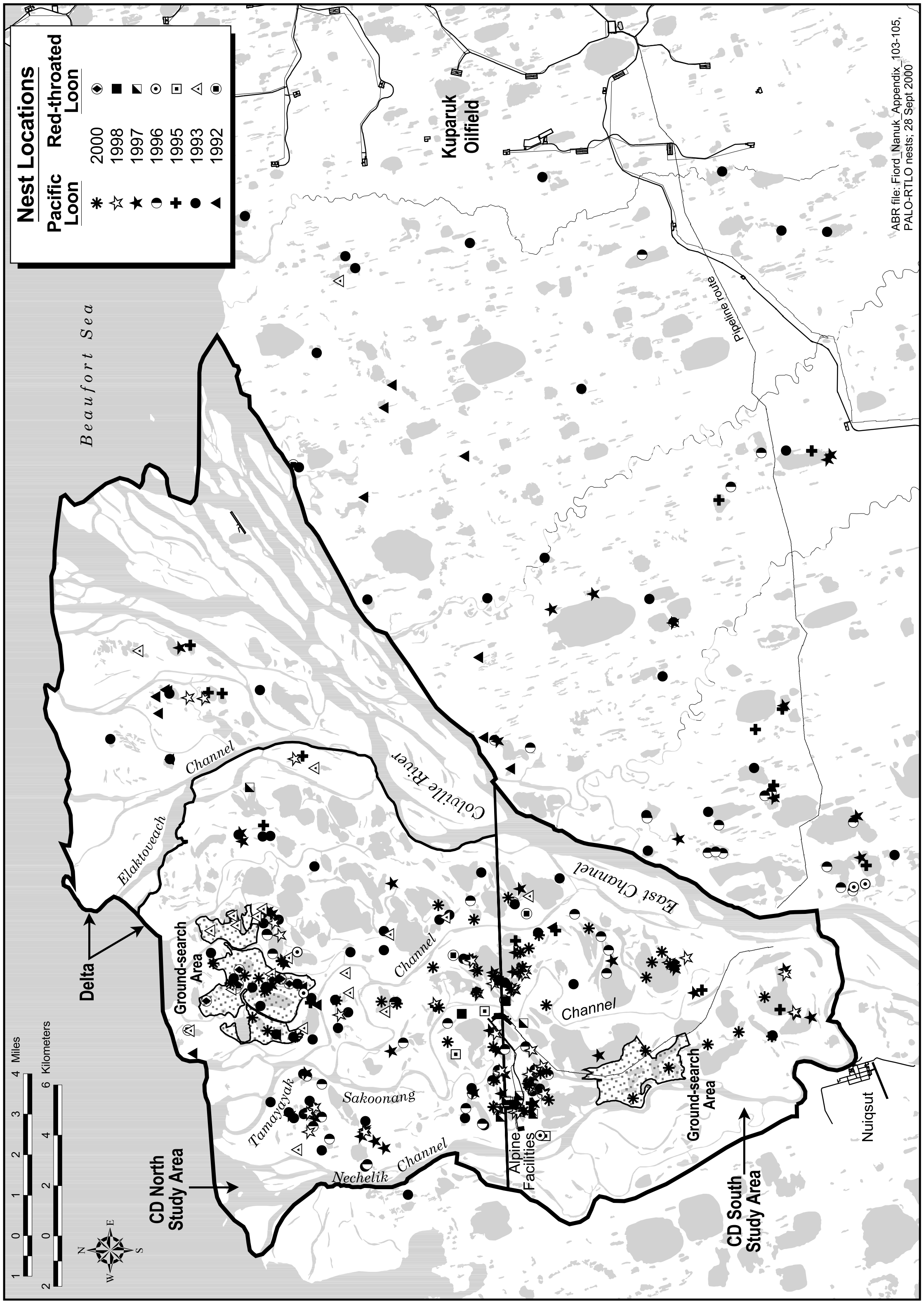
Appendix C7. Distribution of Tundra Swan broods recorded during aerial and ground surveys in the vicinity of the Colville River Delta, Alaska, 1989–1993, 1995–1998, and 2000. Pre-2000 data are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), Smith et al. (1993, 1994), and Johnson et al.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



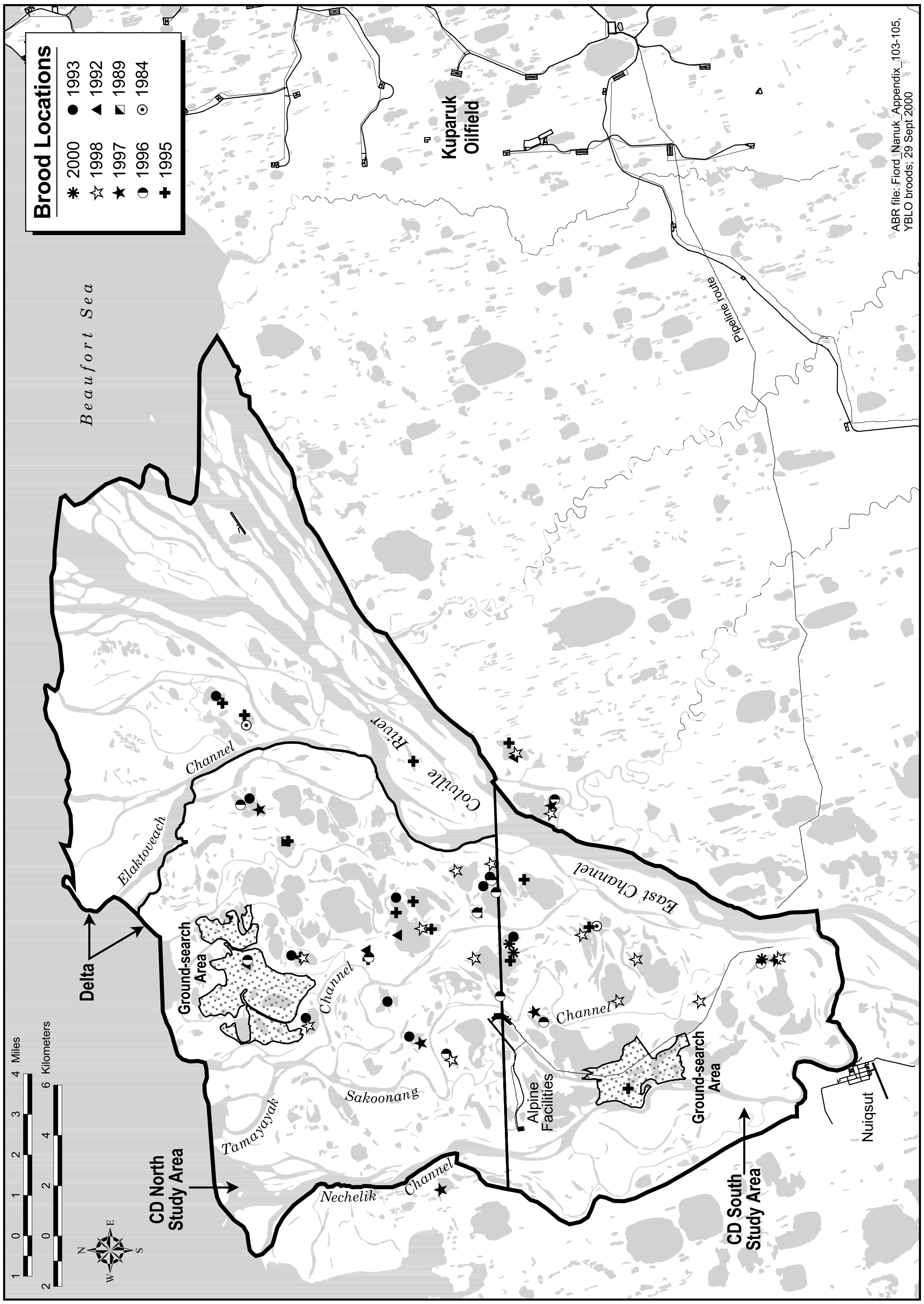
Appendix C8. Distribution of Tundra Swan fall-staging groups recorded during aerial surveys on the Colville River Delta, Alaska, 1993 and 1995–1998, and 2000. Numbers indicate size of groups >10. Pre-2000 data are from Smith et al. (1994) and Johnson et al. (1999a).



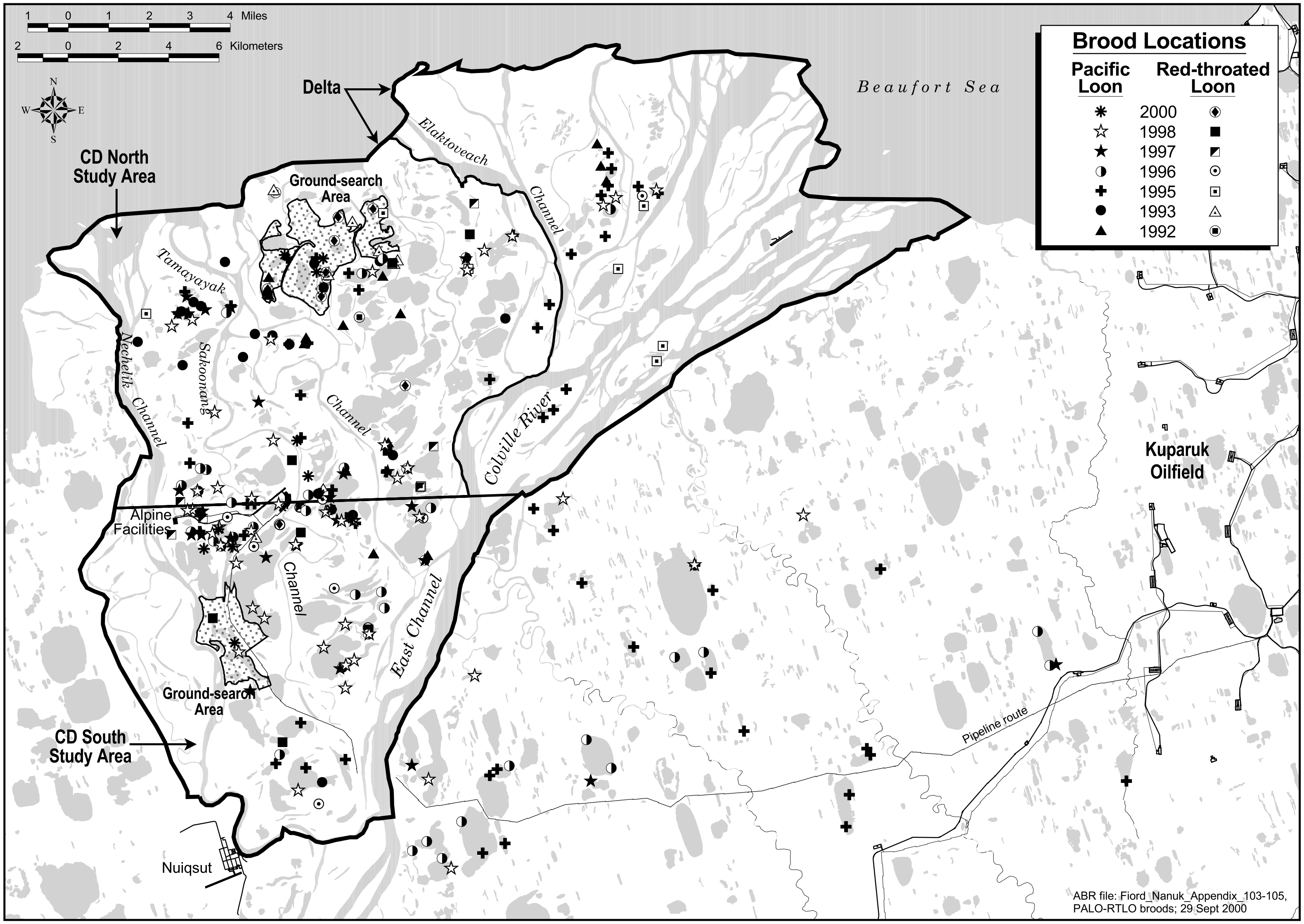
Appendix C9. Distribution of Yellow-billed Loon nests recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1982–1984, 1989, 1990, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from M. North (1982–1984, 1989, 1990, unpubl. data), Smith et al. (1993, 1994), S. Earnst (1995–1997,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



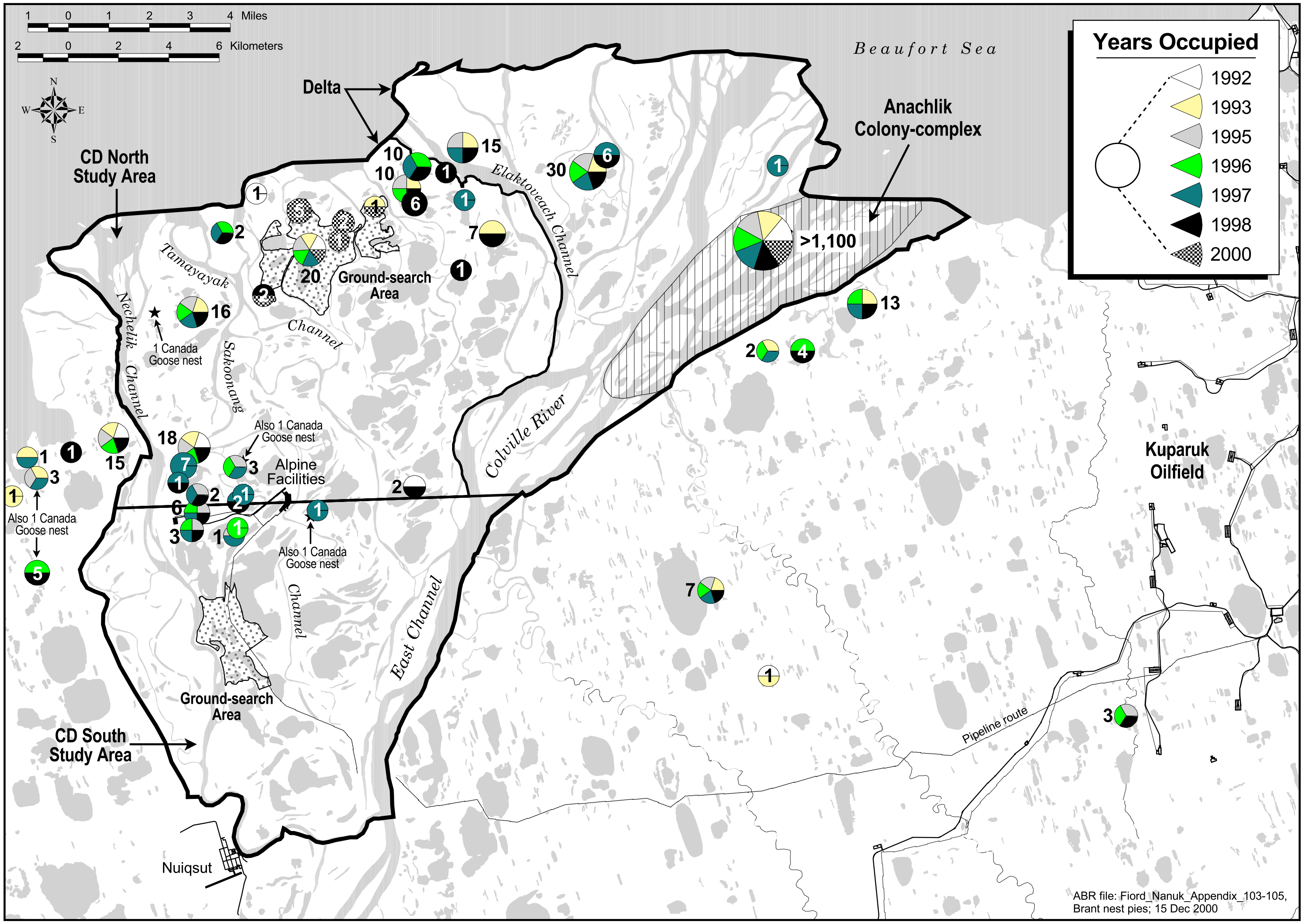
Appendix C10. Distribution of Pacific and Red-throated loon nests recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Smith et al. (1993, 1994) and Johnson et al. (1999a). Survey coverage was not uniform over the area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



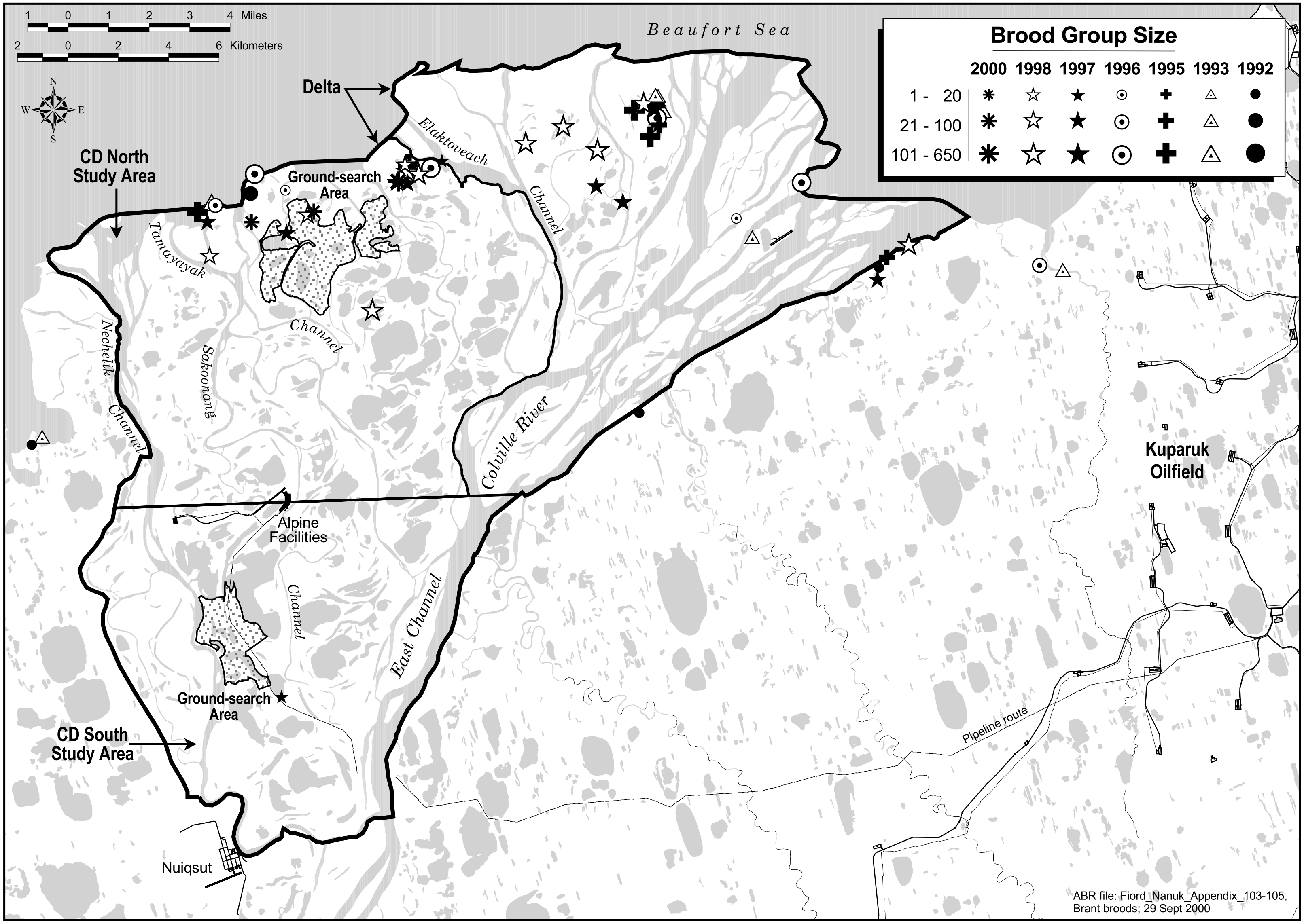
Appendix C11. Distribution of Yellow-billed Loon broods recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1984, 1989, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from M. North (1984, 1989, unpubl. data), Smith et al. (1993, 1994), S. Earnst (1996, unpubl. data), and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



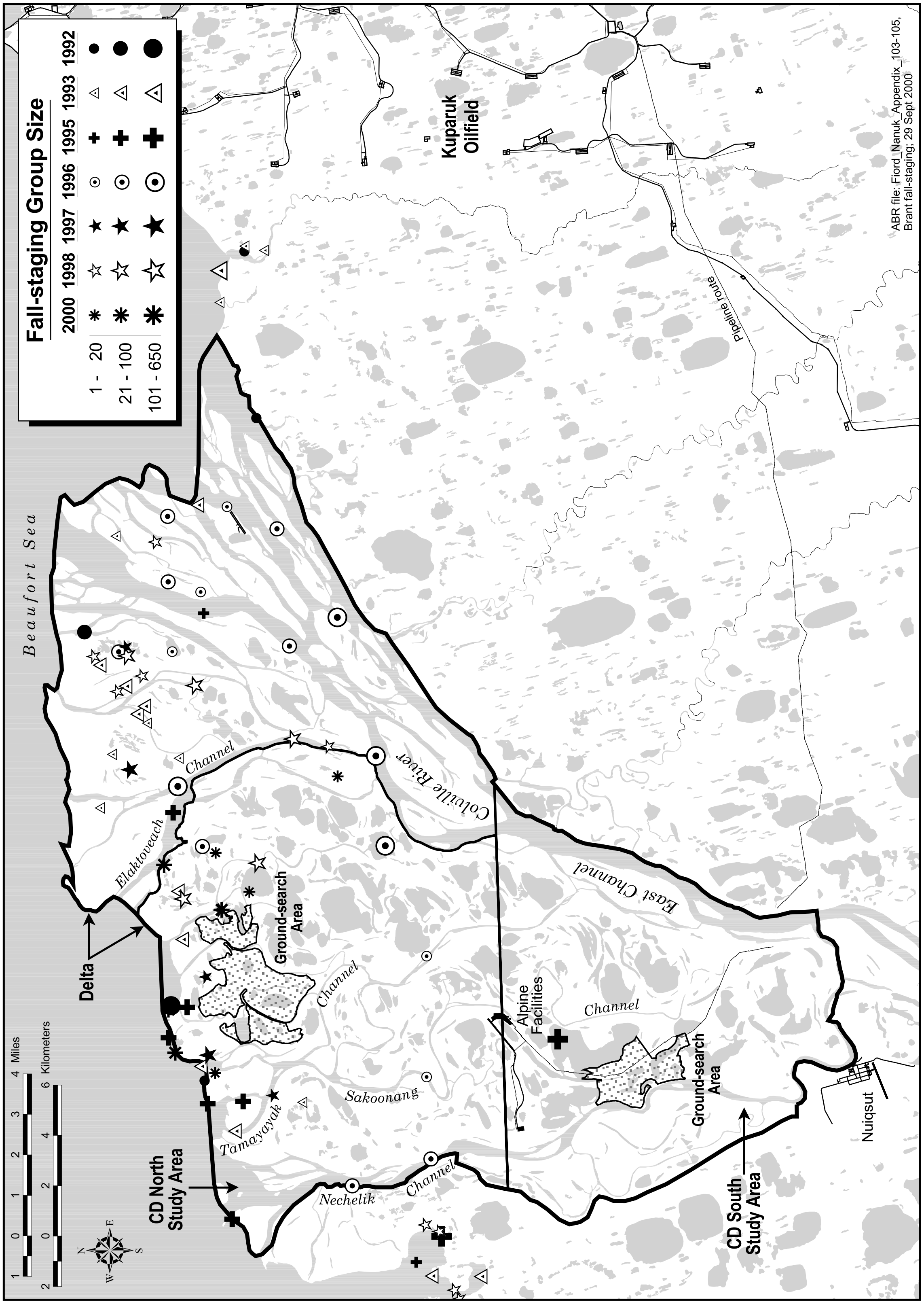
Appendix C12. Distribution of Pacific and Red-throated loon broods recorded during aerial and ground surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Smith et al. (1993, 1994) and Johnson et al. (1999a). Survey coverage was not uniform over the area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



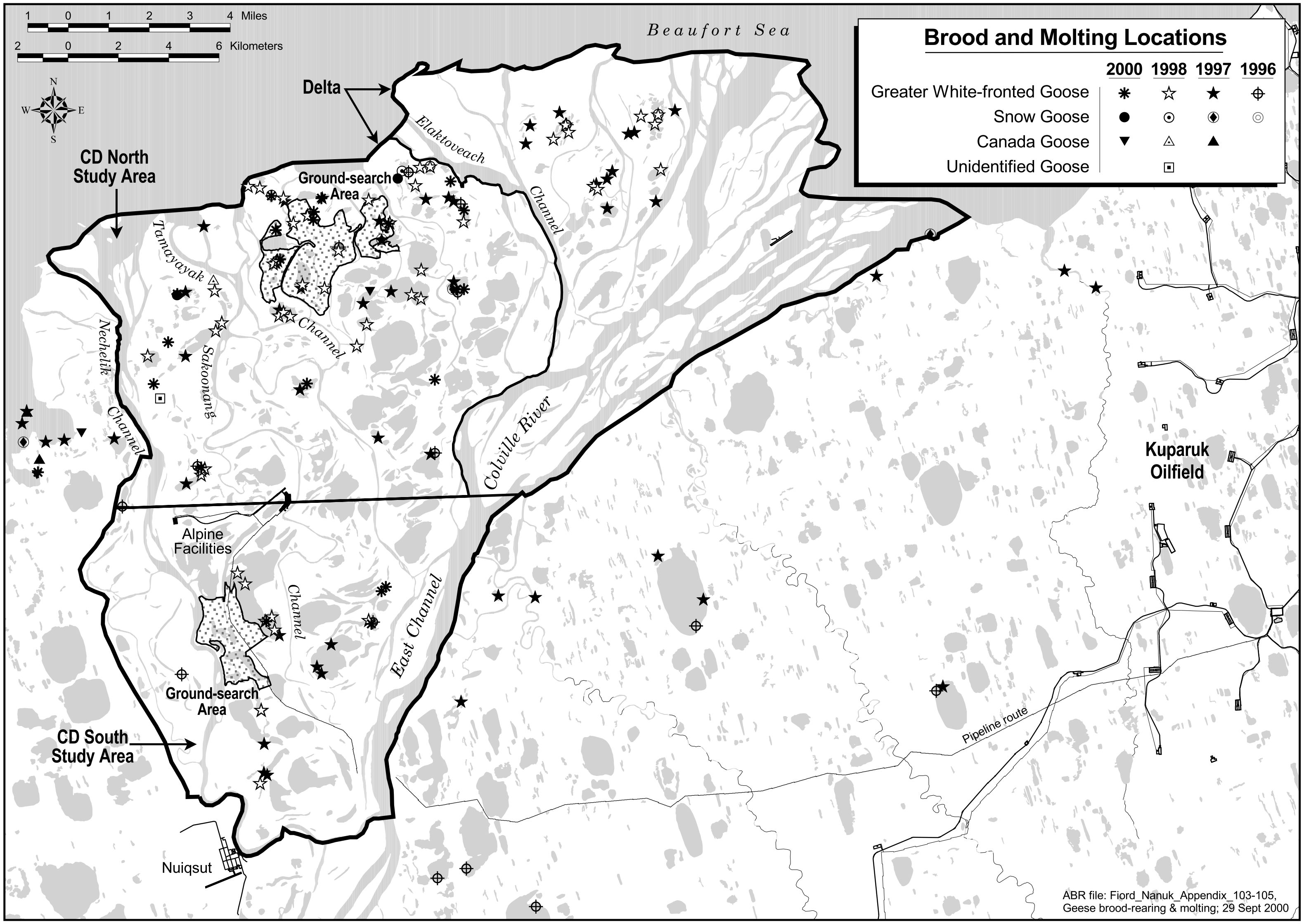
Appendix C13. Distribution and size of Brant colonies and Canada Goose nests located during aerial and ground surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Smith et al. (1993, 1994) and Johnson et al. (1999a). The number near each circle represents the maximal number of nests counted during the 7 years of study.



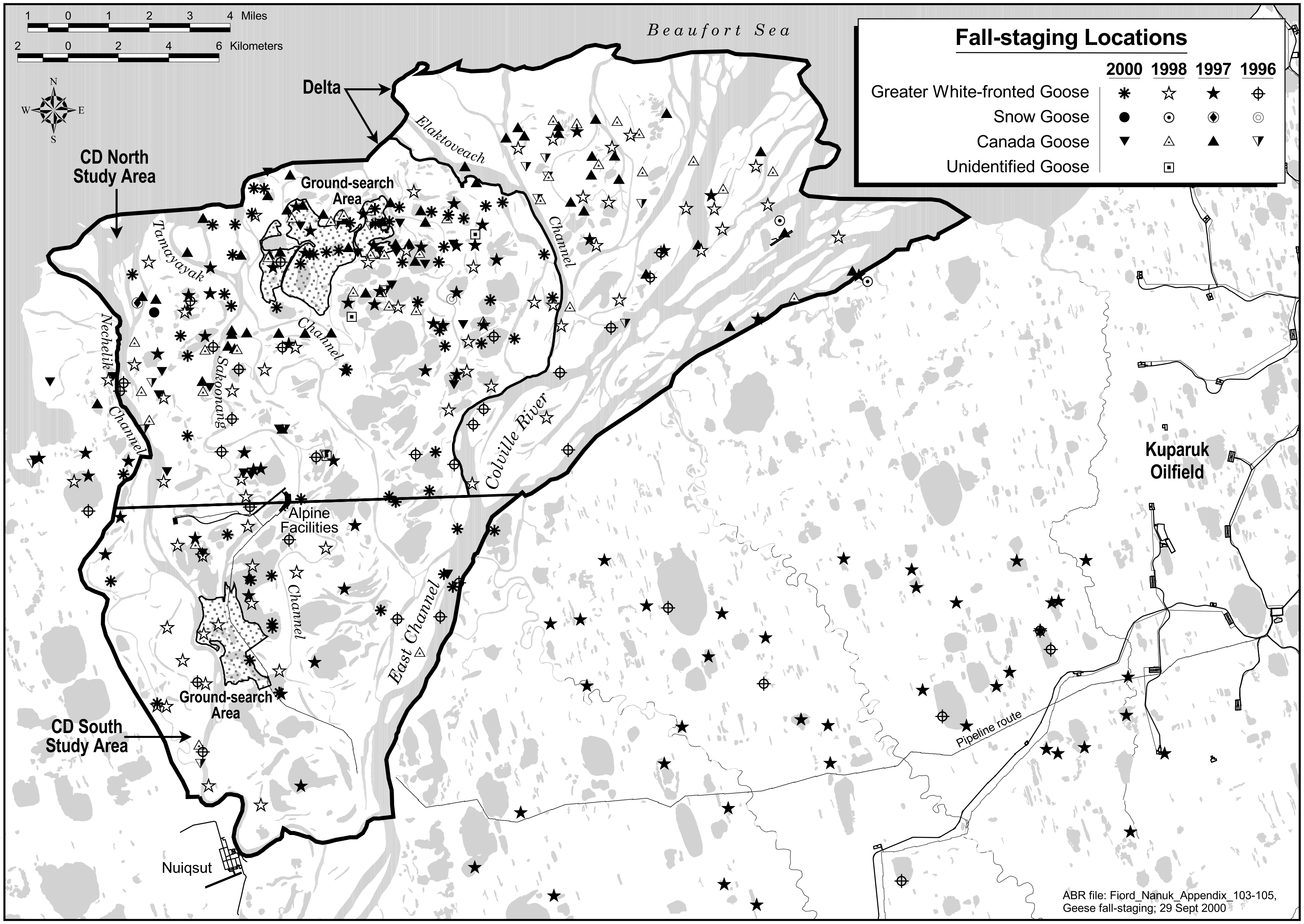
Appendix C14. Distribution and size of Brant brood-rearing groups recorded during aerial surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Smith et al. (1993, 1994) and Johnson et al. (1999a).



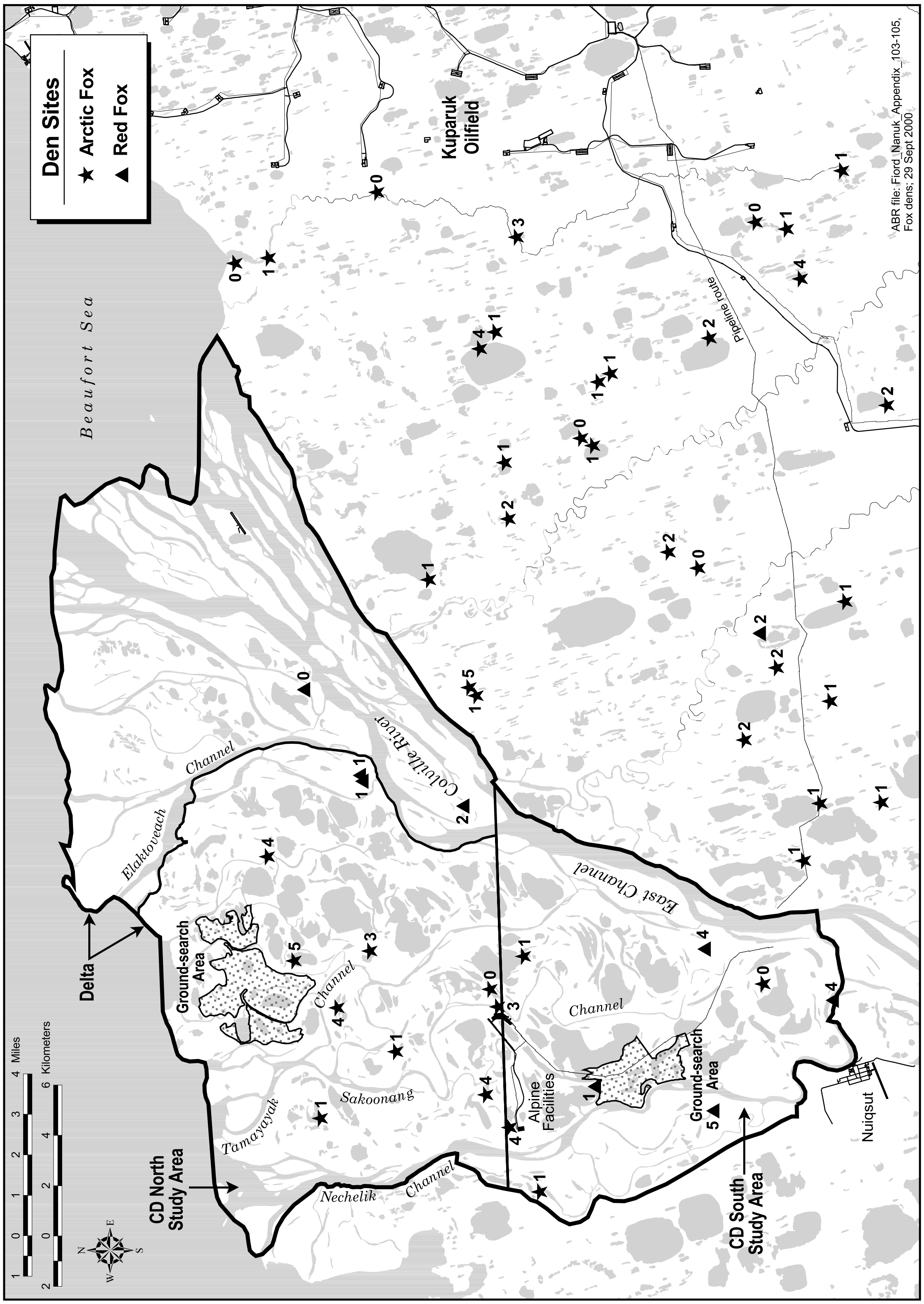
Appendix C15. Distribution and size of Brant fall-staging groups recorded during aerial surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Smith et al. (1993, 1994) and Johnson et al. (1999a).



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



Appendix C18. Distribution of arctic and red fox dens found during aerial and ground surveys in 1992, 1993, and 1995–2000 on Colville River Delta, Alaska. Survey coverage was not uniform over the area portrayed. Numbers represent years active. Pre-2000 data are from Johnson et al. (2000).

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

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

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

Appendix D2. Habitat use by Spectacled Eiders during nesting on the Colville River Delta, Alaska, 1992–1994, 1997–1999, and 2000. Pre-2000 data are from Johnson et al. (1999a). Nests were found during ground searches of selected portions of the study area. No nests were found in 1995 or 1996.

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

[a] Total includes seven unoccupied nests for which we used contour feathers to identify the eider species.
[b] Nearest waterbody (≥0.25 ha in size) was measured from the digital map.

Appendix D3. Habitat use by Spectacled and King eiders during brood-rearing on the Colville River Delta, Alaska, 1992, 1993, 1995, and 2000. Pre-2000 data are from Johnson et al. (1999a). Broods were located during both aerial and ground surveys.

Habitat Type	No. of Brood-rearing Groups	No. of Young	Use (%)
SPECTACLED EIDER			
Brackish Water	3	11	15.0
Tapped Lake w/ Low-water Connection	1	3	5.0
Salt-killed Tundra	4	22	20.0
Deep Open Water w/out Islands	3	8	15.0
Deep Open Water w/ Islands or Polygonized Margins	4	12	20.0
Aquatic Sedge w/ Deep Polygons	1	4	5.0
Aquatic Grass Marsh	1	4	5.0
Wet Sedge–Willow Meadow	3	14	15.0
Total	20	78	100
KING EIDER			
Aquatic Sedge w/ Deep Polygons	1	7	50.0
Wet Sedge–Willow Meadow	1	5	50.0
Total	2	12	100

Appendix D4. Numbers and densities of Tundra Swan nests and broods counted on aerial surveys of the Colville River Delta, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).

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

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

Appendix D5. Habitat selection (pooled among years) by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River, Alaska, 1992, 1993, 1995–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).

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

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

Appendix D6. Numbers and densities of Tundra Swan adults and young counted during fall staging surveys on the Colville River Delta, Alaska, 1993, 1995–1996, and 2000. Pre-2000 data are from Johnson et al. (1999a).

	Adults		Young		
Year	No.	Density (no./km^2)	No.	Density (no./km^2)	Number of Groups
2000	66	0.12	23	0.04	34
1998	411	0.75	20	0.04	26
1997	194	0.35	92	0.17	11
1996	314	0.57	41	0.07	21
1995	28	0.05	36	0.07	15
1993	260	0.47	35	0.06	28
1992	0	–	0	–	0

Appendix D7. Habitat selection (pooled among years) by Yellow-billed Loons during nesting and brood-rearing in the Delta survey area, Colville River, Alaska, 1993, 1995–1998, and 2000. Pre-2000 data are from Johnson et al. (1999a).

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

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

Appendix D8. Habitat selection (pooled among years) by nesting and brood-rearing Brant in the Outer Delta survey area, Colville River, Alaska, 1993, and 1995–1998. Pre-2000 data are from Johnson et al. (1999a). Nesting was based on the cumulative locations of colonies. Data for brood-rearing did not include 1997.

Habitat	Area (km^2)	Max. Estimate of Nests	No. of Colonies/ Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING						
Open Nearshore Water (marine)	10.02	0	0	0.0	4.0	ns
Brackish Water	6.45	7	1	5.3	2.6	ns
Tapped Lake w/ Low-water Connection	5.50	0	0	0.0	2.2	ns
Tapped Lake w/ High-water Connection	2.22	0	0	0.0	0.9	ns
Salt Marsh	13.17	21	3	15.8	5.3	ns
Tidal Flat	56.01	0	0	0.0	22.5	avoid
Salt-killed Tundra	23.18	49	9	47.4	9.3	prefer
Deep Open Water w/out Islands	1.40	0	0	0.0	0.6	ns
Deep Open Water w/ Islands or Polygonized Margins	3.37	0	0	0.0	1.4	ns
Shallow Open Water w/out Islands	0.67	0	0	0.0	0.3	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.26	0	0	0.0	0.1	ns
River or Stream	48.67	0	0	0.0	19.5	avoid
Aquatic Sedge Marsh	0	-	-	-	0	-
Aquatic Sedge w/ Deep Polygons	7.38	23	4	21.1	3.0	prefer
Aquatic Grass Marsh	0.39	0	0	0.0	0.2	ns
Young Basin Wetland Complex	0-	-	-	-	0	-
Old Basin Wetland Complex	0	-	-	-	0	-
Nonpatterned Wet Meadow	15.19	16	1	5.3	6.1	ns
Wet Sedge–Willow Meadow	17.11	15	1	5.3	6.9	ns
Moist Sedge–Shrub Meadow	2.51	0	0	0.0	1.0	ns
Moist Tussock Tundra	1.69	0	0	0.0	0.7	ns
Riverine or Upland Shrub	1.22	0	0	0.0	0.5	ns
Barrens (riverine, eolian, lacustrine)	32.84	0	0	0.0	13.2	ns
Artificial (water, fill, peat road)	0.02	0	0	0.0	0.0	ns
Total	249.29	131	19	100.0	100.0	
BROOD-REARING						
Open Nearshore Water (marine)	10.02		1	2.5	4.6	ns
Brackish Water	6.33		15	37.5	2.9	prefer
Tapped Lake w/ Low-water Connection	5.11		0	0	2.3	ns
Tapped Lake w/ High-water Connection	2.07		0	0	0.9	ns
Salt Marsh	12.66		4	10	5.8	ns
Tidal Flat	56.01		4	10	25.7	avoid
Salt-killed Tundra	22.24		5	12.5	10.2	ns
Deep Open Water w/out Islands	0.60		0	0	0.3	ns
Deep Open Water w/ Islands or Polygonized Margins	1.86		0	0	0.9	ns
Shallow Open Water w/out Islands	0.49		1	2.5	0.2	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.22		0	0	0.1	ns
River or Stream	0		5	12.5	19.5	ns
Aquatic Sedge Marsh	42.41		-	-	0	-
Aquatic Sedge w/ Deep Polygons	6.17		1	2.5	2.8	ns
Aquatic Grass Marsh	0.19		0	0	0.1	ns
Young Basin Wetland Complex	0		-	-	0	-
Old Basin Wetland Complex	0		-	-	0	-
Nonpatterned Wet Meadow	9.69		0	0	4.4	ns
Wet Sedge–Willow Meadow	9.41		1	2.5	4.3	ns
Moist Sedge–Shrub Meadow	1.76		0	0	0.8	ns
Moist Tussock Tundra	1.69		0	0	0.8	ns
Riverine or Upland Shrub	0.81		0	0	0.4	ns
Barrens (riverine, eolian, lacustrine)	28.25		3	7.5	13.0	ns
Artificial (water, fill, peat road)	0.02		0	0	0.0	ns
Total	218.01		40	100	100	

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

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

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability[a] (%)	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-
Brackish Water	0	-	-	0	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-
Tapped Lake w/ High-water Connection	0	-	-	0	-
Salt Marsh	16.55	0	0	4.4	ns
Tidal Flat	56.01	0	0	14.8	ns
Salt-killed Tundra	25.64	0	0	6.8	ns
Deep Open Water w/out Islands	0	-	-	0	-
Deep Open Water w/ Islands or Polygonized Margins	0	-	-	0	-
Shallow Open Water w/out Islands	0	-	-	0	-
Shallow Open Water w/ Islands or Polygonized Margins	0	-	-	0	-
River or Stream	0	-	-	0	-
Aquatic Sedge Marsh	0	-	-	0	-
Aquatic Sedge w/ Deep Polygons	13.22	0	0	3.5	ns
Aquatic Grass Marsh	0	-	-	0	-
Young Basin Wetland Complex	<0.01	0	0	<0.1	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.54	1	4.8	11.0	ns
Wet Sedge–Willow Meadow	102.63	3	14.3	27.2	ns
Moist Sedge–Shrub Meadow	13.20	1	4.8	3.5	ns
Moist Tussock Tundra	2.55	0	0	0.7	ns
Riverine or Upland Shrub	27.58	15	71.4	7.3	prefer
Barrens (riverine, eolian, lacustrine)	78.67	1	4.8	20.8	avoid
Artificial (water, fill, peat road)	0.39	0	0	0.1	ns
Total	377.99	21	100	100	

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