WILDLIFE STUDIES IN THE CD SOUTH STUDY AREA, 2002

THIRD ANNUAL REPORT

Prepared for

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EXECUTIVE SUMMARY

This annual report presents the results from the third year of study of the wildlife resources in the CD South study area. The primary goal of ecological investigations on the Colville River Delta since 1992 has been to describe the distribution and abundance of selected species before, during, and after development-related construction. The overall goal of the study in 2002 was to continue to build the multi-year baseline data set on the use of the CD South study area by selected birds and mammals during June through August-September. Specific objectives for the CD South wildlife studies were to:

1. monitor the distribution, abundance, and habitat use of selected waterbird species during pre-nesting, nesting, brood-rearing, and fall staging;
2. evaluate the use of the specific area proposed for oilfield development by nesting and brood-rearing waterbirds,
3. locate fox dens, estimate litter sizes, and describe denning habitats, and
4. monitor the distribution of large mammals in the study area (reported in Lawhead and Prichard 2003).

Both aerial and ground surveys of wildlife were conducted. Aerial surveys were conducted in both fixed-wing aircraft and helicopters (as described below for each survey) and, between the CD South and CD North study areas, covered most of the delta. Ground surveys of nesting birds were conducted on a study plot that encompassed proposed footprints of CD South facilities. Aerial surveys focused on Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, and geese, but information on other waterbirds, such as Pacific and Red-throated loons, also was collected opportunistically. Ground surveys focused on large waterbirds, including all of the species targeted by aerial surveys plus all other waterfowl, gulls, jaegers, terns, and large shorebirds, and also including other large birds such as ptarmigan and raptors (hawks and owls). Mammalian studies focused on arctic foxes, but information on other species, such as red foxes, brown bears, moose, and muskoxen, also was collected opportunistically (large mammal studies are reported separately in Lawhead and Prichard 2003).

Habitat analyses used a GIS map of wildlife habitats that was developed for previous investigations of the Colville River Delta by Jorgenson et al. (1997). Wildlife observations were plotted on the habitat map for analysis of habitat use. Habitat selection was evaluated for Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, Brant, Greater White-fronted Geese, and foxes.

The 2002 breeding season differed from the preceding 2 years in both the timing of snowmelt and the level of meltwater floods. In 2002, spring break up came roughly 3 weeks earlier than usual and without the excessive flooding of low-lying and coastal areas that has been experienced in recent years. Warm temperatures and minimal snowfall in May accelerated snowmelt. The monthly mean temperature in May 2002 was 7 to 9 degrees warmer than 2000 and 2001. Limited snow cover and low water levels in 2002 allowed earlier access to nesting habitat for many species of birds.

LARGE WATERBIRD GROUND SEARCHES

Ground-based nest searches were conducted in a study plot that encompassed the proposed project facilities. Nest searches were conducted in mid–late June 2000–2002. Nests of waterbirds were revisited after hatch to determine nest fate (waterfowl in mid–July, loons in mid–August). A total of 23 species have been recorded nesting in the CD South ground-search area since surveys were initiated in 2000. In 2002, 79 nests of 16 species of birds were located in the ground-search area. In all years, the most common nesting birds were Greater White-fronted Geese, Willow Ptarmigan, and Northern Pintails (this survey excludes nests of small shorebirds and songbirds).

Broods of 12 species have been observed in the CD South ground-search area since 2000. In 2002, 22 broods of 8 species were observed. In each year, the most abundant brood-rearing species observed was Greater White-fronted Goose, with between 5 (2002) and 15 (2001) broods observed each year. Only 4 other species have been

represented by >2 broods during ground-searches in any year.

For all of the large birds included in the nest search, the overall density of nests was 7.9 nests/km² in the 2002 ground-search area. The density of waterbird nests was 7.1 nests/km². The densities of total nests and of waterbird nests were similar in 2001 and 2002 and nearly 50% higher in 2000.

EIDER SURVEYS

Pre-nesting aerial surveys for eiders were conducted in mid–June 2000–2002. In 2002, all Spectacled Eiders observed on the delta during pre-nesting were in groups of 1–3 birds and these relatively small groups appeared to have already dispersed into breeding habitats. We suspect that the breeding phenology of eiders was more advanced at the time of our surveys in 2002 than it was during surveys in previous years. No eiders were observed in the CD South study area during the pre-nesting survey in 2002. In 9 years of surveys, the number of eiders observed in the CD South study area has ranged from 0 to 11. Although neither species is abundant, King Eiders tend to outnumber Spectacled Eiders (in 6 of 9 years). The largest number of Spectacled Eiders observed in the CD South study area in any year was 2, whereas the largest number of King Eiders observed was 9.

In 9 years of pre-nesting surveys, Spectacled Eiders were observed in 4 habitat types in the CD South study area: both types of Tapped Lakes, River or Stream, and Aquatic Sedge with Deep Polygons. Five of 24 habitats were preferred by pre-nesting Spectacled Eiders: Brackish Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons. None of these habitats comprise more than 2% of the CD South study area. Pre-nesting King Eiders were observed in 5 habitats: River or Stream, Tapped Lake with High-water Connection, Patterned Wet Meadow, Tapped Lake with Low-water Connection, and Riverine or Upland Shrub . Over 9 years of surveys, pre-nesting King Eiders preferred 3 habitats on the delta: Brackish Water, Salt-killed Tundra, and River or Stream. Of preferred habitats, only River or Stream occurs in the CD South study area. The low number of nests found on the delta during later nest searches indicates that the Colville River Delta is used by King Eiders mainly as a stopover during movements to other nesting areas.

The 2 Spectacled Eider nests that have been found in the CD South ground-search area were each located on polygon rims in Patterned Wet Meadow habitat about 0.5 m from permanent water. During 11 years (1992–2002) of nest searching in various locations on the entire delta, 62 nests of Spectacled Eiders have been found in 9 habitats. Most nests were located in Salt-killed Tundra (24% of all nests), Aquatic Sedge with Deep Polygons (23%), Patterned Wet Meadow (16%), and Nonpatterned Wet Meadow (15%). The coastal portion of the delta, where Spectacled and King eiders concentrate during pre-nesting, also is where eiders nest most commonly. The farthest distance from the coast that a Spectacled Eider nest has been observed on the Colville River Delta is 13 km.

Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 3.7 m from permanent water. Most nests were associated with Brackish Water (37% of all nests) and Deep Open Water with Islands or Polygonized Margins (29%). The results of pre-nesting and nesting habitat analyses emphasize the importance of coastal habitats on the outer delta to breeding Spectacled Eiders, including Brackish Water, Salt-killed Tundra, Salt Marsh, and Aquatic Sedge with Deep Polygons. The absence or scarcity of these habitats may explain the low numbers of Spectacled Eiders in the CD South study area during pre-nesting and nesting.

Spectacled Eider broods were located primarily in aquatic and wet habitats: Deep Open Water with Islands or Polygonized Margins, (24% of all groups), Salt-killed Tundra (15%), Aquatic Sedge with Deep Polygons (15%), Deep Open Water without Islands (12%), and Patterned Wet Meadow (12%).

TUNDRA SWAN SURVEYS

Aerial surveys for Tundra Swans were conducted during nesting in mid–late June and brood-rearing in mid–August, 2000–2002. Aerial survey methods during nesting and brood-rearing followed the USFWS Tundra Swan Survey Protocol (USFWS 1987b, 1991). During the nesting survey, 53 swans and 8 nests were observed in the CD South study area in 2002. Seven additional nests were found during other surveys in the CD South study area in 2002, yielding 15 nests total. Since 1992, the number of swans observed in the CD South study area during nesting aerial surveys has varied from 51 in 1993 to 256 in 1998. Although the number of swans observed during the nesting survey was low, 26% (14 of 53) of the swans observed appeared to be breeding in 2002, the largest proportion of breeders observed over 9 years of surveys.

The number of Tundra Swan nests found during aerial surveys of the CD South study area has varied from 3 (1992, 1993) to 17 (1996). Annually, since 1992, 15–38% of swan nests on the delta have been located within the CD South study area.

During the brood-rearing aerial survey in 2002, 35 adult and 10 young Tundra Swans were observed in the CD South study area. Twenty-three percent of adults were accompanied by broods. Four broods were observed, with a mean brood size of 2.5. The apparent nesting success was 50% (8 nests known/4 broods observed), but this estimate may be influenced by movements of broods into or out of the study area. Nonetheless, nesting success appeared to be low in the CD South study area in 2001. Since 1992, the total number of swans observed in the CD South study area during brood-rearing surveys has ranged from 45 (2002) to 98 (1996). The 45 swans counted in 2002 represent the lowest number since surveys were begun.

Although apparent nesting success was low in 2002, the mean brood size (2.5 cygnets/brood) was the highest that has been observed in the CD South study area since 1996. Across the entire delta and all 9 years of aerial surveys, the number of broods has varied from 14 (1993) to 32 (1996). Estimated nesting success for the whole delta in 2002 was 31% (17 of 55 nests), the lowest value recorded since we began aerial surveys in 1992. Delta-wide brood numbers and densities in 2002 were the lowest since 1992, the first year we began our aerial surveys, but mean brood size for the whole delta (3.2; n = 17) was the highest value observed since 1996.

Swan nests occurred in 10 habitat types in the CD South study area. Sixty-five percent of Tundra Swan nests in the CD South study area were located in 2 habitat types: Patterned Wet Meadow (16 nests) and Moist Sedge-Shrub Meadow (10 nests). Although a variety of other habitats were used for nesting, no other habitat had more than 3 nests.

Habitat selection was evaluated for 294 Tundra Swan nests locations that have been recorded on the Colville River Delta since 1992. During 9 years of surveys on the delta, Tundra Swan nests have been recorded in 20 of 24 available habitats. Seven habitat types were preferred, and 7 were avoided. Nearly 40% of nests were located in Patterned Wet Meadow, a preferred habitat. Slightly more than 10% of nests were located in Salt-killed Tundra, a preferred habitat, and Nonpatterned Wet Meadow, which was neither preferred or avoided (i.e., it was used in proportion to its availability). No other habitat in the delta had more than 10% of Tundra Swan nests.

Habitat data were available for 24 Tundra Swan broods observed in the CD South study area since 2000. Tundra Swan broods occurred in 11 habitats in the CD South study area. The habitats used most frequently by brood-rearing swans in the CD South study area were Deep Open Water without Islands (5 broods), Tapped Lakes with Low-water Connection (4 broods), Tapped Lakes with High-water Connection (4 broods), and Patterned Wet Meadow (3 broods).

Habitat selection was evaluated for 192 Tundra Swan brood locations that have been recorded on the Colville River Delta since 1992. Tundra Swan broods occurred in 20 of 24 available habitats. Seven habitats were preferred and 4 were avoided. Preferred habitats were Brackish Water, Tapped Lake with Low-water Connection, Tapped Lake with High-water Connection, Salt Marsh, Deep Open Water (either with or without islands), and Aquatic Grass Marsh. Avoided habitats were Tidal Flats, Rivers and Streams, Riverine or Upland Shrub, and Barrens. Avoided habitats are alike in the absence of foraging and escape habitats.

LOON SURVEYS

Aerial surveys for Yellow-billed Loons were conducted during nesting in late June and brood-rearing during mid–late August 2000–2002. Observations of Pacific and Red-throated loons, their nests and broods, and observations of nesting and brood-rearing Glaucous Gulls were recorded incidentally. In 2002, 24 Yellow-billed Loons and 8 nests were located in the CD South study area during the initial aerial survey. One additional nest was found during the revisit survey, yielding 9 nests total. The density of Yellow-billed Loons in the CD South study area ranged from 0.10 to 0.17 birds/km² during 8 years of surveys (1993, 1995–1998, and 2000–2002).

The count of 9 nests in 2002 was similar to the number of nests found in 5 of the 8 years of surveys. Two or 3 nests were found in the other 3 years. Nest densities for the CD South study area have ranged from 0.01 to 0.06 nests/km² during our 8 years of study. All 9 nests found in 2002 were on lakes where nesting Yellow-billed Loons have been recorded in previous years. Ten Pacific Loon and 2 Red-throated Loon nests were located during aerial and ground surveys of the CD South study area. Pacific Loons were the most abundant loon in the CD South study area during most years of study.

During 2002, 36 adult Yellow-billed Loons and 3 broods were observed during the brood-rearing survey in the CD South study area. The number of loons recorded in 2002 was greater than the number counted in any of the previous 7 years, whereas the number of broods was within the range of the number of broods (1 to 5) seen in previous years. The density of adult Yellow-billed Loons in the CD South study area during brood-rearing in 2002 was 0.23 birds/km² and the density of broods was 0.02 broods/km². In prior years, the density of adults ranged from 0.05 to 0.17 birds/km² and the density of broods from 0.01 to 0.03 broods/km².

In the CD South study area since 2000, a total of 25 Yellow-billed Loon nests have been observed in 6 habitats: Nonpatterned Wet Meadow (32% of nests), Deep Open Water with Islands or Polygonized Margins (28%), Patterned Wet Meadow (24%), Aquatic Sedge with Deep Polygons (8%), Tapped Lake with High-water Connection (4%), and Aquatic Sedge Marsh (4%). Four types of waterbodies were associated with Yellow-billed Loon nests: Deep Open Water without Islands (44%), Deep Open Water with Islands or Polygonized Margins (32%), Tapped Lake with High-water Connection (20%), and Aquatic Sedge Marsh (4%). Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation.

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

During aerial surveys of the entire Colville River Delta in 1995–1998 and 2000–2002, 46 Yellow-billed Loon broods were found in 3 habitats—Tapped Lake with High-water Connection and both types of Deep Open Water—all of which were preferred. Deep Open Water without Islands was used by most broods (59% of total), followed by Tapped Lake with High-water Connection (22%) and Deep Open Water with Islands or Polygonized Margins (20%). No shallow-water habitats were used during brood-rearing. The concurrence of selection analyses for nesting and brood-rearing reaffirms the importance of large, deep waterbodies to breeding Yellow-billed Loons.

GOOSE SURVEYS

Surveys for geese were conducted during brood-rearing in late July and fall staging in mid–late August. Three species of geese have been observed in the CD South study area during brood-rearing: Greater White-fronted Geese, Canada Geese, and Brant. Only Greater White-fronted Geese were observed in every year.

Canada Geese were observed only in 1997 (a single pair with a brood) and 2002 (20 adults with no young). Brant were observed only in 1997 (8 adults and 8 goslings just southeast of the CD South ground-search area). During the brood-rearing survey in 2002, 196 Greater White-fronted Geese (including goslings) were observed in 5 groups in the CD South study area. During 6 years of surveys of the CD South study area, the number of Greater White-fronted Geese observed during brood-rearing has ranged from 33 to 528 birds in 2 to 9 groups. The number of goslings has ranged from 24 in 1997 to 266 in 1998, and 60 goslings were observed in 2002. In all years, densities of brood-rearing Greater White-fronted Geese in the CD South study area (0.8–7.2 birds/km²) were low compared to those in the CD North study area (6.4–13.1/km²) and on the entire delta (4.2–12.8 birds/km²).

As during brood-rearing, 3 species of geese have been recorded in the CD South study area during fall-staging surveys: Greater White-fronted Goose, Canada Goose, and Brant. In 6 years of surveys, Brant were observed in the CD South study area during fall staging only in 2001. Brant typically use salt marshes and other coastal habitats during fall staging (Smith et al. 1994, Johnson et al. 1999a). Canada Geese were not observed in the CD South study area during fall staging in 2002, although they have been present in small numbers (10–94 birds) during 3 of 6 years of surveys. Variability in numbers of fall-staging geese among years is probably attributable mainly to differences in the intensity and timing of aerial surveys. The Greater White-fronted Goose was not observed in the CD South study area during fall-staging surveys in 2002, although it is usually the most common goose species in the area at that time. During previous years of surveys, the number of Greater White-fronted Geese observed during fall staging has ranged from 137 to 686 birds (1.9–8.8 birds/km²). The lack of geese in the CD South study area during fall staging in 2002 may be attributable to the relatively early onset of breeding in 2002. Over all years of surveys, densities of fall-staging Greater White-fronted Geese in the CD South study area (mean = 5.7 birds/km², range 1.9–8.8 birds/km²) are generally somewhat lower than in the CD North study area (mean = 9.5 birds/km², range 1.5–14.8 birds/km²), or across the entire delta (mean = 7.9 birds/km², range 1.0–12.9 birds/km²).

In the CD South ground-search area since 2000, 110 Greater White-fronted Goose nests were located in 5 habitats: Patterned Wet Meadow (76 nests), Moist Sedge–Shrub Meadow (27 nests), Riverine or Upland Shrub (4 nests), Nonpatterned Wet Meadow (2 nests), and Deep Open Water without Islands (1 nest). Only one habitat was preferred for nesting by Greater White-fronted Geese, Patterned Wet Meadow, which was the most abundant habitat on the delta.

During brood-rearing aerial surveys in 2000–2002, Greater White-fronted Geese were observed using 7 of 20 habitats in the CD South study area. Brood-rearing geese occurred mainly near the center of the study area, typically in or near water, although disturbance by the survey aircraft may have influenced brood locations. The most used habitats were Tapped Lake with High-water Connection (33% of groups), Barrens (27%), and Deep Open Water without Islands (13%).

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

GULL SURVEYS

Glaucous Gull nests and broods were recorded during the nesting and brood-rearing aerial surveys for Tundra Swans and Yellow-billed Loons on the Colville River Delta in 2001 and 2002. In 2000, Glaucous Gull nests and broods were recorded on the nesting and brood-rearing aerial surveys for Yellow-billed Loons. Twenty-six Glaucous Gull nests were located during aerial surveys for Tundra Swans and Yellow-billed Loons in the CD South study area in 2002. Eighteen of the 26 nests were part of a Glaucous Gull colony located ~6 km east of the CD South ground-search area. Counts at this colony have ranged from 10 to 18 nests during 4 years of surveys (1998, 2000–2002). In 2001, 17 Glaucous Gull nests, 13 of which were part of the colony, were found in the CD South study area. In 2000, 14 Glaucous Gull nests, 10 of which were part of the colony, were recorded. Based on aerial survey results, the density of Glaucous Gull nests in the CD South study area increased from 0.09 to 0.17 nests/km² between 2000 and 2002. Because Glaucous Gulls were counted on aerial surveys designed to survey other species, some nests probably were missed in all years.

One Glaucous Gull brood with 2 young was seen during aerial surveys in 2002. In contrast to previous years, no young were seen at the colony site during the aerial survey in 2002 (12 young were observed there in 2000 and 7 young in 2001). It is believed that young may have fledged prior to the survey, which is consistent with the generally early nesting phenology observed in the region in 2002.

Habitat information is available for the 57 nests found in the CD South study area in 2000–2002. The colony site was located in each year on the same large island of Patterned Wet Meadow in a Deep Open Lake with Islands or Polygonized Margins. The 41 nests counted at this colony in 2000–2002 were the only nests in the CD South study area in Patterned Wet Meadow (72% of 57 nests). The remaining 16 nests were found mostly on islands in Tapped Lake with High-water Connection, both Deep and Shallow Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, Nonpatterned Wet Meadow, and Barrens.

FOX SURVEYS

Aerial and ground-based surveys were used to evaluate the distribution and status of arctic and red fox dens on the Colville River Delta in 2000–2002. To date, 9 dens have been found in the CD South study area. Additional dens may be present in the CD South study area because of the abundance of arctic ground squirrel burrows in dune habitats, which make it difficult to distinguish fox dens. Five of the dens were arctic fox sites (2 possibly active in 2002) and 4 were red fox sites (one active in 2002). In marked contrast to other areas on the outer coastal plain, red fox dens are as common as arctic fox dens in the CD South study area. The total density of fox dens (active and inactive for both species) in the CD South study area (156 km²) was 1 den/17 km². The densities of arctic and red fox dens were similar, at 1 den/31 km² for the former and 1 den/39 km² for the latter. In contrast, the density of red fox dens in the entire Colville River Delta area was 1 den/69 km².

The red fox dens in the CD South study area have had higher occupancy rates (natal, secondary, and active categories combined) each year than have the arctic fox dens. Since 1995 (no red fox dens had yet been found in 1993), 1 to 4 red fox dens (25–100%) were active each year. The small number of arctic fox dens occupied in the CD South study area makes comparison with other areas difficult. Since 1993, the occupancy rate of arctic fox dens in the study area ranged from 0 to 50% occupied.

Pups were confirmed present only at 1 red fox den in 2002. Two of the arctic fox dens were judged to be potentially active but the amount and nature of fox sign at those sites was minimal and no pups were observed. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to obtain a complete count.

In the CD South study area, the habitat type used most often for denning was Riverine or Upland Shrub (7 of 9 dens, or 78%); the only other habitat type used was Patterned Wet Meadow (2 dens). Across the Colville River Delta, 16 dens (70% of the delta total) were located in the Riverine or Upland Shrub type (upland shrub subtype), the only denning habitat that was preferred. Dens in the other habitats used—Barrens (eolian subtype), Moist Sedge–Shrub Meadow, Patterned Wet Meadow, and Nonpatterned Wet Meadow—actually were located in small patches of higher microrelief that were smaller than the minimal mapping size of habitat areas. Foxes did not den in the extensive river bars and mudflats on the delta.

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INTRODUCTION

In spring 2000, ARCO Alaska, Inc., (now ConocoPhillips Alaska, Inc.) contracted with ABR, Inc., to conduct wildlife studies in 2 areas on the Colville River Delta, CD North and CD South (known during the exploration phase as Fiord and Nanuq, respectively), in support of permit applications for oil development. This annual report on the 2002 field season presents the results from the third year of study of the wildlife resources in the CD South study area (previous field seasons were reported in Burgess et al. 2000 and Burgess et al. 2002). The CD South Development Project proposed by ConocoPhillips Alaska, Inc. (CPAI) is located on the Colville River Delta, 8.8 km north and east of the village of Nuiqsut and 5.5 km south and west of the Alpine Development. Similar investigations for CPAI's proposed CD North Development Project, which lies 10.1 km to the north and east of the Alpine Development, are reported separately (Johnson et al. 2000a, 2002, and 2003b).

Wildlife studies have been conducted by the oil industry in the Colville River Delta region since 1992 when ARCO Alaska, Inc. initiated studies to examine the biological, physical, and cultural resources of the delta (biological reports on the delta include Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b, 2000b, 2001, and 2003a). By 1995, attention was focused on the central delta as the area with highest potential for oil development. The Alpine Development Project received its federal permits on 13 February 1998, and construction began that spring. The Alpine Oilfield is the first oilfield to be developed on the Colville River Delta and the first west of the Kuparuk Oilfield. Oil flowed for the first time through the Alpine pipeline in November 2000 and, with the establishment of the Alpine facilities and pipeline, oil development in other locations on the delta then became more feasible.

The primary goal of ecological investigations on the Colville River Delta since 1992 has been to describe the distribution and abundance of selected species before, during, and after development-related construction. The species-specific approach was developed in consultation with the U.S. Fish and Wildlife Service (USFWS) and the following criteria were used to identify the species of interest: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, or 3) special concerns of regulatory agencies. Accordingly, the Yellow-billed Loon, Tundra Swan, Brant, Spectacled Eider, caribou, and arctic fox were selected for study (Smith et al. 1993; see Appendix A for scientific names of birds and mammals). After 1992, 3 additional species were targeted: King Eider, Greater White-fronted Goose, and Bar-tailed Godwit. Other species were monitored opportunistically, including Red-throated and Pacific loons, gulls, red fox, muskoxen, and brown bear. The 2002 program included ground searches for nests of large waterbirds and the following aerial surveys: surveys for pre-nesting Spectacled Eiders; surveys for nesting and brood-rearing Tundra Swans, Yellow-billed Loons, and Glaucous Gulls; surveys for brood-rearing and fall-staging geese; and surveys for arctic fox dens. Use of the Colville River Delta by caribou in 2002 is described separately (Lawhead and Prichard 2003).

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

The overall goal of the study in 2002 was to continue to build the multi-year baseline data set on the use of the CD South study area by selected birds and mammals during June through August–September. Specific objectives for the CD South wildlife studies were to:

1. monitor the distribution, abundance, and habitat use of selected waterbird species during pre-nesting, nesting, brood-rearing, and fall staging;
2. evaluate the use of the specific area proposed for oilfield development by nesting and brood-rearing waterbirds,
3. locate fox dens, estimate litter sizes, and describe denning habitats, and
4. monitor the distribution of large mammals in the study area (reported in Lawhead and Prichard 2003).

STUDY AREA

Where possible, local Iñupiaq names are used hereafter in specific references to the Colville River and it's distributaries (we will continue to refer to the area as the Colville River Delta). The Colville River is called Kuukpik by local Iñupiat (Kuukpiŋmiut, or people of the Colville). The local Iñupiaq name for the Nechelik Channel is Niġliq and for the Tamayayak, Tamayagiaq. Local and USGS channel names are similar for other channels (we know no local designation for the East Channel, the main distributary of the Kuukpik).

The CD South study area encompasses the region of the Colville River Delta south of the Alpine Development facilities, west of the East Channel of the Kuukpik, and north of the village of Nuiqsut (Figure 1). Within the CD South study area, the CD South ground-search area encompasses the proposed CD South development facilities and lies between the Sakoonang and Niġliq channels, north to the Alpine facilities, and south to approximately midway between the Alpine facilities and Nuiqsut (Figure 1).

The Colville River Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. Two permanent human settlements occur on the Colville River Delta—the Iñupiat village of Nuiqsut and the Helmericks family homesite. Both rely heavily on these fish and wildlife resources.

The Kuukpik drains a watershed of ~53,000 km², or ~29% of the Arctic Coastal Plain of Alaska (Walker 1976). The high-volume flow and heavy sediment load of the Kuukpik have created a large (551 km²), dynamic delta system, which includes a diversity of lakes, wetlands, and terrestrial habitats. The Kuukpik has 2 main distributaries in the delta, the Niġliq Channel and the East Channel. These 2 channels together carry ~90% of the water flowing through the delta during spring floods and 99% of the water after those floods subside (Walker 1983). The East Channel is deep and flows under the ice during winter, whereas the Sakoonang, Tamayagiaq, Niġliq, and other channels are shallow and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta's channels, with the depth of the river at freeze-up being the main factor determining the inland extent of this intrusion (Walker 1983). For its entire length, the Kuukpik flows through land that is underlain by continuous permafrost. This extensive permafrost, combined with freezing of the upper layer of surface water in winter, influences the volume, timing, and character of river flow and erosion within the delta (Walker 1983).

Lakes and ponds are dominant physical features of the Colville River Delta. The most abundant waterbodies on the delta are polygon ponds, which generally are shallow (i.e., ≤2 m deep), freeze to the bottom during winter, and thaw by June. Deep ponds and lakes (>2 m deep) with steep, vertical sides, are more common on the delta than elsewhere on the Arctic Coastal Plain, where deep waterbodies are much less common. Lakes >5 ha in size cover 16% of the delta's surface (Walker 1978) and some of these lakes are deep (to

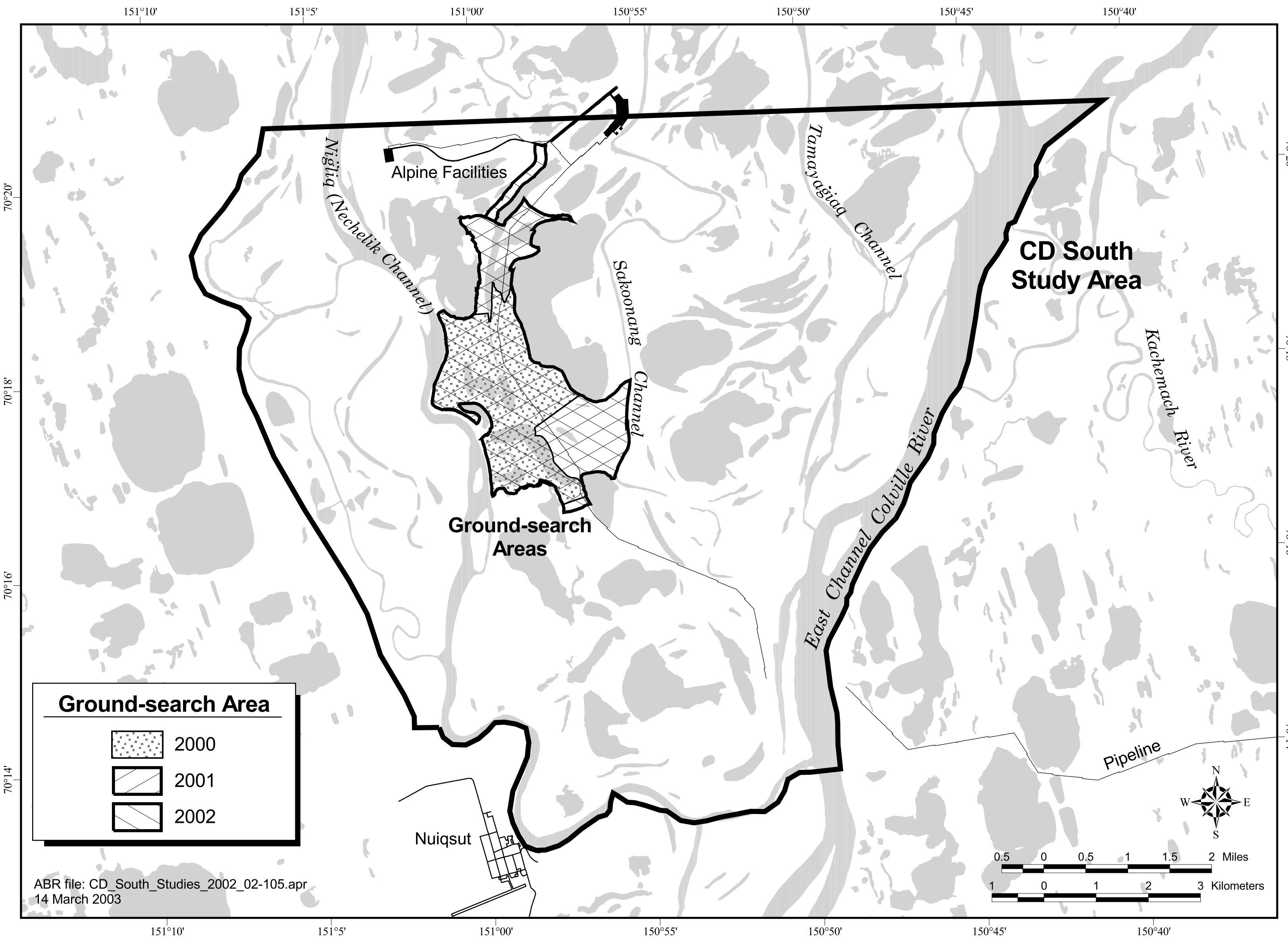

Figure 1. Survey area boundaries for wildlife studies in the CD South study area, Colville River Delta, Alaska, 2000–2002.

10 m), freezing only in the upper 2 m during winter and retaining floating ice until the first half of July (Walker 1978). Several other types of lakes occur on the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes (Walker 1983).

Many lakes on the delta are "tapped" (Walker 1978), meaning that they are connected to the river by narrow channels that result from thermokarst of ice wedges and by the migration of river channels (Walker 1978). Channel connections allow water levels in tapped lakes to fluctuate more dramatically than in untapped lakes, resulting in barren or partially vegetated and often salt-affected shorelines. River sediments gradually fill these narrow channels and adjacent lake bottoms, eventually limiting the flow of river water or restricting it to only the most extreme flood events. Because tapped lakes and river channels are the first areas of the delta to become flooded in spring, they constitute important staging habitat for migrating waterfowl in that season (Rothe et al. 1983).

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

The Colville River Delta supports a wide array of wildlife, providing breeding habitat for passerines, shorebirds, gulls, and predatory birds, such as jaegers and owls. The delta is a regionally important nesting area for waterbirds, including Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders (Rothe et al. 1983, North et al. 1984, Meehan and Jennings 1988). In spring, the delta provides some of the earliest open water and snow-free areas on the Arctic Coastal Plain for migrating birds. In fall, the extensive salt marshes and mudflats on the outer delta are used by geese and shorebirds for feeding and staging (Andres 1994). In addition to use by birds, the delta is used seasonally by caribou for insect-relief habitat, by arctic and red foxes for denning, and by spotted seals for foraging and haul-out sites (Seaman et al. 1981). In recent years, the delta and adjacent areas have been visited increasingly by muskoxen. Brown bears occur regularly, and the delta occasionally is used for denning by both brown and polar bears (see reviews in Johnson et al. 1997).

METHODS

HABITAT USE AND SELECTION

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

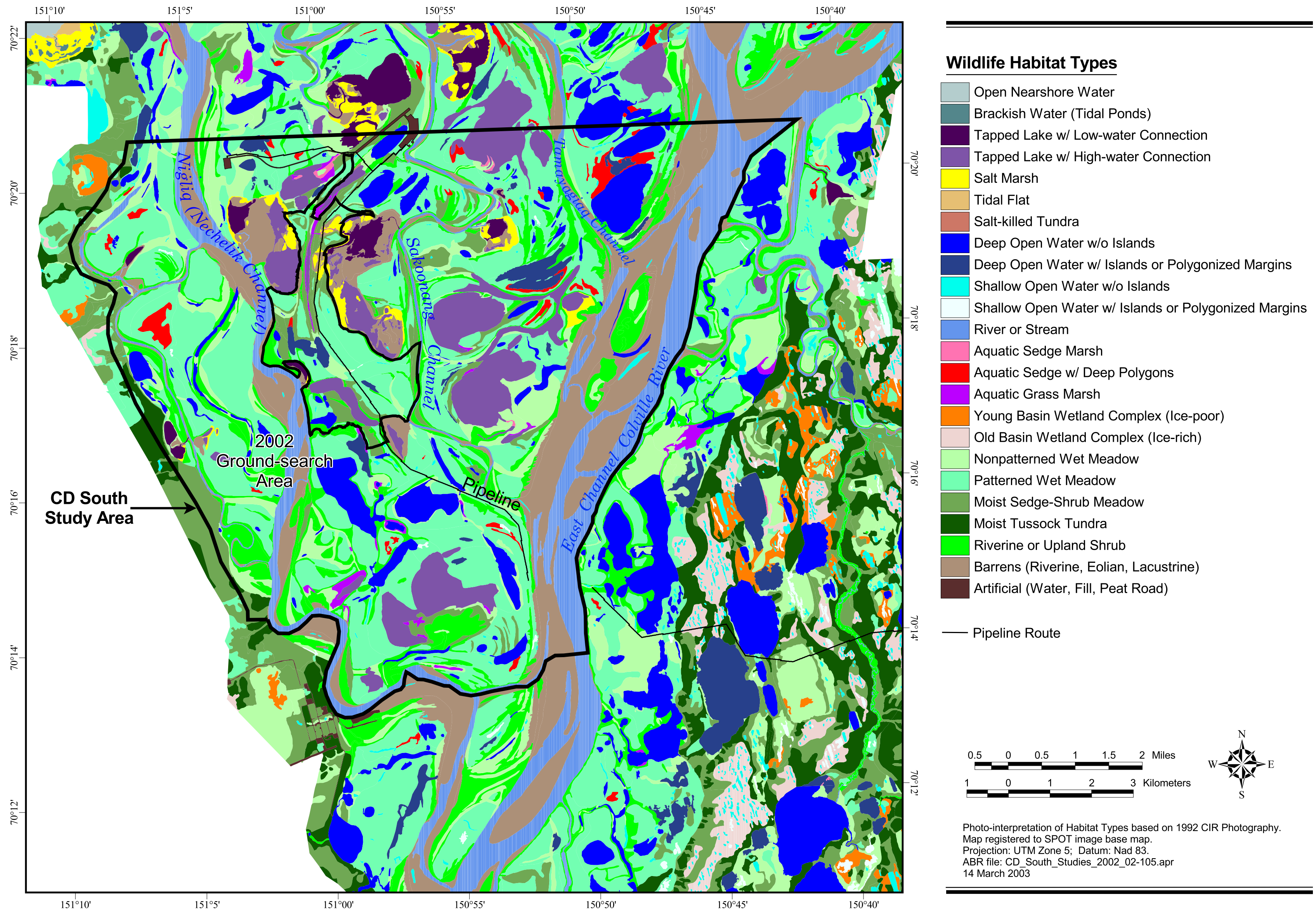

Figure 2. Habitat map of the CD South study area, Colville River Delta, Alaska.

inactive combined) over all years. For all other species, the parameters were calculated for each year of survey. Habitat availability differed between seasons, because survey areas often differed (as described below).

Wildlife observations from all years of study (1992–present, although not all species were studied in all years) and from the entire Colville River Delta (CD South and CD North study areas and other areas of the delta) were used to evaluate habitat selection (i.e., preference and avoidance). (An exception was the analysis of nesting habitat selection of Greater White-fronted Geese, for which the analysis was restricted to data from the CD South ground-search area and excluded observations from the CD North ground-search area. This approach was taken because goose nesting data were obtained only from ground searches and habitat availability differed dramatically between the CD North and CD South ground-search areas.) Habitat selection was evaluated for Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, Brant, Greater White-fronted Geese, and foxes. Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat selection and this distribution was used to calculate an index to habitat selection as the percentile scores of observed habitat use (Haefner 1996, Manly 1997). Random habitat selection was based on the percent availability of each habitat (rounded to the nearest 1%) and the sample sizes in each simulation equaled the number of observed nests, dens, or groups of birds in that season. We defined habitat preference (i.e., use > availability) as observations of habitat use greater than the 97.5 percentile of simulated random use, which represents an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observations below the 2.5 percentile of simulated random use. The simulations and calculations of percentiles were conducted in a Microsoft® Excel spreadsheet.

WILDLIFE SURVEYS

Both aerial and ground surveys of wildlife were conducted. Aerial surveys were conducted in both fixed-wing aircraft and helicopters (as described below for each survey) and, between the CD South and CD North study areas, covered most of the delta. Ground surveys of nesting birds were conducted on a smaller scale, focusing on a study plot that encompassed proposed footprints of CD South facilities (as such, search areas differed among years as the proposed project footprint changed; Figure 1). Aerial surveys focused on Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, and geese, but information on other waterbirds, such as Pacific and Red-throated loons, also was collected opportunistically. Ground surveys focused on large waterbirds, including all of the species targeted by aerial surveys plus all other waterfowl, gulls, jaegers, terns, and large shorebirds, and also including other large birds such as ptarmigan and raptors (hawks and owls). Mammalian studies focused on arctic foxes, but information on other species, such as red foxes, brown bears, moose, and muskoxen, also was collected opportunistically (large mammal studies are reported separately in Lawhead and Prichard 2003).

LARGE WATERBIRD GROUND SEARCHES

A ground-based nest search was conducted to determine the composition and abundance of waterbirds in the proposed development area and to estimate nesting success, with particular attention to eiders and geese. Ground-based nest searches were conducted in a study plot that encompassed the proposed project facilities. Because of changes in the footprints of the proposed project, the ground-search area expanded 65% between years 2000 and 2001 (Figure 1). In 2002, the search area was expanded an additional 3% to cover the proposed road between CD South and Alpine (an area formerly included in the Alpine ground-search area).

Nest searches were conducted between 15 and 25 June 2000, 14 and 28 June 2001, and 15 and 29 June 2002 (Table 1). For loon nests, an additional search of waterbodies was conducted during July (during nest fate checks for other species), because loons initiate nesting later than other species (details are provided below). Nests were located by a 5- or 6-person team that systematically searched the study plot by walking more or less abreast and about 10 m apart. Each team member thoroughly searched all dry ground between themselves and adjacent observers for nests of

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

AREA SURVEYED Survey Type	Season	Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
CD SOUTH GROUND-SEARCH AREA (9.7 km^2)							
Large Waterbird Ground Searches[b]	Nesting	15–29 June	-	-	-	-	
	Brood-rearing[c]	17 July	-	-	-	-	Includes loon nest search
	Brood-rearing	21 August	-	-	-	-	Primarily for loons
CD SOUTH STUDY AREA (156 km^2)							
Eider Survey	Pre-nesting	13 June	C185	0.4	0.4	30–35	
Tundra Swan Surveys	Nesting	22–24 June	C185	1.6	1.6	150	Includes survey for gull nests
	Brood-rearing	21–22 August	C185	1.6	1.6	150	
Yellow-billed Loon Surveys[d]	Nesting	25, 28 June	206L	n/a	n/a	60	Includes survey for gull nests
	Brood-rearing	21 August	206L	n/a	n/a	60	Includes survey for gull broods
Goose Surveys	Brood-rearing	20 July	C206	0.8	1.6	90	
	Fall staging	24 August	C185	0.4	1.6	90	
Fox Den Surveys	Denning	27–30 June	206B	-	-	-	Status check at known den sites
	Denning	11–12 July	-	-	-	-	Pup observations at active den sites

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

large birds, including loons, grebes, geese, swans, ducks, ptarmigan, cranes, large shorebirds (Whimbrel, Bar-tailed Godwit, and Common Snipe), jaegers, gulls, terns, and raptors. (Nests of small shorebirds and songbirds were not noted during this survey.) All bird nests of these species were mapped on aerial photos and, beginning in 2002, nest coordinates were recorded with a GPS (Global Positioning System) unit.

Observers attempted to not flush incubating birds from nests but, when a bird was flushed, the observer counted the eggs and covered them with down before leaving the site. When covering eggs, a sample of down (including contour feathers, if present) was collected to add to a regional reference collection. If the species of bird that flushed could not be determined, the down sample was labeled as unknown species and the length and width of one or 2 eggs were recorded. Down samples from unidentified nests were cross-referenced against the regional reference collection. When possible, unidentified nests later were assigned to species based on this information.

Habitat information was recorded at each waterbird nest, including the distance to nearest standing water, distance and waterbody class of the nearest permanent waterbody, the terrestrial habitat in the area, and the landform and vegetation at the nest site.

Nests of waterbirds were revisited after hatch to determine nest fate (waterfowl on15 July 2000, 17–18 July 2001, and 17 July 2002; loons on 27 August 2000, and 21–22 August 2001 and 21 August 2002). During the July nest check, waterbodies were again searched for nests of loons, which initiate their nests later than other waterbirds. Waterfowl and ptarmigan nests were classified as successful if thickened egg membranes that had detached from the shell were found in the nest bowl and as failed if no such membranes were found. Fate was determined for ptarmigan nests only in 2002 (because GPS coordinates were collected at these nests in 2002, allowing observers to reliably relocate nests). For loons, nests were considered successful if a brood later was associated with that nest site and fate at all other nests was considered unknown unless evidence at the nest indicated failure due to predation or abandonment. Evidence of predation included crushed eggs, fox urine or scat, blood, etc. In addition to nest checks during these visits, the study area was searched for broods. Observers scanned the area with binoculars and searched on foot all shorelines of waterbodies greater than about 25 m on their long axis (approximately the minimal waterbody size to support nesting Red-throated Loons). The number of adults and young of each brood were recorded and their locations plotted on aerial photos of the study area.

Nest densities within the CD South ground-search area were compared with 2 concurrent ground-search studies on the Colville River Delta, Alpine (years 1996-2001) and CD North (years 2000-2002). The Alpine ground-search area lies immediately north of CD South and the CD North ground search area is roughly 8 km north of CD South.

EIDER SURVEYS

Pre-nesting aerial surveys for eiders were conducted on 16 June 2000, 12–14 June 2001, and 13 June 2002 (Table 1). Methods were similar to previous years (1993–1998 and 2000–2001), although the survey areas differed among years. The aerial survey employed 2 observers (in addition to the pilot) in a Cessna 185 fixed-wing aircraft. Flight altitude for each survey was 30–50 m above ground level (agl) and flight speed was approximately 145 km/h. The pilot used a GPS and topographic maps to navigate along pre-determined east–west transect lines spaced 400m (0.25 mi) apart. Eiders were counted in a fixed-width strip (200 m on each side of the aircraft) for 100% coverage of the area surveyed. Each time an eider was sighted, observers recorded on audio tape: the species, number of each sex, number of identifiable pairs, transect number, and whether the birds were flying or on the ground. The location of each observation was recorded on 1:63,360 USGS maps of the study area.

All eider locations were digitized and added to a GIS database that contains all aerial survey observations on the Colville River Delta since 1992. The habitat in which each eider group (singles, pairs, or flocks) occurred was determined by plotting locations on the digital habitat map (Figure 2, Appendix B2). In 1992, the aerial survey covered 3 plots (46.6 km² each) on the delta (not the entire delta, as in subsequent years) and was flown at 50% coverage (0.8 km between transects) (Smith et al. 1993). Results of that survey were included in maps of eider distribution, but not in annual calculations of density or habitat use, because the resulting density and selection estimates were not comparable to the more recent surveys. The aerial survey in 1993 also was conducted at 50% coverage, but the entire delta was surveyed (Smith et al. 1994), so results were included in calculations of density and habitat use with corrections for the lower survey intensity (i.e., counts were doubled to estimate density).

From the pre-nesting survey, the observed number of birds, the observed number of pairs, the indicated number of birds, the indicated number of pairs, and densities (number/km^2) were calculated for the CD South study area (Figure 1). Total indicated birds was calculated following the procedures of the USFWS survey protocol (in which the number of lone males is doubled, and flocks are accounted for depending on composition, USFWS 1987a), and indicated density of birds was based on the total area covered during each survey.

Pre-nesting habitat selection was evaluated from all aerial survey locations across the entire delta in 1993–1998 and 2000–2002 (including both the CD South and CD North study areas in 2000–2002). The pre-nesting survey in 1993 was flown at 50% coverage and habitat availability for that year was determined from the strips that were surveyed. The 2000 survey did not go east of the Elaktoveach Channel, so that area was not included in the habitat availability estimate in that year. A weighted average of habitat availability was used to combine years and was computed by summing availability for each year and dividing by the number of years.

TUNDRA SWAN SURVEYS

Aerial surveys for Tundra Swans were conducted during nesting (22–24 June 2000, 23–26 June 2001, and 22–24 June 2002) and brood-rearing (17–19 August 2000, 16–18 August 2001, and 21–22 August 2002) (Table 1). Aerial survey methods during nesting and brood-rearing followed the USFWS Tundra Swan Survey Protocol (USFWS 1987b, 1991). The CD South study area was surveyed in 2002 in conjunction with similar surveys in the Kuparuk Oilfield (Anderson et al. 2003), the CD North study area (Johnson et al. 2003b), and the northeastern National Petroleum Reserve–Alaska (NPRA) (Burgess et al. 2003). Comparable swan surveys have been conducted in the Kuparuk Oilfield since 1989 (Anderson et al. 2003) and in the Colville River Delta since 1992 (Johnson et al. 1999a).

Surveys for nesting and brood-rearing Tundra Swans were flown in a Cessna 185 aircraft along east-west, 1.6-km wide transects. Navigation of transects was aided with a GPS receiver. Transects were oriented along township and section lines, and swan observations were mapped on 1:63,360 USGS maps. During transects, the pilot maintained a speed of 145 km/h at an altitude of 150 m agl. Each of the 2 observers scanned a transect approximately 800 m wide on his/her side of the aircraft, while the pilot navigated and scanned ahead of the aircraft, yielding 100% coverage of the study area. When an observer identified a swan nest, the aircraft left the transect line and circled the nest, allowing observers to accurately plot the location and photograph the nest with a 35-mm camera. An identical procedure was used during the brood-rearing survey, but we did not photograph broods and attempted to limit disturbance by circling only when necessary. During 2001, nesting Glaucous Gulls were recorded similarly during the swans surveys, except that no photographs were taken.

Aerial surveys for fall-staging Tundra Swans were conducted only during 2000. In that year, staging surveys for Tundra Swans were flown in a Cessna 185 aircraft in mid-September. In addition to the transects described above, non-transect paths were flown over areas on and near the delta that have been previously identified as fall-staging grounds for Tundra Swans (Johnson et al. 1999a). Fall-staging surveys were flown by a single observer and a pilot-observer scanning opposite sides of the aircraft.

After the surveys, all location data were entered into a GIS database and plotted on the wildlife habitat map of the delta (Figure 2, Appendix B2). Summary statistics for nesting surveys followed the format established in 1988 and modified in 1990 (Ritchie et al. 1989, 1991), which categorize adults as either with nests (or broods) or without nests (or broods). The latter category includes nonbreeding subadults, as well as failed or nonbreeding adults. These individuals will be referred to collectively as "nonbreeders."

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

Habitat selection was evaluated from swan nest and brood locations across the entire delta from data collected during 1992–1993, 1995–1998, and 2000–2002. Many nest sites were reused in subsequent years and previous investigators have determined that nests at previously used sites are more successful (Monda et al. 1994). Therefore, to avoid biasing results toward less successful (perhaps less experienced) pairs, all swan nest locations in each year were included in analysis of habitat selection, although reused sites were statistically non-independent observations.

LOON SURVEYS

Aerial surveys for Yellow-billed Loons were conducted during nesting (27 and 30 June 2000, 25–26 and 30 June 2001, and 25 and 28 June 2002) and brood-rearing (25 and 27 August 2000, 20 and 23 August 2001, and 21 August 2002). Similar surveys were conducted on the Colville River Delta in 1993, and 1995–1998 (Smith et al. 1994; Johnson et al. 1999a). The area of the Colville River Delta west of the Niġliq Channel (see Figure 1) was included in the nesting aerial survey in 2002, but was not surveyed in previous years. In 1992, surveys were conducted in 3 plots (46.6 km² each) on the delta (Smith et al. 1993), but only 15.4 km² of one plot were located in the CD South study area. Results of 1992 surveys are included in maps of loon distribution, but not in annual calculations of density or habitat use, because the plots were not representative samples of the delta or CD South study areas. In 2000–2002, all surveys were conducted using a helicopter, whereas in previous years, surveys were conducted by either fixed-wing aircraft or helicopter. In all years (since 1993), an initial nesting loon survey was conducted in a lake-to-lake pattern, concentrating on lakes ≥10 ha in size (typical lake size for nesting Yellow-billed Loons [Sjolander and Agren 1976, North and Ryan 1989]) and adjacent smaller lakes. Coastal lakes and tapped lakes with low-water connections to river channels were excluded, as Yellow-billed Loons are known not to use such lakes for nesting (North 1986, Johnson et al. 1999a). In 1996–1998 and in 2000–2002, a second nesting survey was conducted with a helicopter to visit lakes where Yellow-billed Loons were observed but no nests were found. Observations of Pacific and Red-throated loons, their nests and broods, and observations of nesting and brood-rearing Glaucous Gulls were recorded incidentally. Loon locations were recorded on 1:63,360-scale USGS maps.

From the survey data, the total number of adults, nests, broods, and young were calculated by season for all species of loons in the CD South study area. Density (number/km²) was calculated only for Yellow-billed Loons because the coverage for Pacific and Red-throated loons was inadequate for estimating density. Habitat use was calculated for Yellow-billed Loon nests and broods found in 2000–2002 in the CD South study area. Selection indices were calculated for the entire Colville River Delta (CD North and South combined) from nest locations during 1993, 1995–1998, and 2000–2002, and for brood locations during 1995–1998 and 2000–2002.

GOOSE SURVEYS

Surveys for geese were conducted during brood-rearing (31 July 2000, 26 July 2001, and 20 July 2002) and fall staging (20 August 2000, 19 August 2001, and 24 August 2002) (Table 1). The surveys were developed originally to count Greater White-fronted Geese (although Brant, and Canada Geese, and Snow Geese also were counted) and have been conducted on the Colville River Delta since 1996. Additional information on geese was collected prior to 1996 during non-systematic brood-rearing and fall-staging surveys for Brant and opportunistically during surveys for other species, such as loons or swans.

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

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

GULL SURVEYS

Glaucous Gull nests and broods were recorded during the nesting and brood-rearing aerial surveys for Tundra Swans and Yellow-billed Loons on the Colville River Delta in 2001 and 2002 (see Tundra Swan and Loons survey methods, above). In 2000, Glaucous Gull nests and broods were recorded on the nesting and brood-rearing aerial surveys for Yellow-billed Loons. All Glaucous Gull nests and broods observed on those surveys were recorded on 1:63,360-scale USGS maps. Gull nests and broods also were recorded during aerial surveys of lakes in the Alpine project area in 2000 and 2001 (Johnson et al. 2003a). These lake surveys were conducted by a single observer in a helicopter. Additional gull nest locations were obtained from the CD South ground-search area. By all methods, nest locations of Glaucous Gulls were recorded on aerial photos and/or stored in GPS units.

FOX SURVEYS

Aerial and ground-based surveys were used to evaluate the distribution and status of arctic and red fox dens on the Colville River Delta in 2000–2002, continuing the annual monitoring effort begun in 1992 for baseline wildlife studies across the entire delta and adjacent coastal plain toward the Kuparuk Oilfield. The status of known dens was assessed briefly on helicopter-supported ground visits during 30 June–1 July 2000, 28–30 June 2001, and 27–30 June 2002. Observations of dens known or suspected to be active were made to count pups during 11–13 July 2000, 11–15 July 2001, and 11–12 July 2002. Most survey effort was focused on checking dens found in previous years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998, 1999a, 2000b, 2001), although we also searched opportunistically for dens in suitable habitats while transiting between known dens and conducting surveys for other species. Soil disturbance from digging by adults and pups and soil fertilization by fox feces and prey remains result in a characteristic, lush flora that makes perennially used sites easily visible from the air after "green-up" of vegetation (Chesemore 1969, Garrott et al. 1983a). Green-up occurs earlier on these traditionally used den sites than on surrounding tundra, a difference that is helpful in locating dens as early as the third week of June.

During ground visits, we evaluated evidence of use by foxes and confirmed the species using the den. The nature and extent of fox sign was used to assess den status (following Garrott 1980): presence or absence of adult or pup foxes; presence and appearance of droppings, diggings, and tracks; trampled vegetation (play areas or beds); shed fur; prey remains; and signs of predation (e.g., pup remains). Dens were classified into 4 categories (following Burgess et al. 1993), the first 3 of which are considered to be "occupied" dens:

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

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

Denning habitat selection indices were calculated based on the total number of dens located for both arctic and red foxes during 1992–2001 on the Colville River Delta survey areas (no new dens were discovered in 2002, so the results of the 2001 selection analysis did not change). The total area of all terrestrial habitats was the measure of habitat availability, excluding waterbodies and other aquatic habitats that obviously could not be used for denning. In the selection analysis, no distinction was made between species or between active (including natal and secondary) and inactive dens, because den status can change annually. Only sites actually visited, confirmed as dens, and mapped on aerial photographs or with a GPS receiver were included in the habitat selection analysis.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

The habitat map identified 24 wildlife habitat types in the delta (Appendix B1, Appendix B2); of which 20 occurred in the CD South study area (Figure 2, Table 2). The most abundant wildlife habitat in the CD South study area was Patterned Wet Meadow, which comprised 31% of the total area (Table 2). Other habitats comprising more than 10% of the total area were Barrens, Riverine or Upland Shrub, and River or Stream. Eleven habitats occurred only in trace amounts (≤1% of total area). Because of its more inland location, the CD South study area has lower cover by Nonpatterned Wet Meadows, Tapped Lakes with Low-water Connections, and coastal habitats, such as Open Nearshore Water, Brackish Water, Salt Marsh, and Salt-killed Tundra, than either the more northerly CD North area (Johnson et al. 2003b) or the entire delta as a whole.

The ground-search area at CD South included 13 wildlife habitat types (Figure 2, Table 3). Patterned Wet Meadow also dominated in the ground-search area, comprising 42% of the total area. Moist Sedge–Shrub Meadow and Riverine or Upland Shrub were the only other habitats comprising >10% of the total area. Four habitats occurred in only trace amounts (£1% of total area): Shallow Open Water without Islands, Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Aquatic Grass Marsh.

CONDITIONS IN THE STUDY AREA IN 2002

The 2002 breeding season differed from the preceding 2 years in both the timing of snowmelt and the level of meltwater floods. In 2002, spring break up came roughly 3 weeks earlier than usual and without the excessive flooding of low-lying and coastal areas that has been experienced in recent years. Warm temperatures and minimal snowfall in May accelerated snowmelt. The monthly mean temperature in May 2002 (-2.7° C, recorded at the Colville Village weather station at the Helmerick's homestead, ~24 km northeast of CD South) was 7 to 9 degrees warmer than 2000 and 2001. The monthly mean temperature in June (37.7° C) was similar to 2001 and 3 degrees cooler than 2000 (NOAA:http://lwf.ncdc.noaa.gov /oa/ncdc.html).

For breeding birds it is critical for snowmelt to occur soon after their arrival (approximately 15–31 May) and prior to nest initiation (1–15 June). Cumulative thawing degree-days provide a better index of potential snowmelt than monthly mean temperatures. Cumulative thawing degree-days are calculated by summing the number of degrees that the daily mean temperature was above freezing [0° C] for each day during a particular period. In the late breakup years of 2000 and 2001, thawing degree-days did not accumulate prior to June. In 2002, thaw was well underway in late May with 15 thawing degree-days accumulated by 31 May (Figure 3) and snow was gone by 17 May at the Colville Village weather station as compared to 7 June in 2001 and 10 June in 2000. The accumulation of thawing degree-days

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

	CD South Study Area		Colville Delta	
Habitat	Area (km²)	Availability (%)	Area (km²)	Availability (%)
Open Nearshore Water	0	0	10.02	1.8
Brackish Water	0	0	6.53	1.2
Tapped Lake with Low-water Connection	1.61	1.0	21.62	3.9
Tapped Lake with High-water Connection	13.56	8.7	20.77	3.8
Salt Marsh	1.59	1.0	16.55	3.0
Tidal Flat	0	0	56.01	10.2
Salt-killed Tundra	0	0	25.64	4.7
Deep Open Water without Islands	10.02	6.4	20.77	3.8
Deep Open Water with Islands or Polygonized Margins	2.43	1.6	7.76	1.4
Shallow Open Water without Islands	0.39	0.3	2.02	0.4
Shallow Open Water with Islands or Polygonized Margins	0.10	0.1	0.54	0.1
River or Stream	16.64	10.7	82.07	14.9
Aquatic Sedge Marsh	0.13	0.1	0.13	<0.1
Aquatic Sedge with Deep Polygons	1.78	1.1	13.22	2.4
Aquatic Grass Marsh	0.86	0.6	1.45	0.3
Young Basin Wetland Complex	<0.01	<0.1	<0.01	<0.1
Old Basin Wetland Complex	<0.01	<0.1	0.01	<0.1
Nonpatterned Wet Meadow	9.99	6.4	41.54	7.5
Patterned Wet Meadow	47.45	30.5	102.63	18.6
Moist Sedge–Shrub Meadow	8.20	5.3	13.20	2.4
Moist Tussock Tundra	0.85	0.6	2.55	0.5
Riverine or Upland Shrub	18.22	11.7	27.58	5.0
Barrens	21.80	14.0	78.67	14.3
Artificial	0.22	0.1	0.39	<0.1
TOTAL	155.86	100	551.67	100

in early June 2002 was similar to that in 2001 (39.4 and 34.4 thawing degree-days, respectively) and twice that observed during early June 2000. Nesting was delayed in 2001, despite a warming period in June, due to widespread flooding that resulted from sudden thaw of a record high snow pack. One consequence of delayed breeding in 2001 was that the young of many swans, geese and loons did not become flight-capable prior to freeze-up. In contrast, limited snow cover and low water levels in 2002 allowed earlier access to nesting habitat for many species of birds. Observations of Greater White-fronted Goose hatchlings on 23 June 2002 indicates that nest initiation occurred as early as 28 May. Based on the Kuparuk Oilfield weather records (taken ~25 km east of CD South), late May 2002 was the third warmest in the last 14 years, just behind 1996 and 1998, and early June 2002 was tied with 1995 for third warmest, again just behind 1996 and 1998 (Figure 3).

WILDLIFE SURVEYS AND HABITAT ANALYSES

GROUND SEARCHES FOR LARGE WATERBIRDS

A total of 23 species have been recorded nesting in the ground-search area since surveys were initiated in 2000 (Figure 4 and Figure 5). In 2002, 79 nests of 16 species of birds were located in the 10.0 km² CD South ground-search area

Table 3. Availability of wildlife habitat types in the CD South ground-search area, Colville River Delta, Alaska, 2002.

Habitat	Area (km^2)	Availability (%)
Tapped Lake with High-water Connection	0.64	6.4
Salt Marsh	0.24	2.4
Deep Open Water without Islands	0.22	2.2
Deep Open Water with Islands or Polygonized Margins	0.44	4.4
Shallow Open Water without Islands	0.02	0.2
Shallow Open Water with Islands or Polygonized Margins	0.01	0.1
Aquatic Sedge with Deep Polygons	0.02	0.2
Aquatic Grass Marsh	0.11	1.1
Nonpatterned Wet Meadow	0.41	4.1
Patterned Wet Meadow	4.15	41.5
Moist Sedge–shrub Meadow	2.29	22.9
Riverine or Upland Shrub	1.17	11.7
Barrens	0.30	3.0
TOTAL	10.01	100

(Table 4). In all years, the most common nesting birds were Greater White-fronted Geese, Willow Ptarmigan, and Northern Pintails (this survey excludes nests of small shorebirds and songbirds). No other species had more than 4 nests in any year. A single pair of Spectacled Eiders nested in the CD South ground-search area during each of the first 2 years of this study, but no eider nests were found in 2002.

Broods of 12 species have been observed in the CD South ground-search area since 2000 (Figure 6 and Figure 7). In 2002, 22 broods of 8 species were observed (Table 5). In each year, the most abundant brood-rearing species observed was Greater White-fronted Goose, with between 5 (2002) and 15 (2001) broods observed each year. Only 4 other species have been represented by >2 broods during ground-searches in any year: Pacific Loon (3 broods in 2002), Tundra Swan (3 broods in 2001 and 4 broods in 2002), Red-breasted Merganser (4 broods in 2001), and Willow Ptarmigan (5 broods in 2002). It is notable that broods of Red-breasted Mergansers were observed in the CD South ground-search area in 2000 (1 brood) and 2001 (4 broods), although mergansers were not known to nest in the area. In addition it is notable that goose and ptarmigan hatchlings were observed during the 2002 nest searches, indicating that the 2002 nesting season was 1–2 weeks earlier than 2000 and 2001 nesting seasons.

Nesting success of waterfowl was determined from remains at nests. Nesting success was high (91%) for Greater White-fronted Geese in the CD South ground-search area in 2002, in contrast to moderate nesting success in prior years (55% in 2000 and 56% in 2001) (Table 4). In all years, nesting success of ducks was consistently lower than that of geese. Northern Pintail nesting success was 29% in 2000 and 8% 2001 and 2002. All nests of all other duck species in all 3 years failed, except for a single Green-winged Teal nest in 2002.

Nesting success was remarkably high for ptarmigans in 2002. At least 7 of 8 nests were successful, as evidenced by eggshell fragments (one nest's fate was unknown), and high nesting success was corroborated by sightings of 5 broods during nest checks (Table 4 and Table 5). Data on nesting success for ptarmigan were not available in 2000 and 2001 but the low brood counts (≤ 1 broods) from those years suggest nesting success was lower than in 2002 (Table 5).

Nesting success of loons was determined by brood observations, with additional information from examination of nest contents (Table 4). In 2001, no loon broods were located (Table 5). One brood of Red-throated Loons was observed in the

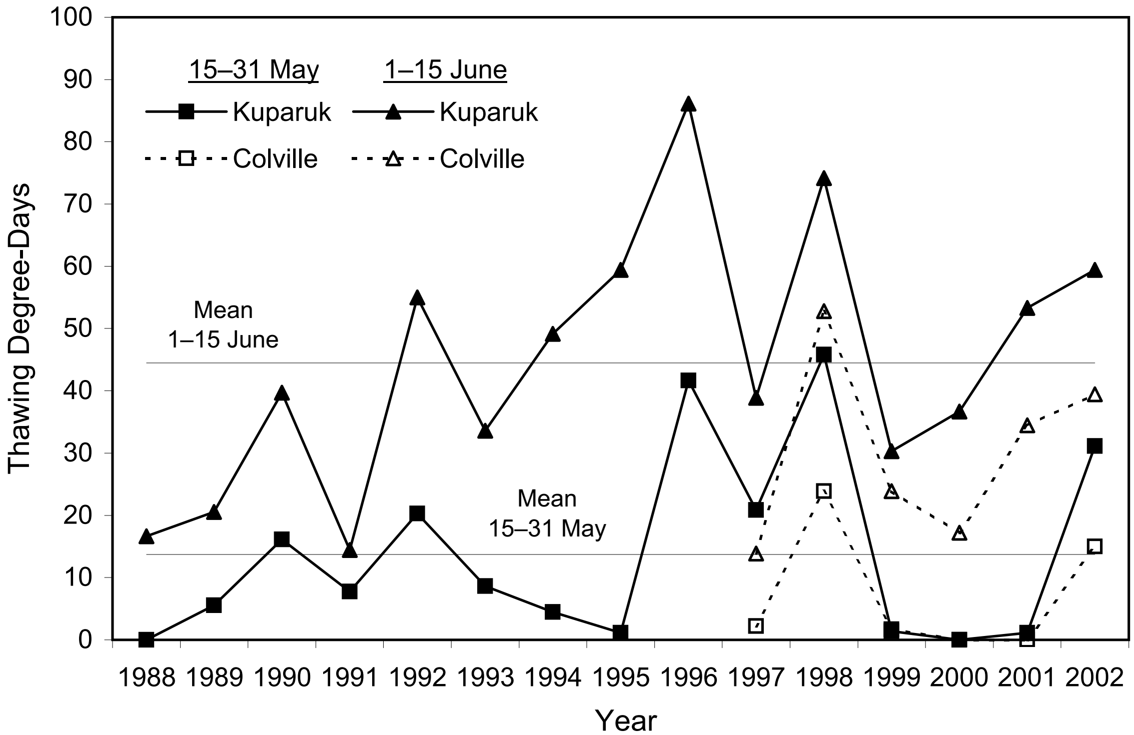

Figure 3. Cumulative number of thawing degree-days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield (1988–2002) and Colville River Delta (1997–2002), Alaska. Mean values computed from Kuparuk data (n = 15 years).

CD South ground-search area in both 2000 and 2001. The number of Pacific Loon broods increased from 1 in 2000 to 3 in 2002. The single Yellow-billed Loon nest in the ground-search area in 2000 and 2002 failed in both years.

For all of the large birds included in the nest search, the overall density of nests was 7.9 nests/km² in the 2002 ground-search area (Table 6). The density of waterbird nests was 7.1 nests/km². The densities of total nests and of waterbird nests were similar in 2001 and 2002 and nearly 50% higher in 2000. Although the area searched also increased among years, nest densities similarly decreased after 2000 in the smaller area that was searched in all 3 years. The 3-year mean total nest density in the ground-search area at CD South (10.2 nests/km², SD = 3.3 nests/km²) was higher than the 6-year mean nest density in the ground-search area at Alpine (7.7 nests/km², SD = 1.9 nests/km²), and considerably lower than the 3-year mean for the ground-search area at CD North (18.4 nests/km², SD = 1.7 nests/km²). The 3-year mean density of waterbird nests in the CD South ground-search area was slightly greater than at the Alpine ground-search area but half of that that recorded in the ground-search area at CD North (Table 6). The CD South ground-search area supports higher densities of Greater White-fronted Goose, Northern Pintail, and ptarmigan nests and lower densities of Long-tailed Duck nests than does the Alpine ground-search area (Table 6; Johnson et al. 2003a). Higher densities were reported for most species in the CD North ground-search area than in either CD South or Alpine; exceptions were Northern Pintail and ptarmigan, which were higher in both Alpine and CD South.

Between 3 (in 2001) and 7 (in 2002) loon nests were observed annually in the CD South ground-search area between 2000 and 2002. Pacific Loons were the most abundant loon species, with 2–4 nests annually. The number of Red-throated Loon nests increased from 1 in 2000 and 2001 to 2 in 2002. A single Yellow-billed Loon nest occurred in the ground-search area in 2000 and 2002. The number of loon broods in the CD South ground-search area has ranged from 0 (in 2001) to 4 (in 2002). Red-throated Loon nests

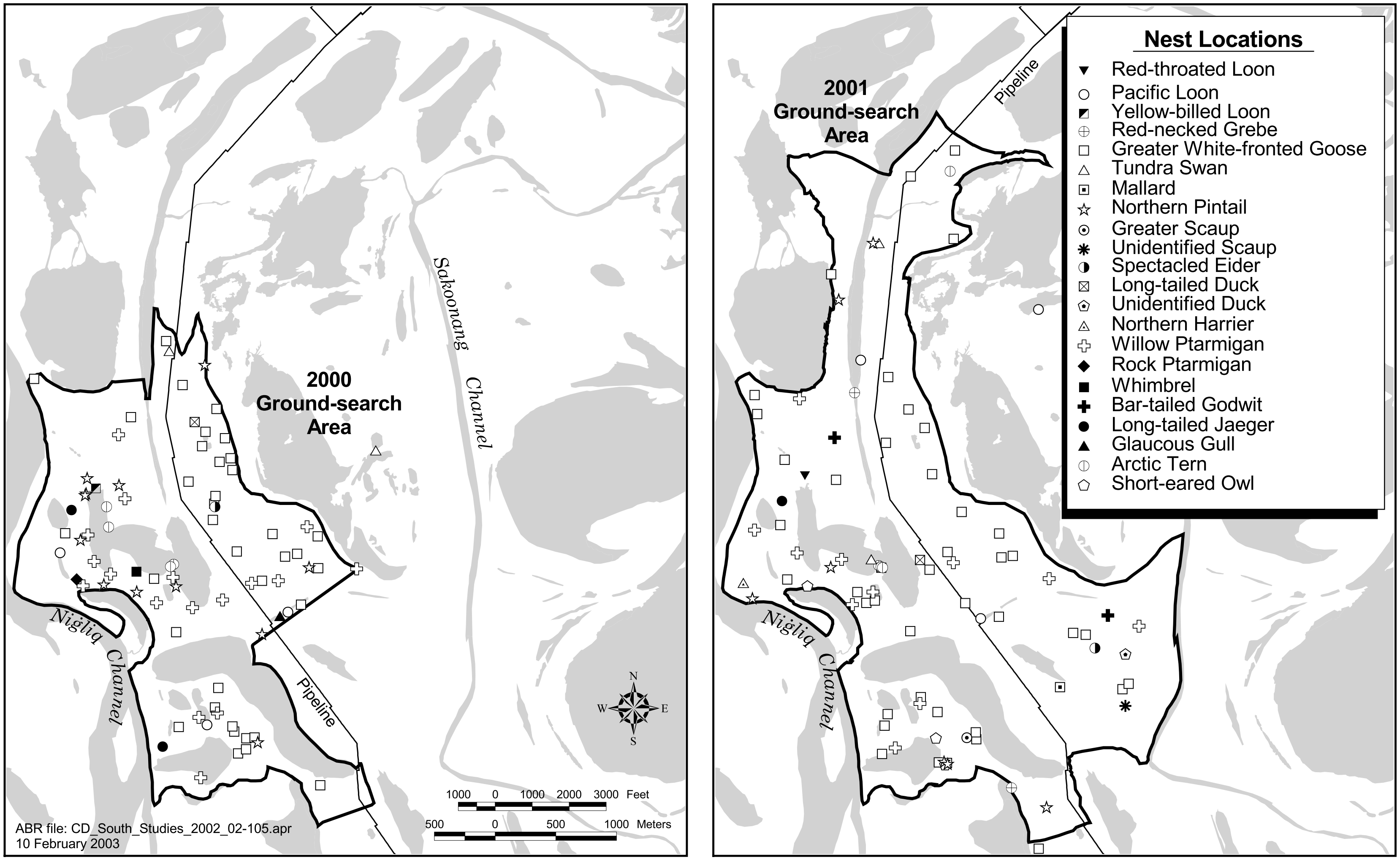

Figure 4. Distribution of waterfowl, loon, and other waterbird nests in the CD South ground-search area, Colville River Delta, Alaska, 2000–2001.

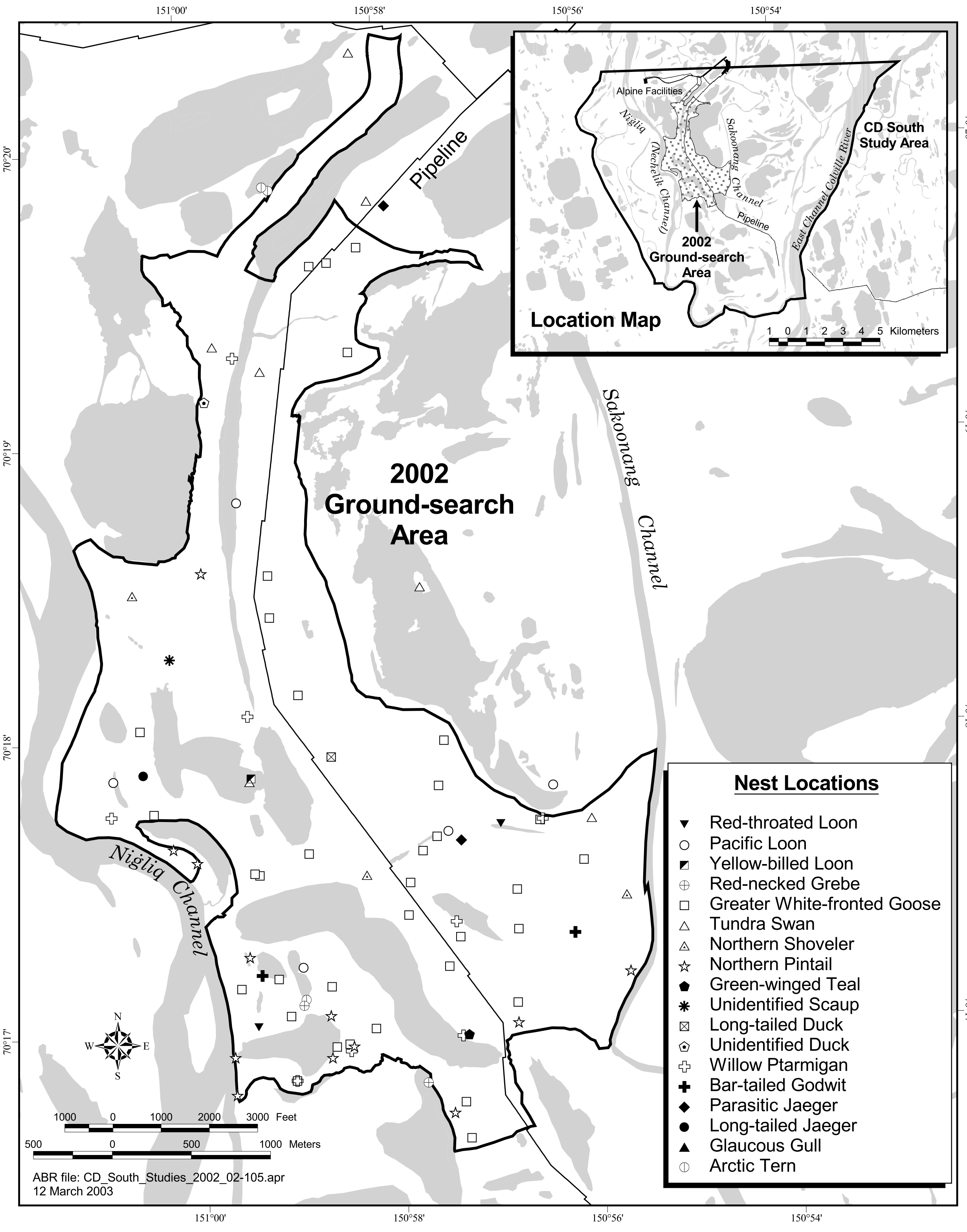

Figure 5. Distribution of waterfowl, loon, and other waterbird nests in the CD South ground-search area, Colville River Delta, Alaska, 2002.

Table 4. Number of nests and nesting success of birds in the CD South ground-search area, Colville River Delta, Alaska, 2000–2002.

	Number of Nests						Nesting Success (%)[a]		
	2000	2001	2002						
Species	Total	Total	Total	Failed	Successful	Unknown Fate	2000	2001	2002
Red-throated Loon	1[b]	1	2	0	1	1	-	-	-
Pacific Loon	3	2	4	0	1	3	-	-	-
Yellow-billed Loon	1[c]	0	1	1	0	0	-	-	-
Red-necked Grebe	0	2	2	0	2	0	-	unk	100
Greater White-fronted Goose	36	40	34	3	31	0	55	56	91
Tundra Swan	1	2	4	0	5	0	0	100	100
Mallard	0	1	0	-	-	-	-	100	-
Northern Shoveler	0	0	3	2	0	0	-	-	0
Northern Pintail	12	7[d]	12	11	1	0	29	8	8
Green-winged Teal	0	0	1	0	1	0	-	-	100
Greater Scaup	0	1	0	-	-	-	-	0	-
Unidentified scaup	0	1[e]	1	1	0	0	-	0	0
Spectacled Eider	1	1	0	-	-	-	0	0	-
Long-tailed Duck	1	2	1	1	0	0	0	0	0
Unidentified duck	0	1	1	1	0	0	-	0	0
Northern Harrier	0	1	0	-	-	-	-	0	-
Willow Ptarmigan	17	11	8	0	7	1	unk	unk	100
Rock Ptarmigan	1	0	0	-	-	-	unk	-	-
Whimbrel	1	0	0	-	-	-	unk	-	-
Bar-tailed Godwit	0	2	2	1	1	0	-	unk	unk
Parasitic Jaeger	0	0	1	0	0	1	-	-	unk
Long-tailed Jaeger	2	1	1	0	0	1	unk	unk	unk
Glaucous Gull	1	0	0	-	-	-	0	-	-
Arctic Tern	4	4	1	0	1	0	unk	unk	unk
Short-eared Owl	0	3	0	-	-	-	-	33	-
TOTAL	82	83	79						

[a] Nesting success equals the number of successful nests divided by the number of nests of know fate (successful plus failed) times 100. Success rates were estimated for waterfowl and ptarmigan (in 2002) based on eggshell remain (see text) and for owls, which have a long nestling period. Estimates of nesting success were not calculated for other species due to the large percentage of nests of unknown fate.
[b] Includes nests presumed from the presence of broods during the nest fate check.
[c] Yellow-billed Loon nest seen on aerial survey.
[d] Includes two probable Northern Pintail nests identified from down and feather characteristics.
[e] Includes one probable Scaup spp. nest identified from down and feather characteristics.

occurred in 3 habitat types (4 nests total; Table 7): Shallow Open Water without Islands, Aquatic Sedge with Deep Polygons, and Patterned Wet Meadow. Red-throated Loon broods occurred in 2 types (2 broods; Table 8): Shallow Open Water without Islands, and Patterned Wet Meadow. The 9 Pacific Loon nest sites occurred in 5 habitats: Deep Open Water without Islands, Shallow Open Water with Islands, Aquatic Grass Marsh, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow. Four Pacific Loon broods occurred in 3 habitat types: Tapped Lake with High-water Connection, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins. The 2 Yellow-billed Loon nests were located in Deep Open Water with Islands and Aquatic Sedge with Deep Polygons. The distribution of loon nests and broods across the CD South study area, as well as habitat selection on the delta is discussed in greater detail under *Loon Surveys*, below.

Two Red-necked Grebe nests were found in both 2001 and 2002. These 4 grebe nests were located in patches of aquatic sedge or grass in 3 habitat types: Tapped Lake with High-water

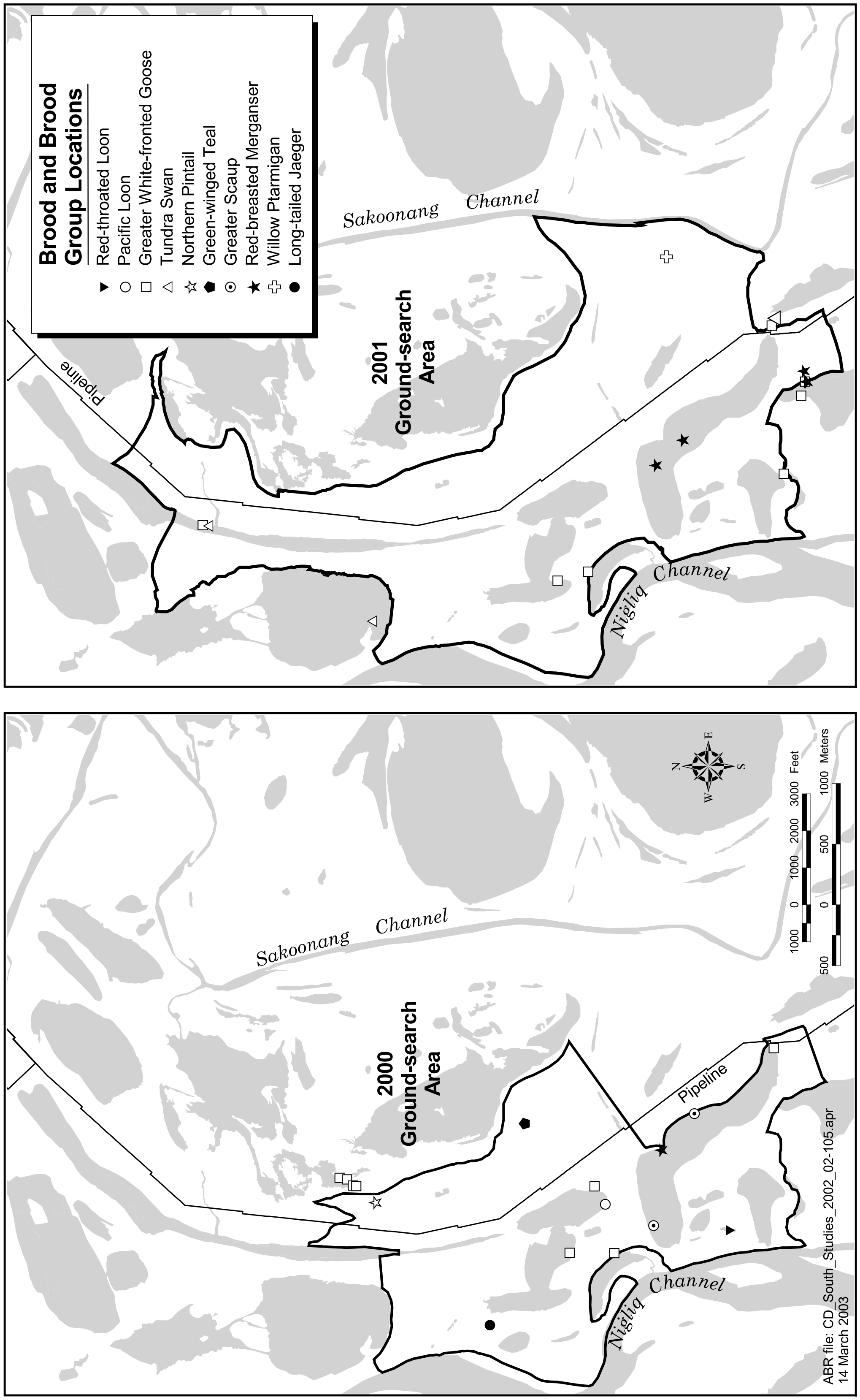

Figure 6. Distribution of broods in the CD South ground-search area, Colville River Delta, Alaska, 2000–2001.

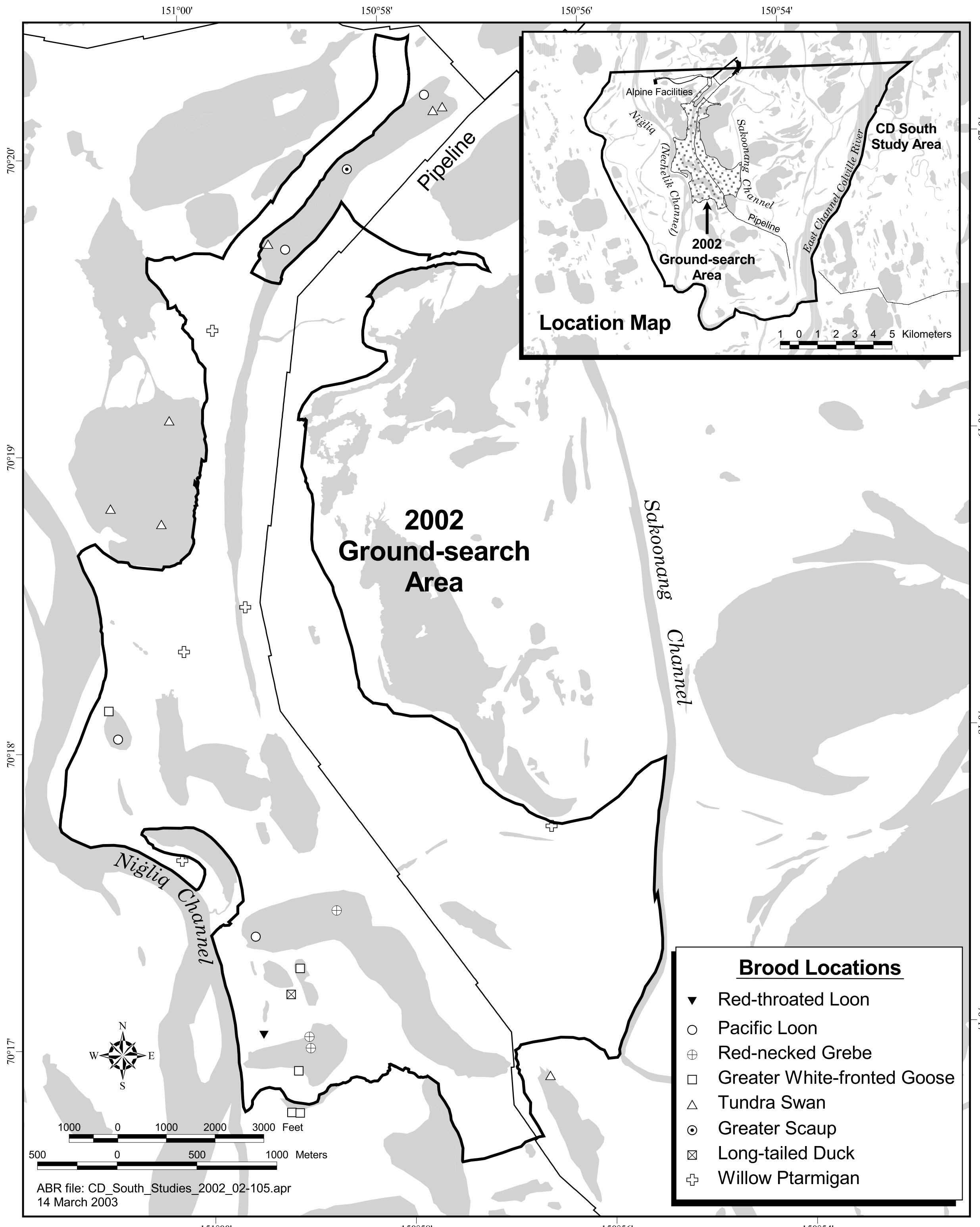

Figure 7. Distribution of broods in the CD South ground-search area, Colville River Delta, Alaska, 2002.

Table 5. Broods or brood groups located in the CD South ground-search area, Colville River Delta, Alaska, 2000–2002.

	2000			2001			2002		
Species	Adults	Young	Broods or Brood Groups	Adults	Young	Broods or Brood Groups	Adults	Young	Broods or Brood Groups
Red-throated Loon	2	1	1	0	0	0	1	1	1
Pacific Loon	1	1	1	0	0	0	5	3	3
Red-necked Grebe	0	0	0	0	0	0	3	2	2
Greater White-fronted Goose	22	32	8	28	51	15	9	14	5
Tundra Swan	0	0	0	6	7	3	8	15	4
Northern Pintail	1	7	1	0	0	0	0	0	0
Green-winged Teal	1	6	1	0	0	0	0	0	0
Greater Scaup	2	11	2	0	0	0	1	3	1
Long-tailed Duck	0	0	0	0	0	0	4	4	1
Red-breasted Merganser	1	5	1	4	16	4	0	0	0
Willow Ptarmigan	0	0	0	2	4	1	9	19	5
Long-tailed Jaeger	2	1	1	0	0	0	0	0	0
TOTAL	32	64	16	40	78	23	40	61	22

Connection, Aquatic Grass Marsh, and Patterned Wet Meadow.

The Greater White-fronted Goose is the most abundant large waterbird nesting on the Colville River Delta (Table 6) and is only goose species found nesting in the CD South ground-search area. Despite a decline in nest densities over the last 3 years (from 6.5 to 3.4 nests/km²) the 3-year mean density of Greater White-fronted Goose nests is higher in the CD South ground-search area (4.6 nests/km²) than in the adjacent Alpine ground-search area, where the 6-year mean was 3.4 nests/km² (range 2.0–5.0; Johnson et al. 2003a). These densities are in the upper limit of ranges reported for the Colville River Delta in the early 1980s (0–6.6 nests/km²; Rothe et al. 1983), and in the upper limit of ranges reported for other known nesting areas of Greater White-fronted Geese: the Yukon-Kuskokwin Delta in western Alaska (2.7–6.3 nests/km²) and Kent Peninsula in the Northwest Territories (2.6–5.2 nests/km²) (Ely and Dzubin 1994). The highest nest density recently was recorded in the CD North ground-search area, where the 3-year mean nest density for Greater White-fronted Geese was 10.3 nests/km² (Johnson et al. 2003b). The high nesting success in the CD South ground-search area in 2002 (91%, n =34) coincided with early snowmelt and warm spring temperatures and with observations of a very early hatching of at least some nests. Greater White-fronted Goose nests were located in 4 habitats: Patterned Wet Meadow (76 nests), Moist Sedge–Shrub Meadow (28 nests), Riverine or Upland Shrub (4 nests), and Nonpatterned Wet Meadow (2 nests) (Table 7). Broods were widespread, occurring in 10 of 13 available habitats during 2000-2002 (Table 8). The habitat most used by brood-rearing Greater White-fronted Geese was Aquatic Grass March (39% of all groups), although habitat use by broods may have been affected by disturbance during ground searches. Analysis of habitat selection and further discussion of the abundance and distribution of Greater White-fronted Geese during brood-rearing and fall staging can be found under *Goose Surveys*, below.

The number of Tundra Swan nests in the CD South ground-search area has increased from 1 in 2000 to 4 in 2002 (Table 4). Since 2000 (when the single nest failed), all swan nests in the ground-search area were hatched successfully. The number of swan broods observed in the ground-search area has increased from 0 in 2000 to 4 in 2002 (Table 5). Three swan broods were

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

	CD South				CD North	Alpine
Species	2000	2001	2002	3-yr mean	3-yr mean	6-yr mean
Red-throated Loon	0.2[a]	0.1	0.2	0.16	0.62[a]	0.18
Pacific Loon	0.5	0.2	0.4	0.37	0.77	0.47
Yellow-billed Loon	0.2[a]	0	0.1	0.09[b]	0.22[b]	0.08
Red-necked Grebe	0	0.2	0.2	0.14	0	0.12
Greater White-fronted Goose	6.2	4.1	3.4	4.56	10.33[c]	3.43[c]
Snow Goose	0	0	0	0	0.02	0
Canada Goose	0	0	0	0	0.04	0.07
Brant	0	0	0	0	1.67[c]	0.23[c]
Unidentified goose	0	0	0	0	0.02	0
Tundra Swan	0.2	0.2	0.4	0.26	0.30	0.39
Mallard	0	0.1	0	0.03	0	0
Northern Shoveler	0	0	0.3[b]	0.10[c]	0.02	0.07[c]
Northern Pintail	2.1[b]	0.7	1.2[b]	1.32 [c]	0.15[c]	0.48[c]
Green-winged Teal	0	0	0.1	0.03	0	0.09[c]
Greater Scaup	0	0.1	0	0.03	0	0.13
Lesser Scaup	0	0	0	0	0	0.01
Unidentified scaup	0	0.1	0.1	0.07	0	0.14[c]
Spectacled Eider	0.2	0.1	0	0.09	0.64[c]	0.04
King Eider	0	0	0	0	0.11[c]	0.01
Unidentified eider	0	0	0	0	0.04	0
Long-tailed Duck	0.2	0.2	0.1[b]	0.16 [c]	1.29[c]	0.39[c]
Unidentified duck	0	0.1	0.1	0.07	0.08	0.08
Northern Harrier	0	0.1	0	0.03	0	0
Willow Ptarmigan	2.9	1.1	0.8	1.61	0.40	0.72
Rock Ptarmigan	0.2	0	0	0.06	0	0.03
Unidentified ptarmigan	0	0	0	0	0.02	0.07
Sandhill Crane	0	0	0	0	0	0.01
Whimbrel	0.2	0	0	0.06	0	0
Bar-tailed Godwit	0	0.2	0.2	0.14	0.02	0.08
Common Snipe	0	0	0	0	0	0.02
Parasitic Jaeger	0	0	0.1	0.03	0.10	0.12
Long-tailed Jaeger	0.3	0.1	0.1	0.18	0	0.06
Glaucous Gull	0.2	0	0	0.06	0.28	0.06
Sabine's Gull	0	0	0	0	0.37	0.02
Arctic Tern	0.7	0.4	0.1	0.40	0.74	0.44
Short-eared Owl	0	0.3	0	0.10	0	0.01
Area Searched (km²)	5.85	9.7	10.0	5.8–10.1	12.2–1.9	11.4–17.2
Waterbird Density[d]	10.8	7.0	7.1	8.49	17.94	7.26
Total Nest Density	14.0	8.6	7.9	10.24	18.37	7.94
Total Number of Nests	82	83	79	79–83	245–346	69–182
Number of Species	14	16	17	14–16	15–19	16–20

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

Table 7. Number of nests in each habitat type in the CD South ground-search area, Colville River Delta, Alaska, 2000–2002.

Species	Tapped Lake with High-water Connection	Salt Marsh	Deep Open Water without Islands	Deep Open Water with Islands	Shallow Open Water without Islands	Shallow Open Water with Islands	Aquatic Sedge with Deep Polygons	Aquatic Grass Marsh	Nonpatterned Wet Meadow	Patterned Wet Meadow	Moist Sedge–Shrub Meadow	Riverine or Upland Shrub	Total
Red-throated Loon					1		1			2			4
Pacific Loon			1			1		2		3	2		9
Yellow-billed Loon				1			1						2
Red-necked Grebe	1							1		2			4
Greater White-fronted Goose									2	76	28	4	110
Tundra Swan				2						2	3		7
Mallard										1			1
Northern Shoveler									1	1	1		3
Northern Pintail									1	6	15	9	31
Green-winged Teal												1	1
Greater Scaup											1		1
Unidentified scaup							1			1			2
Spectacled Eider										2			2
Long-tailed Duck										4			4
Unidentified duck										1	1		2
Northern Harrier												1	1
Willow Ptarmigan									1	16	8	11	36
Rock Ptarmigan											1		1
Whimbrel										1			1
Bar-tailed Godwit										4			4
Parasitic Jaeger										1			1
Long-tailed Jaeger										1	3		4
Glaucous Gull						1							1
Arctic Tern		1		2						6			9
Short-eared Owl											2	1	3
TOTAL	1	1	1	5	1	2	3	3	5	130	65	27	244

Table 8. Number of broods or brood groups in each habitat type in the CD South ground-search area, Colville River Delta, Alaska, 2000–2002.

Species	Tapped Lake with Low-water Connection	Tapped Lake with High-water Connection	Salt Marsh	Deep Open Water without Islands	Deep Open Water with Islands	Shallow Open Water without Islands	Aquatic Grass Marsh	Nonpatterned Wet Meadow	Patterned Wet Meadow	Moist Sedge–Shrub Meadow	Riverine or Upland Shrub	Barrens	Total
Red-throated Loon						1			1				2
Pacific Loon		2		1	1								4
Red-necked Grebe		1		1									2
Greater White-fronted Goose	1	2	2	1	1		11	1	2		5	2	28
Tundra Swan		4					2					1	7
Northern Pintail										1			1
Green-winged Teal									1				1
Greater Scaup		3											3
Long-tailed Duck									1				1
Red-breasted Merganser		3					2						5
Willow Ptarmigan									2	2	2		6
Long-tailed Jaeger										1			1
TOTAL	1	15	2	3	1	1	15	1	7	4	7	3	61

observed in the ground-search area in 2001, although only 2 nests were found, indicating movements of at least one brood into the area. The mean density of swan nests was similar among the 3 ground-search areas on the delta: 0.26 nests/km² in CD South, 0.30 nests/km² in CD North, and 0.39 nests/km² in the Alpine area (Table 6). Swan nests occurred in 3 habitats in the ground-search area at CD South: Deep Open Water with Islands (2 nests), Moist Sedge–Shrub Meadow (3 nests), and Patterned Wet Meadow (2 nests) (Table 7). Broods were observed in 3 habitats (Tapped Lake with High-water Connection, Aquatic Grass Marsh, and Barrens; Table 8), but brood locations may have been affected by disturbance from observers on foot. Analysis of habitat selection and further information on abundance and distribution of Tundra Swans is provided under *Swan Surveys*, below.

Seven species of duck have nested in the ground-search area at CD South: Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal, Greater Scaup, Spectacled Eider, and Long-tailed Duck (Table 4). Although no nests have been located, broods of Red-breasted Merganser were observed in the ground-search area in both 2000 and 2001 (Table 5). American Wigeons occur regularly in the area but there is no evidence of American Wigeons nesting on the Colville River Delta (Johnson and Herter 1989; ABR, unpubl. data). Northern Pintails and Long-tailed Ducks are the only ducks that have nested in the ground-search area in each of the 3 years of study. Northern Pintails are the most abundant ducks with between 7 and 12 nests annually (Table 4). Pintails also have exhibited the highest nesting success among ducks, in fact only one other species is known to have successfully hatched a nest – a single Green-winged Teal nest was successful in 2002 (Table 4). Pintails nest at higher densities in the CD South ground-search area than in either the Alpine or CD North areas (Table 6). Northern Pintails nested in 4 habitat types: Moist Sedge–Shrub Meadow (15 nests), Riverine or Upland Shrub (9 nest), Patterned Wet Meadow (6 nests), and Nonpatterned Wet Meadow (1 nest) (Table 7).

Long-tailed Duck nests occurred in low densities in all years (≤0.2 nests/km²; 1 or 2 nests each year). The density of Long-tailed Duck nests appears to increase from south to north on the Colville River Delta ground-search areas, ranging from the low density at CD South to moderate densities at Alpine (6-year mean = 0.4 nests/km²) to the highest densities at CD North (3-year mean 1.3 nests/km). All Long-tailed Duck nest and brood observations within the ground-search area at CD South were located in Patterned Wet Meadow (Table 7 and Table 8). In the early 1980s, the USFWS recorded the Long-tailed Duck as the second-most-abundant large bird on the Colville River Delta and the average density of 7.4 birds/km² in June was higher than that recorded for any other location on the Arctic Coastal Plain (Rothe et al. 1983).

A Spectacled Eider nest was located in the ground-search area at CD South in 2000 and 2001. Both nests failed. The 2 nest sites were 1.8 km apart, both were in Patterned Wet Meadow, and located 9.6-11.4 km inland from the Beaufort Sea coast. The 3-year mean nest density for Spectacled Eiders is 0.09 nests/km². Nesting Spectacled Eiders are uncommon this far inland on the delta and nest densities are much higher in the more coastal CD North area (3-year mean: 0.64 nest/km²) (Table 6). Eider distribution and habitat selection are discussed in greater detail under *Eider Surveys*, below.

EIDER SURVEYS

Background

Between 1957 and 1992, Spectacled Eiders suffered large population declines, particularly in the Yukon–Kuskokwim Delta in western Alaska (Kertell 1991, Stehn et al. 1993), and as a result they were listed as a threatened species under the Endangered Species Act in 1993 (58 FR 27474–27480). Since 1993, the western Alaska population appears to be stable or declining only slightly (Peterson et al. 2000). On the Arctic Coastal Plain, Spectacled Eider numbers may have declined slightly (<2%) since 1993, but the trend is not significant (Larned et al. 2003). Spectacled Eiders are uncommon nesters (i.e., they occur regularly but are not found in all suitable habitats) on Alaska's Arctic Coastal Plain, and tend to concentrate on large river deltas (Johnson and Herter 1989). Spectacled Eiders arrive on the Colville River Delta in early June, and the earliest nests have been recorded between 8 and 24 June (Simpson et al. 1982, North et al. 1984, Nickles et al. 1987, Gerhardt et al. 1988). The latest record of Spectacled Eiders on the Colville River Delta is 28 August (Gerhardt et al. 1988).

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

Common Eiders have a circumpolar distribution and along the Beaufort Sea coast they favor barrier islands as nesting sites (Johnson and Herter 1989). Except for the barrier islands, Common Eiders are rare on the Colville River Delta (Simpson et al. 1982, Renken et al. 1983, North et al. 1984, Johnson et al. 1998). None have been observed in the CD South study area.

The Steller's Eider was listed as threatened under the Endangered Species Act in 1997 (62 FR 31748–31757). In Alaska, Steller's Eiders breed in the west and northwest with few recent records east of Point Barrow (Johnson and Herter 1989). Five Steller's Eiders were seen briefly on the outer delta in June 1995 (J. Bart, Boise State University, pers. comm.), and one pair was observed on the outer delta in June 2001 (Johnson et al. 2002). Single pairs also were sighted nearby in the Kuparuk Oilfield in June 2000 and 2001 (S. Schlentner and D. Lum, ABR, pers. comm.).

Distribution and Abundance

Pre-nesting

Eider pre-nesting surveys were conducted annually between 13 and 16 June 2000–2002 (13 June in 2002). In 2002, all Spectacled Eiders observed on the delta during pre-nesting were in groups of 1–3 birds and these relatively small groups appeared to have already dispersed into breeding habitats. We suspect that the breeding phenology of eiders was more advanced at the time of our surveys in 2002 than it was during surveys in previous years. Snowmelt was more advanced and temperatures were higher in early June 2002 compared with conditions in 2000–2001.

The pre-nesting distributions of Spectacled and King eiders on the delta in 2002 were similar to those recorded on surveys flown between 1993 and 2001 (Figure 8, Appendices C1 and C2). Pre-nesting Spectacled and King eiders on the Colville River Delta were closely associated with coastal areas in all years. Across the entire delta, the mean distance of pre-nesting Spectacled Eiders from the coast was 4.0 km (n = 233 sightings, 1993–1998 and 2000–2002 [1992 surveys were incomplete and were not included]). The greatest distance of Spectacled Eiders from the coast during pre-nesting was 14.3 km. Pre-nesting King Eiders on the Colville River Delta had a similar affinity for coastal areas with the farthest inland observation (1993–2002) being 14.2 km from the coast. The mean distance of pre-nesting King Eiders from the coast was 4.9 km (n = 154 sightings).

No eiders were observed in the CD South study area during the pre-nesting survey in 2002 (Table 9). In 9 years of surveys, the number of eiders observed in the CD South study area has ranged from 0 to 11. Although neither species is abundant, King Eiders tend to outnumber Spectacled Eiders (in 6 of 9 years). The largest number of Spectacled Eiders observed in the CD South study area in any year was 2, whereas the largest number of King Eiders observed was 9.

The density of eiders in the CD South study area is relatively low by comparison with nearby areas. Over 9 years, the indicated density of pre-nesting Spectacled Eiders in the CD South study area has been ≤0.01 birds/km² (Table 9). The indicated density of King Eiders during pre-nesting has varied from 0 to 0.08 birds/km², averaging 0.03 birds/km². For the same years in the adjacent CD North study area, indicated densities of Spectacled Eiders averaged 0.20 birds/km² and densities of King Eiders averaged 0.06 birds/km² (Johnson et al. 2003b). In the Kuparuk Oilfield, immediately to the east, indicated densities of pre-nesting Spectacled Eiders averaged 0.08 birds/km² (n = 9 years), and King Eiders averaged 0.47 birds/km² (Anderson et al. 2003). Immediately to the west in the Northeast Planning Area of NPRA, indicated densities of pre-nesting Spectacled Eiders (mean = 0.03 birds/km², n = 2 years) were similar to those in the CD South study area, whereas King Eiders occurred at relatively high densities in the NPRA study area (mean = 0.28 birds/km²; Burgess et al. 2003). Across the entire Arctic Coastal Plain, the mean indicated density of pre-nesting Spectacled Eiders was 0.23 birds/km² (n = 10 years) and of King Eiders was 0.42 birds/km² (Larned et al. 2003).

Nesting and Brood-rearing

Only 2 Spectacled Eider nests have been found in the ground-search areas at CD South, one each in 2000 and 2001 (Figure 4, Appendix C3). In 2002, the ground-search area encompassed the areas searched in 2000–2001, but no eider nests were found. King Eiders have not been found nesting in the ground-search area, although one nest was found nearby in the Alpine project area in 1996 (Appendix C4). Neither of the 2 Spectacled Eider nests found in 2000–2001 hatched. As might be expected from the scarcity of nests, eider broods have not been observed in the CD South study area. The CD South study area appears to be at the southern extent of eider distribution on the Colville River Delta, although suitable habitat for nesting and brood-rearing is available.

Habitat Use

Pre-nesting

In 9 years of pre-nesting surveys, Spectacled Eiders were observed in 4 habitat types in the CD South study area: both types of Tapped Lakes, River or Stream, and Aquatic Sedge with Deep Polygons (1 group of 2 adults in each type; Appendix D1). Pre-nesting King Eiders were observed in 5 habitats (Appendix D1): River or Stream (54% of 13 groups), Tapped Lake with High-water Connection (15%), Patterned Wet Meadow (15%), Tapped Lake with Low-water Connection (8%), and Riverine or Upland Shrub (8%).

Over 9 years of surveys of the Colville River Delta, 5 of 24 habitats were preferred by pre-nesting Spectacled Eiders: Brackish Water,

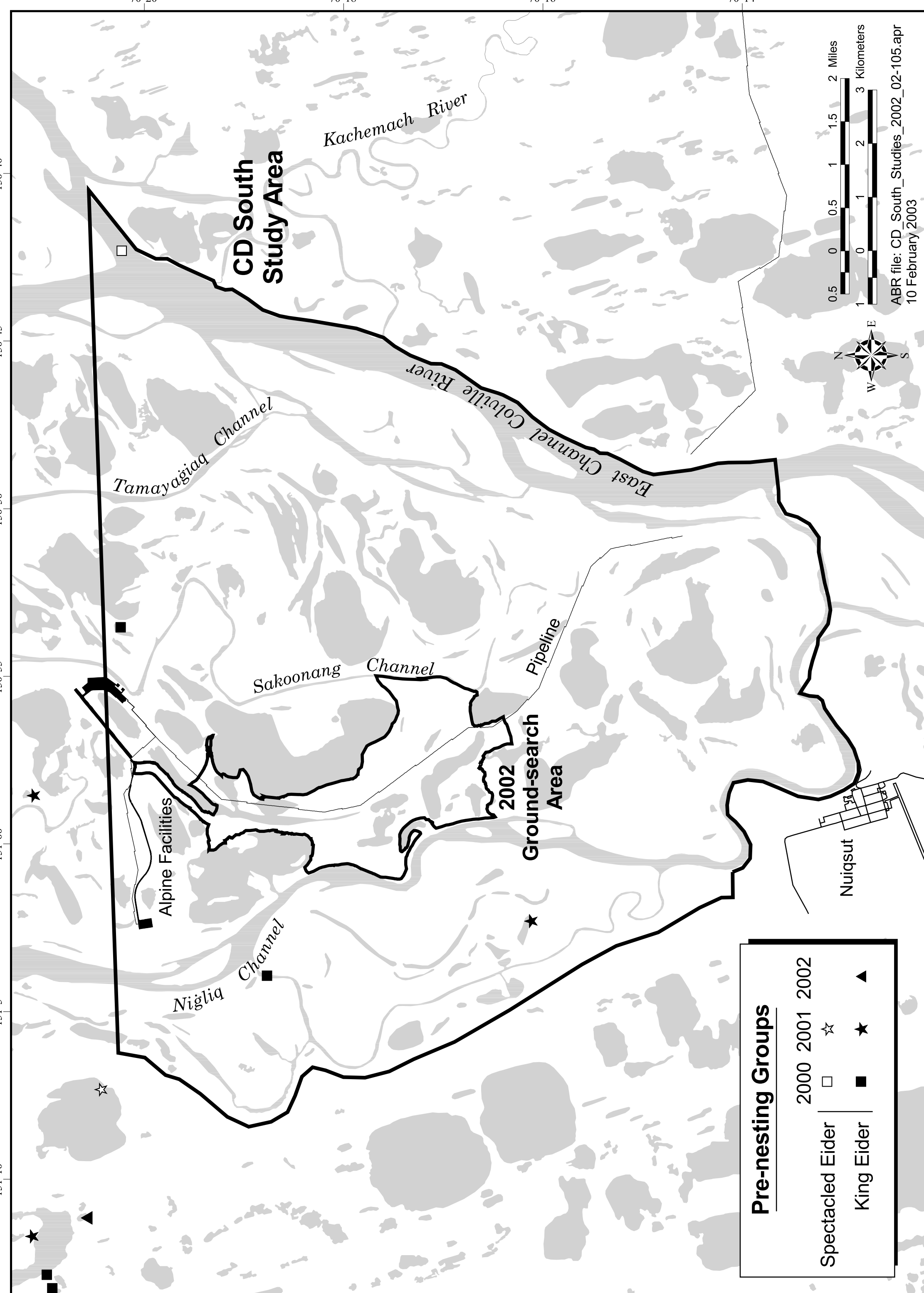

Figure 8. Distribution of Spectacled and King eider groups during pre-nesting aerial surveys in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Table 9. Observed number (flying and non-flying birds), indicated number, and indicated density (birds/km²) of eiders during pre-nesting aerial surveys in the CD South study area (155.9 km²), Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 1999a).

	Spectacled Eider			King Eider		
Year	Observed Number	Indicated Number[a]	Indicated Density	Observed Number	Indicated Number	Indicated Density
1993[b]	0	0	0	3	2	0.03
1994[c]	0	0	0	0	0	0
1995	2	2	0.01	4	4	0.03
1996	0	0	0	8	12	0.08
1997	2	2	0.01	9	10	0.06
1998	2	2	0.01	0	0	0
2000	2	2	0.01	6	6	0.04
2001	0	0	0	2	2	0.01
2002	0	0	0	0	0	0

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

Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons (Appendix D2). None of these habitats comprise more than 2% of the CD South study area and Brackish Water and Salt-killed Tundra do not occur there (Table 2). Pre-nesting Spectacled Eiders avoided 6 habitats on the delta, and the remaining habitats were used in proportion to their availability (Appendix D2). Elsewhere, studies have emphasized the importance of emergent vegetation for eiders using waterbodies. West of the Colville River Delta in the NPRA, Spectacled Eiders were found in shallow *Arctophila* ponds and deep open lakes in June, with shallow *Carex* ponds becoming more important through the summer (Derksen et al. 1981). East of the Kuukpik, 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. 2003). Bergman et al. (1977) found most pre-nesting Spectacled Eiders at Storkersen Point in deep *Arctophila* wetlands. In Prudhoe Bay, pre-nesting Spectacled Eiders used flooded terrestrial habitats, but preferred ponds with emergent vegetation (both *Arctophila* and *Carex*) and impoundments (Warnock and Troy 1992). Lakes with emergents are not abundant on the Colville River Delta; however, Aquatic Sedge with Deep Polygons (a preferred habitat on the delta), Aquatic Sedge Marsh, and Aquatic Grass Marsh probably are analogous to the *Carex* and *Arctophila* ponds described elsewhere. None of these habitats is abundant in the CD South study area; combined they occupy <2% of the area (Table 2).

Over 9 years of surveys, pre-nesting King Eiders preferred 3 habitats on the delta: Brackish Water, Salt-killed Tundra, and River or Stream (Appendix D2). Of preferred habitats, only River or Stream occurs in the CD South study area (Table 2). At Storkersen Point, where they nest in relatively high densities, King Eiders 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). The nest density of King Eiders also is high at Prudhoe Bay and pre-nesting King Eiders there used almost all habitats, but preferred wet or aquatic nonpatterned ground, aquatic strangmoor, and water with and without emergents (Warnock and Troy 1992). Although many of the habitats used in other areas are available in the CD South study area, King

Eiders do not appear to use them. The low number of nests found on the delta during later nest searches indicates that the Colville River Delta is used by King Eiders mainly as a stopover during movements to other nesting areas.

Nesting

The 2 Spectacled Eider nests that have been found in the CD South ground-search area were each located on polygon rims in Patterned Wet Meadow habitat about 0.5 m from permanent water. During 11 years (1992–2002) of nest searching in various locations on the entire delta, 62 nests of Spectacled Eiders have been found in 9 habitats (Appendix D3). Most nests were located in Salt-killed Tundra (24% of all nests), Aquatic Sedge with Deep Polygons (23%), Patterned Wet Meadow (17%), and Nonpatterned Wet Meadow (16%). The coastal portion of the delta, where Spectacled and King eiders concentrate during pre-nesting, also is where eiders nest most commonly (Appendices C3 and C4). The farthest distance from the coast that a Spectacled Eider nest has been observed on the Colville River Delta is 13 km. Derksen et al. (1981) also reported that Spectacled Eiders in the NPRA occurred mainly in coastal areas, and Kistchinski and Flint (1974) similarly found the highest numbers of Spectacled Eiders in the maritime area on the Indigirka delta. The mean distances from the coast of all eider nests on the Colville Delta for which we have records are 3.5 km for Spectacled Eider ($n = 62$), 3.7 km for King Eider ($n = 9$), and 1.4 km for Common Eider ($n = 1$).

Spectacled Eider nests were strongly associated with waterbodies in all habitats across the delta, averaging 3.7 m from permanent water (range = 0.1–80 m, $n = 62$). Most nests were associated with Brackish Water (37% of all nests) and Deep Open Water with Islands or Polygonized Margins (29%) (Appendix D3). The results of pre-nesting and nesting habitat analyses emphasize the importance of coastal habitats on the outer delta to breeding Spectacled Eiders, including Brackish Water, Salt-killed Tundra, Salt Marsh, and Aquatic Sedge with Deep Polygons. The absence or scarcity of these habitats may explain the low numbers of Spectacled Eiders in the CD South study area during pre-nesting and nesting.

Similar habitat associations have been reported for nesting Spectacled Eiders in other locations. Nests on the Yukon-Kuskokwim Delta averaged 2.1 m from water (Dau 1974). Annual mean distances of Spectacled Eider nests to water in the Kuparuk Oilfield ranged from 0.6 to 5.7 m over 9 years, and the waterbodies closest to nests were primarily basin wetland complexes, shallow and deep open lakes, and water with emergents (both *Carex* and *Arctophila*) (Anderson et al. 2003). Spectacled Eiders at Storkersen Point preferred deep *Arctophila* ponds for both pre-nesting and nesting (Bergman et al. 1977). In the NPRA, Spectacled Eiders used shallow *Carex* ponds during summer (Derksen et al. 1981). In Prudhoe Bay, nests were found in *Carex* ponds and wet, nonpatterned tundra (Warnock and Troy 1992). Waterbodies with emergent vegetation are relatively scarce on the Colville River Delta: the 3 habitat types that comprise waterbodies with emergents (Aquatic Sedge with Deep Polygons, Aquatic Grass Marsh, and Aquatic Sedge Marsh) together cover only 2.8% of the delta. Therefore, Spectacled Eider nesting habitat on the delta differs somewhat from adjacent tundra areas that have more abundant *Carex* and *Arctophila* waterbodies.

Brood-rearing

No Spectacled or King eider broods were observed during 2000–2002 in the CD South study area. Since our surveys began on the delta in 1992, we have seen only one Spectacled Eider brood in the CD South study area, and it was using Patterned Wet Meadow. Little effort has been expended specifically to locate eider broods on the Colville River Delta, but 34 groups of brood-rearing Spectacled Eiders have been recorded since 1983 (Appendices C5 and D4). Spectacled Eider broods were located primarily in aquatic and wet habitats: Deep Open Water with Islands or Polygonized Margins (24% of all groups), Salt-killed Tundra (15%), Aquatic Sedge with Deep Polygons (15%), Deep Open Water without Islands (12%), and Patterned Wet Meadow (12%). Broods appear to be attracted to coastal lakes; most broods (74%) were seen on water and the mean distance to the coast was 3.6 km ($n = 34$). In the NPRA, Spectacled Eider broods primarily used shallow *Carex* ponds, deep open lakes, and deep *Arctophila* (Derksen et al. 1981).

Post-nesting adults without broods at Storkersen Point also preferred deep *Arctophila* wetlands (Bergman et al. 1977).

Only 2 King Eider broods have been seen on the delta since studies began in 1992 (Appendix D4). One King Eider brood was seen in Aquatic Sedge with Deep Polygons, and the other King Eider brood was found in Patterned Wet Meadow.

TUNDRA SWAN SURVEYS

Background

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

Distribution And Abundance

Nesting

During the nesting survey, 53 swans and 8 nests were observed in the CD South study area in 2002 (Table 10). Seven additional nests were found during other surveys in the CD South study area in 2002, yielding 15 nests total (Figure 9): 4 occurred in the CD South ground-search area (Figure 5) and 3 were found during helicopter-based aerial searches for loon nests.

Since 1992, the number of swans observed in the CD South study area during nesting aerial surveys has varied from 51 in 1993 to 256 in 1998 (Table 10). Fewer than 100 swans were observed during the years 1992–1995 and 2001–2002, while nearly twice as many (between 174 and 256) were observed during the period 1996–2000. The increased numbers during that period are attributable mainly to large numbers of nonbreeding swans. Over the 9 years of nesting surveys, between 4 and 26% of swans in the CD South study area appeared to be breeding. Although the number of swans observed during the nesting survey was low, 26% (14 of 53) of the swans observed appeared to be breeding in 2002, the largest proportion of breeders observed over 9 years of surveys.

The number of Tundra Swan nests found during aerial surveys of the CD South study area has varied from 3 (1992, 1993) to 17 (1996) (Table 10, Appendix C6). The high density of nests in 1996 reflected a regional increase in nest numbers in that year (Anderson et al. 1996, Johnson et al. 1997). Although the CD South study area had relatively few nests in 2002 (8, by comparison with a high of 17 in 1996), swans nested in record numbers in the greater region in 2002 (55 nests on the Colville River Delta, Appendix D5 and D6; and 115 nests in the Kuparuk Oilfield study area, Anderson et al. 2003).

Aerial survey data from 9 years indicate that the mean density of swan nests within the CD South study area (0.06 nests/km²) has closely paralleled that estimated for the Colville River Delta as a whole (Table 10, Appendix D5, Appendix C6). Annually, since 1992, 15–38% of swan nests on the delta have been located within the CD South study area. The larger CD North study area (206.87 km²), supports a greater number of nesting swans, with a 9-year mean density of 0.08 nests/km² (Johnson et al. 2003b).

Simpson et al. (1982) reported similar densities of Tundra Swans on the Colville River Delta in 1982, when 48 nests (~0.11 nests/km²) were found on the northern 80% of the delta during intensive foot-surveys. In other areas of the Arctic Coastal Plain, nest densities were similar to or lower than those for the CD South study area: 0.04–0.06 nests/km² on the eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km² in the Kuparuk Oilfield and adjacent areas (Anderson et al. 2003).

Brood-rearing

During the brood-rearing aerial survey in 2002, 35 adult and 10 young Tundra Swans were

Table 10. Number and density (no./km²) of Tundra Swans and swan nests during nesting aerial surveys in the CD South study area, Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Johnson et al. 1999a).

	Birds			Nests		
Year	Total	Density	Percent Nesting	Total	Density	Apparent Success[a] (%)
1992[b]	72	0.46	4	3	0.02	166
1993	51	0.33	10	3	0.02	133
1995	87	0.56	15	7	0.04	71
1996	174	1.12	15	17	0.11	65
1997	232	1.49	8	11	0.07	64
1998	256	1.64	7	11	0.07	64
2000	179	1.15	10	10	0.06	120
2001	98	0.63	18	9	0.06	89
2002	53	0.34	26	8	0.05	50
MEAN	134	0.86	13	9	0.06	80

[a] Apparent nesting success is calculated by dividing the number of broods observed during aerial surveys (Table 11) by the number of nests (see text).
[b] Data from a survey conducted by the Alaska Department of Fish and Game.

observed in the CD South study area (Figure 9, Table 11). Twenty-three percent of adults were accompanied by broods. Four broods were observed, with a mean brood size of 2.5 (Table 11). The apparent nesting success was 50% (8 nests known/4 broods observed), but this estimate may be influenced by movements of broods into or out of the study area. Nonetheless, nesting success appeared to be low in the CD South study area in 2001.

Since 1992, the total number of swans observed in the CD South study area during brood-rearing surveys has ranged from 45 (2002) to 98 (1996) (Table 11). The 45 swans counted in 2002 represent the lowest number since surveys were begun. The number of young swans observed in the CD South study area has varied from 10 (1993, 2002) to 35 (1996), and the number observed in 2002 was well below the 9-year mean of 17.6 cygnets/year.

Estimates of apparent nesting success have ranged from 50 to >100% in the CD South study area (Table 10), although values of more than 100% in 1992, 1993, and 2000 indicate that either all nests were not located during aerial surveys or broods from outside the study area moved into the area after hatching. Although apparent nesting success was low in 2002, the mean brood size (2.5 cygnets/brood) was the highest that has been observed in the CD South study area since 1996. Across the entire delta and all 9 years of aerial surveys, the number of broods has varied from 14 (1993) to 32 (1996) (Appendix D5, Appendix C7). Estimated nesting success for the whole delta in 2002 was 31% (17 of 55 nests), the lowest value recorded since we began aerial surveys in 1992 (Appendix D5). Delta-wide brood numbers and densities in 2002 were the lowest since 1992, the first year we began our aerial surveys, but mean brood size for the whole delta (3.2; $n = 17$) was the highest value observed since 1996.

Over the 9 years of monitoring on the Colville River Delta and adjacent Arctic Coastal Plain, productivity (as indicated by nesting success, brood density, and mean brood size) on the Colville River Delta generally has been similar to or greater than that in other areas on the North Slope. Aerial surveys between the Kuparuk and Kuukpik rivers (1988–1993, 1995–2002) recorded mean brood sizes of 2.0–2.8 young/brood and

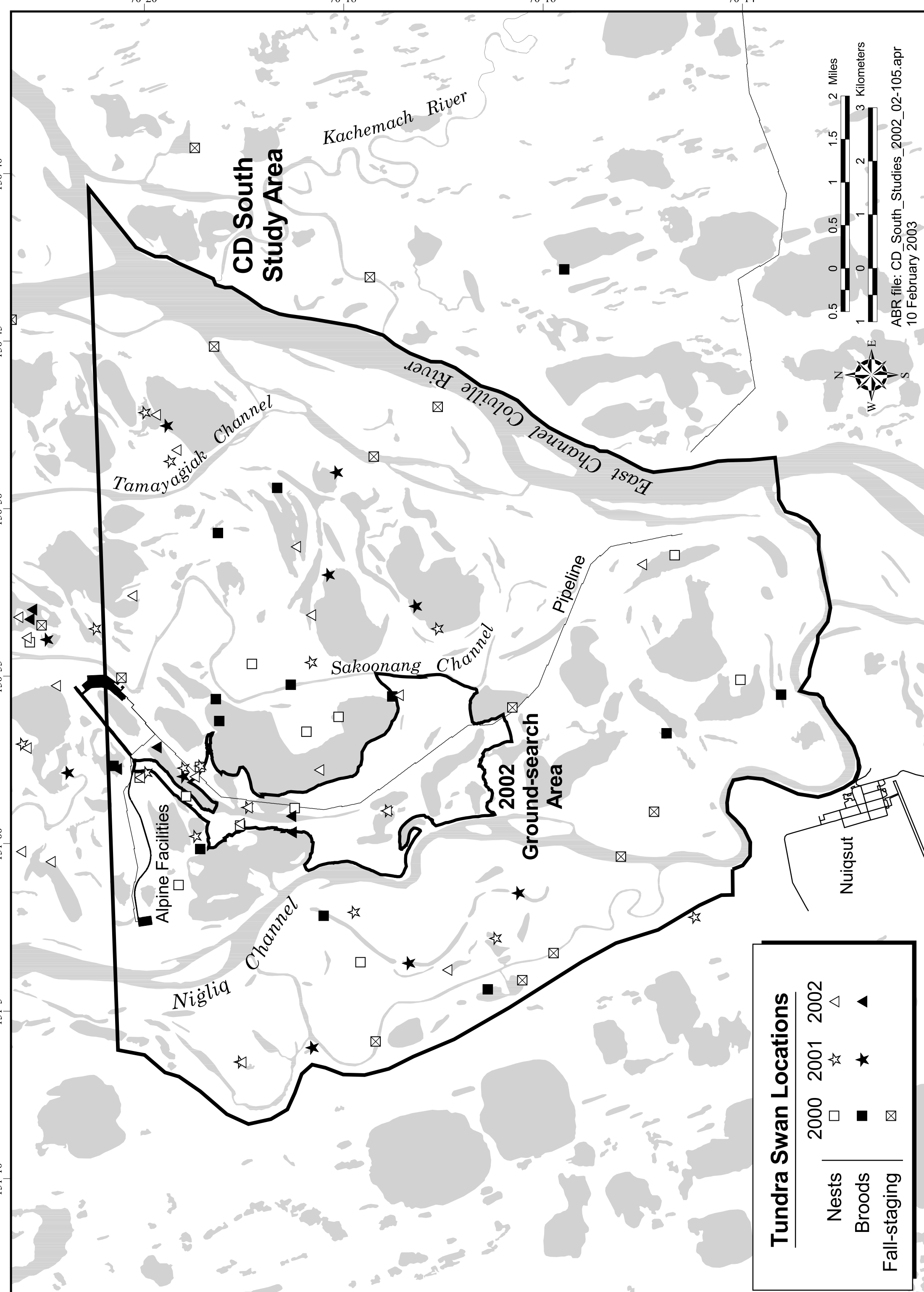

Figure 9. Distribution of Tundra Swan nests, broods, and fall-staging groups in the CD South study area, Colville River Delta, Alaska, 2000–2002. Fall-staging surveys were not conducted in 2001–2002.

Table 11. Numbers and density (no./km²) of Tundra Swans and broods during brood-rearing aerial surveys in the CD South study area, Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Johnson et al. 1999a).

Year	Adults	Young	Total	Density[a]	Percent with Broods[b]	Percent Young	Mean Brood Size	Broods Total	Broods Density
1992[c]	53	12	65	0.42	15	18	2.4	5	0.03
1993	57	10	67	0.43	10	15	2.5	4	0.03
1995	53	17	70	0.45	14	24	3.4	5	0.03
1996	63	35	98	0.63	21	36	3.2	11	0.07
1997	56	17	73	0.47	18	23	2.4	7	0.04
1998	78	16	94	0.60	15	17	2.3	7	0.04
2000	60	25	85	0.55	28	29	2.1	12	0.08
2001	54	16	70	0.45	30	23	2.0	8	0.05
2002	35	10	45	0.29	23	22	2.5	4	0.03
MEAN	57	17.6	74	0.48	19	23	2.5	7	0.04

[a] Density is calculated based on total birds (adults plus young).
[b] Calculated as number of adults with broods divided by the number of adults without broods.
[c] Data from a survey conducted by the Alaska Department of Fish and Game.

densities of 0.02–0.04 broods/km² (Anderson et al. 2003). In the Kuparuk Oilfield, nesting success of swans was 58% and mean brood size was 2.4 young (n = 67) in 2002. As in the Colville River Delta, these statistics represent the lowest estimate of nesting success and the highest estimate of mean brood size in the Kuparuk Oilfield since 1996 (Anderson et al. 2003).

Two earlier studies on the Colville River Delta, both employing intensive ground surveys, provide comparative historical data. Rothe et al. (1983) reported nesting success of 91% (n = 32 nests) and a mean of 2.1 young/brood for the Colville River Delta in late July 1981. In 1982, nesting success was 71% (n = 48 nests), and mean brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). In a 3-year study (1988–1990) of swans nesting on the Canning and Kongakut river deltas, the overall nesting success was 76% (n = 110 nests) (Monda et al. 1994). Platte and Brackney (1987) estimated 63–85% nesting success, 0.04 broods/km², and 2.5 young/brood on portions of the Arctic National Wildlife Refuge (ANWR) during 1982–1985.

Fall Staging

Fall-staging surveys for swans have not been flown since 2000 (Johnson et al. 2000a). During fall-staging surveys in past years (1992–1993, 1995–1998, and 2000), most swans generally have occurred in several large flocks that occupy river channels on the outer Colville River Delta (Appendix C8). Wetlands immediately east of the delta, lying between the Miluveach River and Kalubik Creek, have had the largest aggregations of Tundra Swans on the Arctic Coastal Plain of Alaska during fall staging (Seaman et al. 1981), and we have observed large numbers there as well. Large flocks of swans also have been found on the Tingmeachsiovik River-Fish Creek delta, adjoining the Colville River Delta on the west, during fall-staging surveys. Surveys in 4 of 9 years documented large numbers (286–411 swans) staging on or near the Colville River Delta prior to migration (Johnson et al. 1999a), an event also reported by Campbell et al. (1988).

Habitat Use

Nesting

Since 2000, nesting habitat information has been obtained for 40 Tundra Swan nests that were found during aerial and ground surveys in the CD South study area (Table 12). Swan nests occurred in 10 habitat types in the CD South study area. Sixty-five percent of Tundra Swan nests in the CD South study area were located in 2 habitat types: Patterned Wet Meadow (16 nests) and Moist Sedge-Shrub Meadow (10 nests). Although a variety of other habitats were used for nesting, no other habitats had more than 3 nests.

Habitat selection was evaluated for 294 Tundra Swan nests locations that have been recorded on the Colville River Delta since 1992 (Appendix D7). During 9 years of surveys on the delta, Tundra Swan nests have been recorded in 20 of 24 available habitats. Seven habitat types were preferred, and 7 were avoided. Nearly 40% of nests were located in Patterned Wet Meadow, a preferred habitat. Slightly more than 10% of nests were located in Salt-killed Tundra, a preferred habitat, and Nonpatterned Wet Meadow, which was neither preferred or avoided (i.e., it was used in proportion to its availability). No other habitat in the delta had more than 10% of Tundra Swan nests.

Tundra Swans breeding on the Canning and Kongakut river deltas in northeastern Alaska selected marsh habitats and nested near either large lakes or coastal lagoons (Monda et al. 1994). Because only 7 habitats were classified for these deltas and because the habitats differed in availability from those on the Colville River Delta, the habitat use reported by Monda et al. (1994) was not directly comparable with our findings. Monda et al. (1994) found that nesting habitat preferences differed between their 2 study sites, which reflected differences in habitat availability. On the Kongakut River delta, 42% of 36 nests were in areas classified as saline graminoid-shrub (probably equivalent to Salt Marsh). On the Canning River delta, 52% of 54 nests were in graminoid-marsh (probably equivalent to Aquatic Grass and Aquatic Sedge marshes), and 26% were in graminoid-shrub-water sedge (probably equivalent to Patterned Wet Meadow).

Brood-Rearing

Habitat data were available for 24 Tundra Swan broods observed in the CD South study area since 2000 (Table 12). Tundra Swan broods occurred in 11 habitats in the CD South study area. The habitats used most frequently by brood-rearing swans in the CD South study area were Deep Open Water without Islands (5 broods), Tapped Lakes with Low-water Connection (4 broods), Tapped Lakes with High-water Connection (4 broods), and Patterned Wet Meadow (3 broods).

Habitat selection was evaluated for 192 Tundra Swan brood locations that have been recorded on the Colville River Delta since 1992 (Appendix D7, Appendix C7). Tundra Swan broods occurred in 20 of 24 available habitats. Seven habitats were preferred and 4 were avoided. One hundred and three broods were in preferred habitats and 25 broods were in avoided habitats. Preferred habitats were Brackish Water, Tapped Lake with Low-water Connection, Tapped Lake with High-water Connection, Salt Marsh, Deep Open Water (either with or without islands), and Aquatic Grass Marsh. Avoided habitats were Tidal Flats, Rivers and Streams, Riverine or Upland Shrub, and Barrens. Avoided habitats are alike in the absence of foraging and escape habitats.

The apparent preference for salt-affected habitats (Brackish Water, Salt Marsh, Tidal Flat, Salt-killed Tundra, and Tapped Lake with Low-water Connection) by brood-rearing swans indicates a seasonal change in distribution and habitat preference: 37% of all swan broods on the delta were in salt-affected habitats, compared with only 21% of all nests. Similarly, swan broods on the Kongakut River delta in northeast Alaska used different habitats as the brood-rearing season progressed (Monda et al. 1994), from saline graminoid marsh and aquatic-marsh habitats early in the season to aquatic-marsh habitat later in the season, where swans used both surface and sub-surface foraging. Changes in habitat and foraging methods may be related to nutritive quality of different plants or the increasing ability of older, larger cygnets to feed on submerged vegetation (e.g., pondweeds [*Potamogeton* spp.]) in deeper water.

In brackish water environments of river deltas of the Kobuk-Selawik lowlands, Spindler and Hall (1991) found swans feeding on various species of submergent pondweed in late August and September. On the Colville River Delta, swans also favored pondweeds during the brood-rearing and molting periods (Johnson and Herter 1989). Wilk (1988) describes spring-staging swans feeding on abundant pondweeds in tidally

Table 12. Habitat use by nesting and brood-rearing Tundra Swans in the CD South study area, Colville River Delta, Alaska, 2000–2002. Nesting habitat use derived from nests found during both aerial and ground surveys.

	Nests		Broods	
Habitat Type	No.	Use (%)	No.	Use (%)
Tapped Lake with Low-water Connection	0	0	4	16.7
Tapped Lake with High-water Connection	2	5.0	4	16.7
Salt Marsh	2	5.0	2	8.3
Salt-killed Tundra	1	2.5	0	0
Deep Open Water without Islands	3	7.5	5	20.8
Deep Open Water with Islands or Polygonized Margins	2	5.0	1	4.2
River or Stream	0	0	1	4.2
Aquatic Sedge with Deep Polygons	1	2.5	0	0
Aquatic Grass Marsh	0	0	1	4.2
Nonpatterned Wet Meadow	1	2.5	0	0
Wet Sedge-Willow Meadow	16	40.0	3	12.5
Moist Sedge-Shrub Meadow	10	25.0	1	4.2
Riverine or Upland Shrub	2	5.0	1	4.2
Barrens	0	0	1	4.2
TOTAL	40	100.0	24	100.0

influenced habitat near the Naknek River. Monda et al. (1994) also found that pondweeds were an important component of the diet of swans of the Kongakut and Canning river deltas. Pondweeds and alkali grass (*Puccinellia phryganodes*), another important food, grow well in salt-affected environments. Although we did not collect data on the feeding habits of swans, the use of salt-affected and aquatic marsh habitats by broods and fall-staging flocks suggests similar diets on the Colville River Delta.

LOON SURVEYS

Background

On the Arctic Coastal Plain of Alaska, Yellow-billed Loons nest primarily between the Kuukpik and Meade rivers, with the highest densities found south of Smith Bay (Brackney and King 1992). The Colville River Delta 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 they 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 during the second week of June, hatching occurs in mid-July, and broods usually are raised in the nesting lake (Rothe et al. 1983); however, broods occasionally move to different lakes (North 1986). North (1986) found most nests on the delta in what he described as deep open lakes and deep lakes with emergent grass.

Distribution and Abundance

Nesting

In 2002, 24 Yellow-billed Loons and 8 nests were located in the CD South study area during the initial aerial survey (Table 13). One additional nest was found during the revisit survey, yielding 9 total (Figure 10). The number of loons recorded in 2002 was in the upper end of the range (15–26) seen during nesting aerial surveys of the previous 7 years (Table 13). The density of Yellow-billed Loons in the CD South study area ranged from 0.10 to 0.17 birds/km^2 during 8 years of surveys (1993, 1995–1998, and 2000–2002; plot surveys in 1992 were not included because they were not a representative sample of loon habitat). Similar

Table 13. Numbers and densities (no./km²) of loons and their nests and broods during aerial surveys of the CD South study area, Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 1999a).

	Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
	Number			Density		(number)			(number)		
Year	Adults	Nests or Broods[b]	Young	Adults	Nests or Broods[b]	Adults	Nests or Broods	Young	Adults	Nests or Broods	Young
NESTING											
1993	15	2	-	0.10	0.01	63	10	-	10	0	-
1995	15	3	-	0.10	0.02	29	4	-	7	0	-
1996	23	7 (10)	-	0.15	0.04 (0.06)	37	7	-	0	0	-
1997	18	3 (3)	-	0.12	0.02 (0.02)	48	12	-	0	0	-
1998	17	8 (9)	-	0.11	0.05 (0.06)	26	6	-	0	0	-
2000	21	7 (7)	-	0.13	0.04 (0.04)	61	17	-	15	0	-
2001	26	9 (9)	-	0.17	0.06 (0.06)	41	18	-	3	0	-
2002	24	8 (9)	-	0.15	0.05 (0.06)	24	5	-	2	0	-
MEAN	19.9	5.9 (7.8)	-	0.13	0.04 (0.05)						
BROOD-REARING											
1993	8	1	1	0.05	0.01	13	1	1	0	0	0
1995	18	3	5	0.12	0.02	68	6	7	2	0	0
1996	20	1	1	0.13	0.01	52	13	17	10	5	8
1997	27	2	4	0.17	0.01	65	8	10	12	2	3
1998	13	5	7	0.08	0.03	66	18	21	10	5	8
2000	13	2	2	0.08	0.01	38	2	2	2	1	2
2001	17	2	2	0.11	0.01	55	3	3	5	0	0
2002	36	3	3	0.23	0.02	55	5	5	1	0	0
MEAN	19.0	2.4	3.1	0.12	0.02						

[a] Densities and averages of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and survey intensity varied among years.
[b] Number or density of nests found on initial survey and, in parentheses, cumulative number or density found after revisiting locations where loons, but no nests, were seen.

densities have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska: Square Lake in the NPRA (0.14 birds/km²; Derkson et al. 1981) and the Alaktak region south of Smith Bay (0.16 birds/km²; McIntyre 1990). The distribution of Yellow-billed Loons in the CD South study area in 2002 was similar to that recorded on aerial surveys in 1993, 1995–1998, and 2000–2001 (Figure 10, Appendix C9; Smith et al. 1994; Johnson et al. 1999a), and during ground-based surveys in 1981, 1983, and 1984 (Appendix C9; Rothe et al. 1983, North 1986).

The count of 9 nests in 2002 was similar to the number of nests found in 5 of the 8 years of surveys (Table 13). Two or 3 nests were found in the other 3 years. Nest densities for the CD South study area have ranged from 0.01 to 0.06 nests/km² during our 8 years of study. During intensive ground surveys of the delta in 1983 and 1984, North (1986) found 6 and 8 nests, respectively, in the CD South study area. All 9 nests found in 2002 were on lakes where nesting Yellow-billed Loons

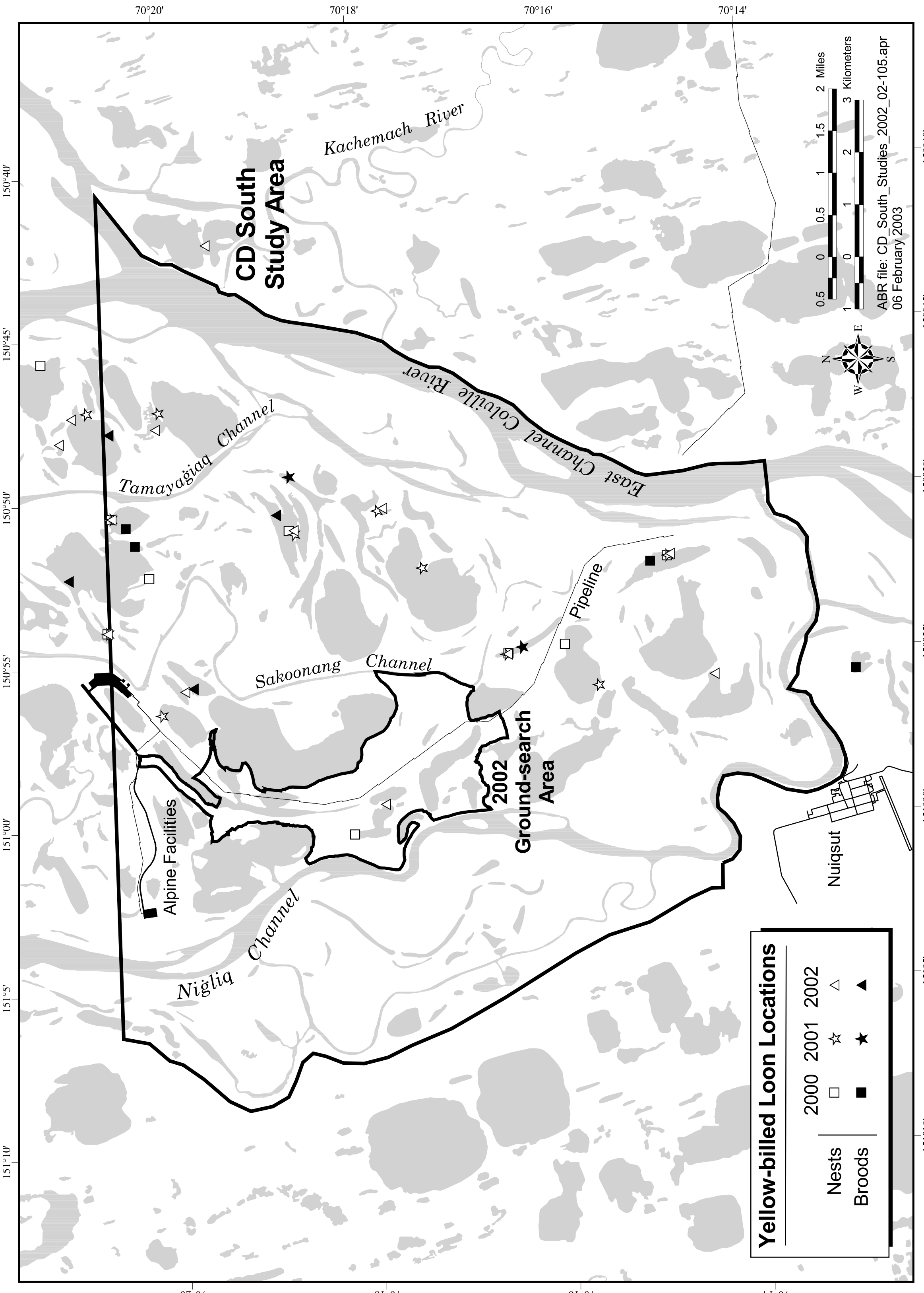

Figure 10. Distribution of Yellow-billed Loon nests and broods in the CD South study area, Colville River Delta, Alaska, 2000–2002.

have been recorded in previous years (Figure 10, Appendix C9). One Yellow-billed Loon nest was found in the CD South ground-search area in 2002 (Figure 5). Nesting also occurred within the ground-search area in 1995 and 2000 (Figure 4, Appendix C9).

Five nests of Pacific Loons were identified during Yellow-billed Loon surveys in the CD South study area in 2002; no nests of Red-throated Loons were seen during the aerial survey (Table 13). Five additional Pacific Loon nests and 2 Red-throated Loon nests were located during ground-searches, yielding a total of 10 Pacific Loon and 2 Red-throated Loon nests for the CD South study area (Figure 11). Opportunistic counts of Pacific and Red-throated loons reflect their general distribution in the CD South study area but are not indicative of the relative abundance of these species (due to biases in species detectability) or annual changes in abundance (because of annual variation in survey intensity) (Appendix C10). Therefore, densities are not calculated for these 2 species. Although our counts are not adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon in the CD South study area during most years of study (Table 13). From sample plots on the Colville River Delta in 1981, Rothe et al. (1983) estimated densities of 1.5 birds/km² for Pacific Loons and 0.6 birds/km² for Red-throated Loon, and suggested that these densities were comparable to other areas on the Arctic Coastal Plain.

Brood-rearing

During 2002, 36 adult Yellow-billed Loons and 3 broods were observed during the brood-rearing survey in the CD South study area (Table 13, Figure 10). The number of loons recorded in 2002 was greater than the number counted in any of the previous 7 years, whereas the number of broods was within the range of the number of broods (1 to 5) seen in previous years (Table 13, Figure 10). Two flocks of Yellow-billed Loons, one of 7 adults and the other of 6 adults, were seen during the 2002 survey. Flocks of >3 loons have been seen in only 2 other years of brood-rearing surveys in the CD South study area (1992 and 1996). In the adjacent Yellow-billed Loon nesting area in the NPRA, where simultaneous surveys were conducted, low numbers of brood-rearing Yellow-billed Loons were observed in 2002 by comparison with earlier years (Burgess et al. 2003), suggesting that failed breeders had moved out of breeding areas to stage on the Colville River Delta prior to migration.

The density of adult Yellow-billed Loons in the CD South study area during brood-rearing in 2002 was 0.23 birds/km² and the density of broods was 0.02 broods/km². In prior years, the density of adults ranged from 0.05 to 0.17 birds/km² and the density of broods from 0.01 to 0.03 broods/km² (Table 13). The highest number of Yellow-billed Loon broods recorded in the CD South study area during our 8 years of surveys was in 1998 when there were 7 young in 5 broods (Appendix C11). Most adult loons seen on the brood-rearing survey in 2002 were found on lakes where nesting occurred either in 2002, or in a previous year. North and Ryan (1988, 1989) found that adults with young remain on or near the nest lake during brood-rearing, and that non-nesting and failed breeders also maintain their territories throughout the summer.

During the 2002 aerial survey, 5 Pacific Loon broods and no Red-throated Loon broods were observed in the CD South study area (Table 13). The numbers of Pacific and Red-throated loons and their broods counted in the CD South study area and across the Colville River Delta (Figure 11, Appendix C12) have varied during 8 years of surveys because survey intensity has differed each year and the surveys were not intended to be quantitative for these species. These loon species can rear their young on smaller waterbodies than were surveyed for Yellow-billed Loons so an unknown number of broods were missed. Because survey intensity for these smaller waterbodies varied among years and coverage was never complete, abundance and density cannot be compared among years for these 2 species.

Habitat Use

Nesting

During aerial surveys of the CD South study area in 2000–2002, a total of 25 Yellow-billed Loon nests were observed in 6 habitats (Table 14): Nonpatterned Wet Meadow (32% of nests), Deep Open Water with Islands or Polygonized Margins (28%), Patterned Wet Meadow (24%), Aquatic Sedge with Deep Polygons (8%), Tapped Lake

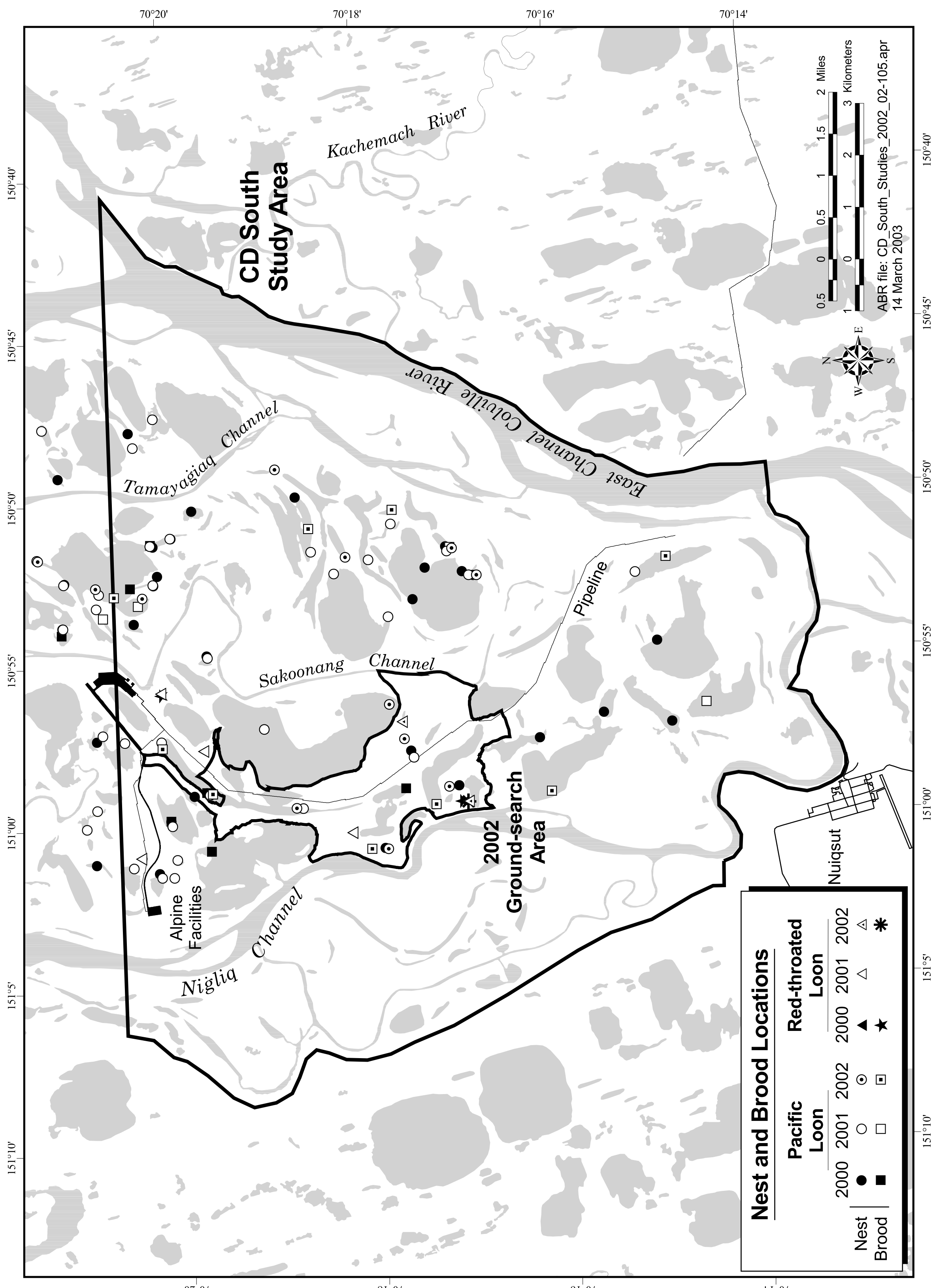

Figure 11. Distribution of Pacific and Red-throated loon nests and broods in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Table 14. Habitat use by nesting Yellow-billed Loons in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Habitat	No. Nests	Use (%)
NEST LOCATION		
Tapped Lake with High-water Connection	1	4.0
Deep Open Water with Islands or Polygonized Margins	7	28.0
Aquatic Sedge March	1	4.0
Aquatic Sedge with Deep Polygons	2	8.0
Nonpatterned Wet Meadow	8	32.0
Patterned Wet Meadow	6	24.0
TOTAL	25	100
NEAREST WATERBODY		
Tapped Lake with High-water Connection	5	20.0
Deep Open Water without Islands	11	44.0
Deep Open Water with Islands or Polygonized Margins	8	32.0
Aquatic Sedge March	1	4.0
TOTAL	25	100

with High-water Connection (4%), and Aquatic Sedge Marsh (4%). However, because Yellow-billed Loons usually raise broods on the lakes where they nest, forage in lakes within their territories, and use lakes for escape habitat, the waterbody type (or aquatic habitat) adjacent to the nest site is more indicative of habitat selection than the terrestrial habitat on which the nest is actually built. Four types of waterbodies were associated with Yellow-billed Loon nests: Deep Open Water without Islands (44%), Deep Open Water with Islands or Polygonized Margins (32%), Tapped Lake with High-water Connection (20%), and Aquatic Sedge Marsh (4%). Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. Measurements of the distance from the nest to the nearest waterbody were not recorded during aerial surveys, but all nests were close (<5 m) to water. Other ground-based studies of nesting Yellow-billed Loons on the Arctic Coastal Plain found nests occurring within 2 m of water (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989).

During 8 years of nesting aerial surveys on the Colville River Delta, 123 Yellow-billed Loon nests were found in 8 of 24 available habitats (Appendix D8). Seventy-eight nests (63%) were located in the 2 preferred habitats: Deep Open Water with Islands or Polygonized Margins and Patterned Wet Meadow. Patterned Wet Meadow was the habitat most frequently used for nesting (38% of all nests), and it was the most abundant habitat on the delta (25% of the loon survey area; Appendix D8). Nesting Yellow-billed Loons significantly avoided 7 habitats—Tapped Lake with Low-water Connection, Tidal Flat, Salt-killed Tundra, River or Stream, Moist Sedge-Shrub Meadow, Riverine or Upland Shrub, and Barrens—that were unused and together occupied a large portion of the loon survey area (44%).

North (1986) found that similar waterbody types were used by nesting Yellow-billed Loons on the Colville River Delta in 1983 and 1984: 40% of 25 nests occurred on deep-*Arctophila* lakes, 48% on deep-open lakes, and 12% on ponds 0.5–1.0 ha and shallow lakes >1.0 ha with emergent sedge or grass. Deep lakes, as described by North (1986), include the 2 Deep Open Water types and Tapped Lakes with High-water Connections that we have described. Although North and Ryan (1988) reported that Yellow-billed Loons did not nest on tapped lakes, they did not discriminate Tapped Lakes with High-water Connections, which may appear to be untapped because they commonly are connected to channels by low, vegetated areas that do not flood every year. The small waterbodies where North (1986) found nests probably correspond to our Aquatic Sedge with Deep Polygons, Aquatic Sedge Marsh, and Aquatic Grass Marsh. Consistent with our observations, North (1986) found that nests on small waterbodies (<10 ha) always were near (<70 m) larger waterbodies.

Brood-rearing

In the CD South study area in 2002, 3 Yellow-billed Loon broods were found in both types of Deep Open Water. During aerial surveys of the entire Colville River Delta in 1995–1998 and 2000–2002, 46 Yellow-billed Loon broods were found in 3 habitats—Tapped Lake with High-water Connection and both types of Deep Open Water—all of which were preferred (Appendix D8). Deep Open Water without Islands was used by most broods (59% of total), followed by Tapped Lake with High-water Connection (22%) and Deep Open Water with Islands or Polygonized Margins (20%). No shallow-water habitats were used during brood-rearing. The concurrence of selection analyses for nesting and brood-rearing reaffirms the importance of large, deep waterbodies to breeding Yellow-billed Loons. North (1986) found that similar lake types were used during brood-rearing in 1983 and 1984. Small lakes (<13.4 ha) were not used during brood-rearing, but coastal wetlands (probably equivalent to our Tapped Lake with High-water Connection or Brackish Water) were used by 2 broods (North 1986).

GOOSE SURVEYS

Background

Brant are uncommon in the CD South study area, but they are much more abundant on the northern Colville River Delta and a thorough analysis of their distribution and abundance on the Colville River Delta can be found in the annual report for the CD North study area (Johnson et al. 2003b). During aerial surveys between 1992 and 1998, 5 colonies/nesting locations of Brant were observed on the northern edge of the CD South study area: 3 colonies that were occupied during 2–4 years of observation with between 1 and 6 nests annually, and 2 solitary nest locations that were occupied only during a single year of observation (Appendix C13; Johnson et al. 1999a). In 2001, 2 nests were found in the northern part of the CD South study area in the Alpine ground-search area (Appendix C13; Johnson et al. 2003a). During brood-rearing, most Brant on the Colville River Delta move from nesting areas to salt marshes along the coast from Milne Point in the east to the Tingmeachsiovik River in the west (Smith et al. 1994, Martin and Nelson 1996, Martin et al. 1997, Anderson et al. 2003), both outside the CD South 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, provide important resting and feeding areas for Brant at that time (Johnson and Richardson 1981).

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

Early in the 1900s, Snow Geese may have nested commonly and gathered for molting and brood-rearing in widespread portions of the Arctic Coastal Plain (Anderson 1913, Bailey 1948, Gabrielson and Lincoln 1959). In the past few decades, however, only small numbers have nested sporadically along the Beaufort Sea coast, generally west of the Sagavanirktok River delta (Derksen et al. 1981; Simpson et al. 1982; Ritchie et al. 2000). On the Colville River Delta, occasional nests and small groups of brood-rearing and staging Snow Geese have been recorded, all on the outer delta within the CD North study area (Johnson et al. 2003b).

Prior to 1996, Canada Geese were not reported nesting either on the Colville River Delta or in NPRA, although local residents have observed Canada Geese nesting in the NPRA at least since the 1980s (J. Helmericks, pers. comm.). Since 1997, 1–2 Canada Goose nests have been recorded on the Colville River Delta (Johnson et al. 1999a, 2003a, 2003b). Although the Colville River Delta has not been identified as an important molting or brood-rearing area for Canada Geese, it is important during fall migration (Smith et al. 1994), when geese traveling along the Beaufort Sea coast stop and feed (Johnson and Richardson 1981, Garner and Reynolds 1986).

Distribution and Abundance

Brood-rearing

Three species of geese have been observed in the CD South study area during brood-rearing: Greater White-fronted Geese, Canada Geese, and Brant (Appendix C14 and Appendix C15). Only Greater White-fronted Geese were observed in every year. Canada Geese were observed only in 1997 (a single pair with a brood) and 2002 (20 adults with no young) (Appendix C15). Brant were observed only in 1997 (8 adults and 8 goslings just southeast of the CD South ground-search area; Appendix C14).

During the brood-rearing survey in 2002, 196 Greater White-fronted Geese (including goslings) were observed in 5 groups in the CD South study area (Figure 12, Table 15). During 6 years of surveys of the CD South study area, the number of Greater White-fronted Geese observed during brood-rearing has ranged from 33 to 528 birds in 2 to 9 groups. The number of goslings has ranged from 24 in 1997 to 266 in 1998, and 60 goslings were observed in 2002. In all years, densities of brood-rearing Greater White-fronted Geese in the CD South study area (0.8–7.2 birds/km²) were low compared to those in the CD North study area (6.4–13.1/km²) and on the entire delta (4.2–12.8 birds/km²). However, the density in the CD South study area was generally higher than that observed for these geese in the nearby eastern NPRA study area during either 2001 or 2002 (0.8 birds/km²; Burgess et al. 2003).

Fall Staging

As during brood-rearing, 3 species of geese have been recorded in the CD South study area during fall-staging surveys: Greater White-fronted Goose, Canada Goose, and Brant. In 6 years of surveys, Brant were observed in the CD South study area during fall staging only in 2001, when one group of 20 birds was observed (Figure 13; Appendix C16). Brant typically use salt marshes and other coastal habitats during fall staging (Smith et al. 1994, Johnson et al. 1999a). Canada Geese were not observed in the CD South study area during fall staging in 2002, although they have been present in small numbers (10–94 birds) during 3 of 6 years of surveys (Table 16). Canada Geese also were recorded in the CD South study area in 1995, when 6 geese were observed during a loon survey and a flock of 75 geese was observed during a Brant staging survey (Appendix C17). Variability in numbers of fall-staging geese among years is probably attributable mainly to differences in the intensity and timing of aerial surveys. Canada Geese occurred in small numbers in the CD South study area relative to coastal areas, including the CD North study area (Johnson et al. 2003b).

The Greater White-fronted Goose was not observed in the CD South study area during fall-staging surveys in 2002, although it is usually the most common goose species in the area at that time (Table 16, Figure 13). During previous years of surveys, the number of Greater White-fronted Geese observed during fall staging has ranged from 137 to 686 birds (1.9–8.8 birds/km²). Prior to 1996, groups of fall-staging Greater White-fronted Geese also were recorded in the CD South study area during aerial surveys for other species: 84 geese in 1991, 20 in 1992, and 232 in 1995 (Appendix C17). The lack of geese in the CD South study area during fall staging in 2002 may be attributable to the relatively early onset of breeding in 2002, as a decline in numbers also was observed in the adjacent CD North study area.

Over all years of surveys, densities of fall-staging Greater White-fronted Geese in the CD South study area (mean = 5.7 birds/km², range 1.9–8.8 birds/km²) are generally somewhat lower than in the CD North study area (mean = 9.5 birds/km², range 1.5–14.8 birds/km²), or

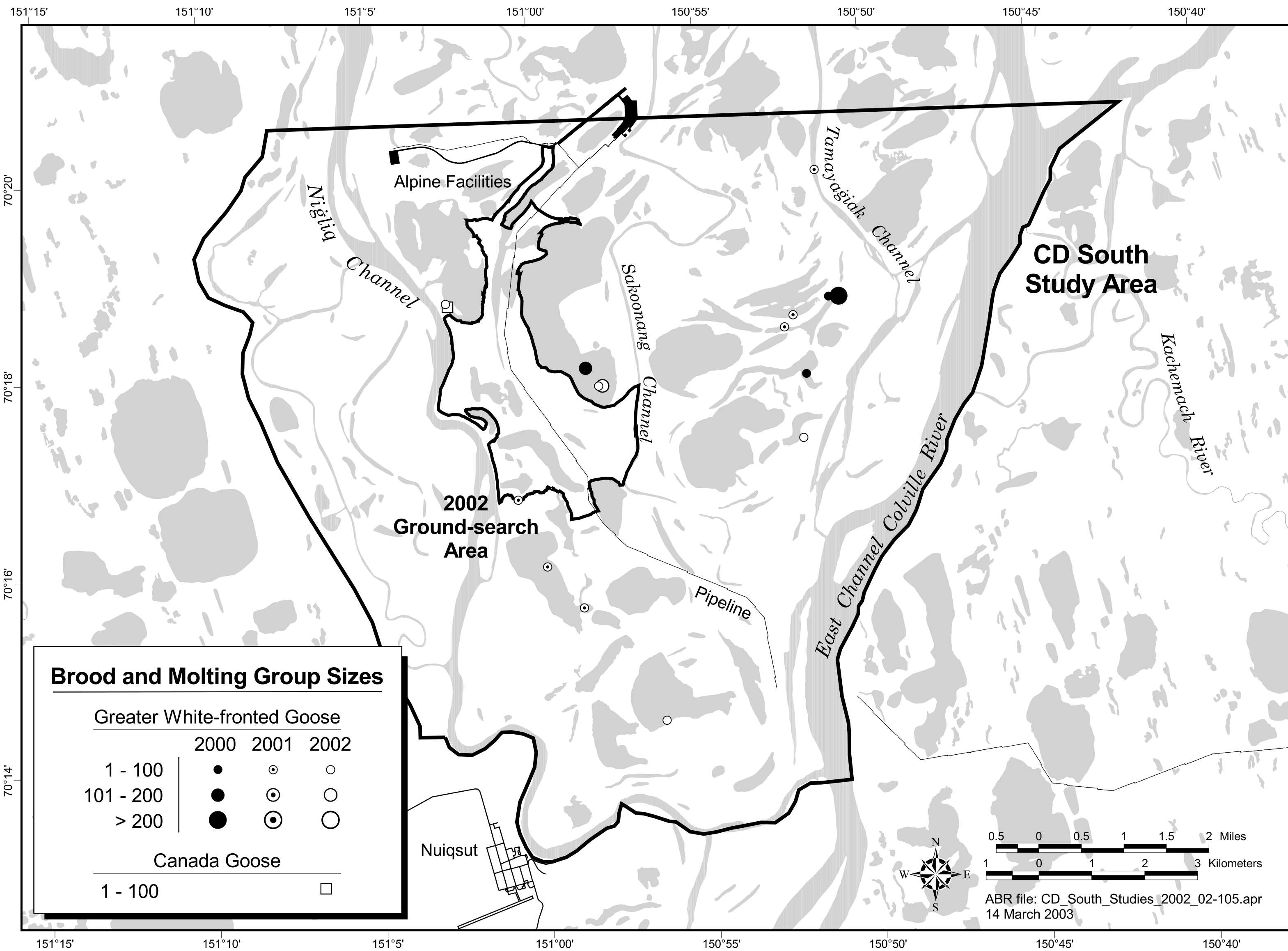

Figure 12. Distribution of brood-rearing and molting groups of Greater White-fronted and Canada geese in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Table 15. Numbers and density (no./km²) of Greater White-fronted Geese during brood-rearing aerial surveys in the CD South study area, Colville River Delta, Alaska, 1996–2002 (pre-2000 data from Johnson et al. 1999a). In 1996, survey coverage was 25%; in all other years, coverage was 50% of the study area.

Year	Total Birds[a]	Density	Total Groups	Group size (Range)	Total Goslings	% Groups w/ Goslings
1996	33	0.8	2	15–18	15	100
1997	263	3.4	7	11–94	24	14
1998	528	6.8	9	8–190	266	89
2000	425	7.2	4	16–220	91	75
2001	274	3.9	6	13–90	36	67
2002	196	2.5	5	11–101	60	60

[a] Total birds equals adults plus goslings.

across the entire delta (mean = 7.9 birds/km², range 1.0–12.9 birds/km²). The adjacent NPRA study area had lower densities in both 2001 and 2002 (1.0 birds/km²; Burgess et al. 2003).

Habitat Use

Habitat use information was collected only for Brant and Greater White-fronted Geese. Brant primarily use coastal areas during nesting, brood-rearing, and fall staging, and a complete analysis of habitat selection by Brant on the outer Colville River Delta can be found in the report on the CD North wildlife studies (Johnson et al. 2003b).

Data on habitat use of Greater White-fronted Geese during nesting were obtained from the ground-search area at CD South, where 110 nests were located in 5 habitats: Patterned Wet Meadow (76 nests), Moist Sedge–Shrub Meadow (27 nests), Riverine or Upland Shrub (4 nests), Nonpatterned Wet Meadow (2 nests), and Deep Open Water without Islands (1 nest) (Table 7). Only one habitat was preferred for nesting by Greater White-fronted Geese, Patterned Wet Meadow, which was the most abundant habitat on the delta (Appendix D9). Patterned Wet Meadow also was a preferred habitat for nesting Greater White-fronted Geese at CD North (Johnson et al. 2003b) and at Alpine (Johnson et al. 2003a). However, in those areas another habitat also was preferred—Aquatic Sedge with Deep Polygons. Aquatic Sedge with Deep Polygons was rare in the CD South ground-search area. Broods of Greater White-fronted Geese were widespread in the CD South ground-search area, occurring in 10 of 14 available habitats (Table 8). The habitat most used for brood-rearing by Greater White-fronted Geese was Aquatic Grass Marsh (39% of all groups).

During brood-rearing aerial surveys in 2000–2002, Greater White-fronted Geese were observed using 7 of 20 habitats in the CD South study area (Table 17). Brood-rearing geese occurred mainly near the center of the study area (Figure 12), typically in or near water (Table 17), although disturbance by the survey aircraft may have influenced brood locations. The most used habitats were Tapped Lake with High-water Connection (33% of groups), Barrens (27%), and Deep Open Water without Islands (13%). Other habitats had only a single group of brood-rearing geese.

During fall-staging aerial surveys, Greater White-fronted Geese were observed in 7 of 20 habitats in the CD South study area (Table 17). As during the brood-rearing period, staging Greater White-fronted Geese were found primarily in lake habitats (both types of Tapped Lakes and Deep Open Water, and River or Stream) or in other terrestrial habitats adjacent to lakes or river channels.

GULL SURVEYS

Background

The Glaucous Gull is a common migrant and breeder in the Beaufort Sea area (Johnson and

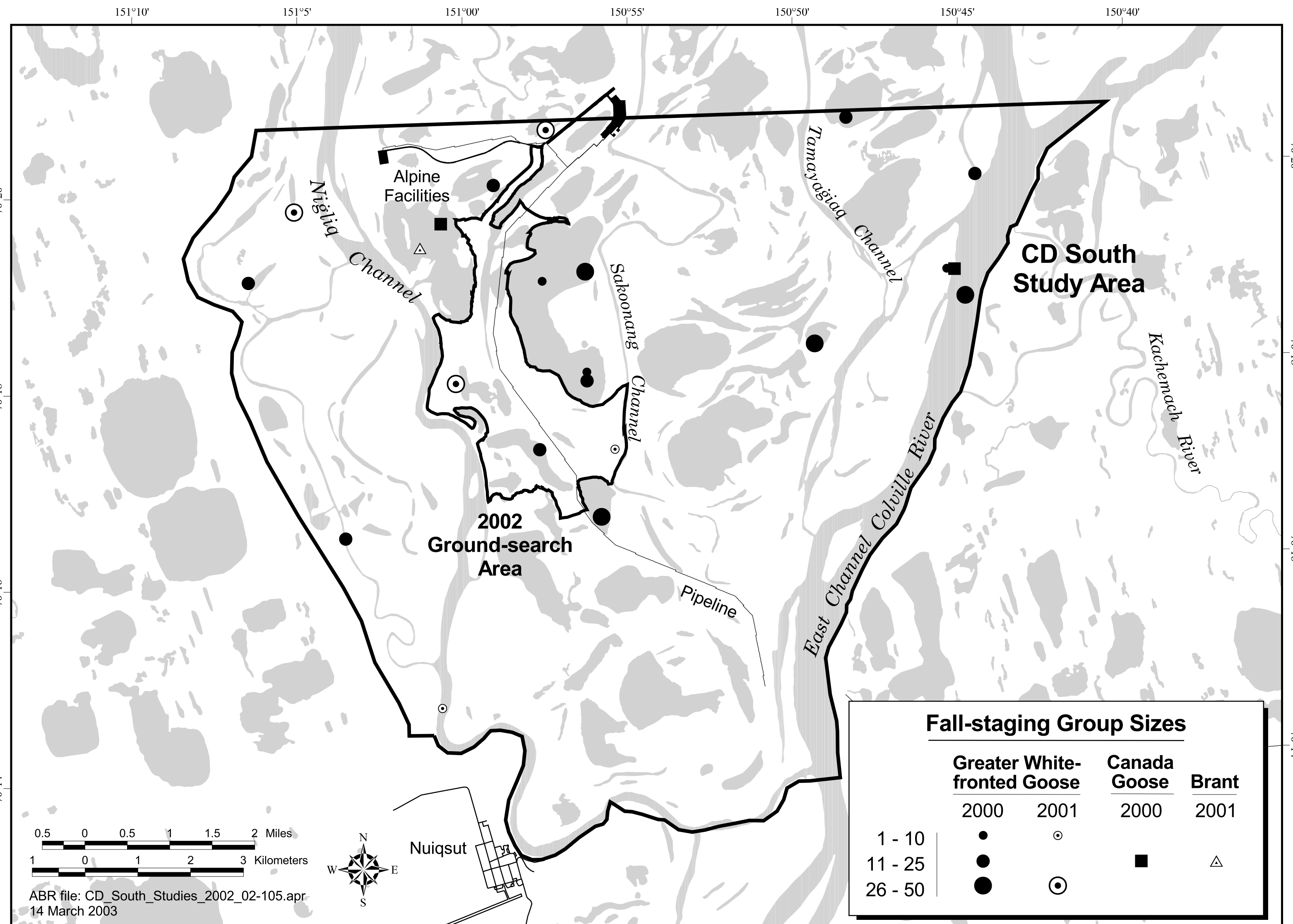

Figure 13. Distribution of fall-staging groups of Greater White-fronted and Canada geese and Brant in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Table 16. Numbers and density (no./km²) of Greater White-fronted Geese and Canada Geese during fall-staging aerial surveys in the CD South study area, Colville River Delta, Alaska, 1996–2002 (pre-2000 data from Johnson et al. 1999a). In 1996, survey coverage was 25%; in all other years, coverage was 50% of the study area.

	Greater White-fronted Goose					Canada Goose				
Year	Total Birds	Density	Total Groups	Mean Group Size	Range	Total Birds	Density	Total Groups	Mean Group Size	Range
1996	181	4.6	8	22.6	7–35	10	0.3	1	10.0	-
1997	686	8.8	10	68.6	1–500	0	0	0	-	-
1998	607	7.8	17	35.7	5–150	94	1.2	3	31.3	10–70
2000	307	5.2	14	21.9	4–40	45	0.8	2	22.5	20–25
2001	137	1.9	5	27.4	3–60	0	0	0	-	-
2002	0	0	0	-	-	0	0	0	-	-

Herter 1989). Glaucous Gulls arrive in mid-May and are commonly found near offshore leads and along island and mainland shorelines (Richardson and Johnson 1981). Pairs nest either solitarily or colonially on islands and cliffs on or near the coast (Larson 1960), on inland river bars (Sage 1974), or on small islands in lakes (Martin and Moitoret 1981). Egg-laying begins by mid-June and continues into the last week of June (Johnson and Herter 1989). Hatching begins in mid-July and fledging occurs in late August to early September (Bergman et al. 1977). During the breeding season, Glaucous Gulls prey heavily on the eggs and chicks of other birds, especially those of waterfowl (Johnson and Herter 1989). Glaucous Gulls also feed on human food waste and are attracted to landfills (Murphy and Anderson 1993, Campbell 1975), which may artificially increase their numbers (Day 1998). The nearest landfill to CD South is 8.8 km away at Nuiqsut, which has the largest concentration of Glaucous Gulls in the area (ABR, unpubl. data).

Distribution and Abundance

Twenty-six Glaucous Gull nests were located during aerial surveys for Tundra Swans and Yellow-billed Loons in the CD South study area in 2002 (Figure 14). Eighteen of the 26 nests were part of a Glaucous Gull colony located ~6 km east of the CD South ground-search area. Counts at this colony have ranged from 10 to 18 nests during 4 years of surveys (1998, 2000–2002). In 2001, 17 Glaucous Gull nests, 13 of which were part of the colony, were found in the CD South study area during aerial surveys for Tundra Swans and Yellow-billed Loons. In 2000, 14 Glaucous Gull nests, 10 of which were part of the colony, were recorded during aerial surveys for Yellow-billed Loons. Based on aerial survey results, the density of Glaucous Gull nests in the CD South study area increased from 0.09 to 0.17 nests/km² between 2000 and 2002. Because Glaucous Gulls were counted on aerial surveys designed to survey other species, some nests probably were missed in all years.

One Glaucous Gull brood with 2 young was seen in 2002 during the brood-rearing aerial survey for Yellow-billed Loons (Figure 14). In contrast to previous years, no young were seen at the colony site during the aerial survey in 2002 (12 young were observed there in 2000 and 7 young in 2001). It is believed that young may have fledged prior to the survey, which is consistent with the generally early nesting phenology observed in the region in 2002. In the nearby NPRA study area, flight-capable Glaucous Gull fledglings were observed the day before the CD South survey (ABR, unpub. data).

Habitat Use

Habitat information is available for the 57 nests found in the CD South study area in 2000–2002. The colony site was located in each year on the same large island of Patterned Wet

Table 17. Habitat use by Greater White-fronted Geese during brood-rearing and fall staging in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Habitat Type	Brood-rearing /Molting: Number of Groups	Brood-rearing /Molting: Habitat Use (%)	Fall Staging: Number of Groups	Fall Staging: Habitat Use (%)
Tapped Lake with Low-water Connection	1	6.7	1	7.1
Tapped Lake with High-water Connection	5	33.3	4	28.6
Deep Open Water without Islands	2	13.3	2	14.3
Deep Open Water with Islands or Polygonized Margins	1	6.7	0	0
River or Stream	1	6.7	2	14.3
Nonpatterned Wet Meadow	1	6.7	0	0
Patterned Wet Meadow	0	0	1	7.1
Moist Sedge–Shrub Meadow	0	0	1	7.1
Barrens	4	26.7	3	21.4
TOTAL	10	100.0	14	100.0

Meadow in a Deep Open Lake with Islands or Polygonized Margins. The 41 nests counted at this colony in 2000–2002 were the only nests in the CD South study area in Patterned Wet Meadow (72% of 57 nests). The remaining 16 nests were found mostly on islands in Tapped Lake with High-water Connection, both Deep and Shallow Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, Nonpatterned Wet Meadow, and Barrens.

FOX SURVEYS

Background

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are much more common on the coastal plain and red foxes are more common in the foothills and mountains of the Brooks Range. On the coastal plain, red foxes are restricted largely to major drainages (such as the Kuukpik and Sagavanirktok rivers), where they are much less common than the arctic fox (Eberhardt 1977, Johnson et al. 2003a). 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. 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 August (Chesemore 1975). 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, 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). We began recording information on fox dens on the Colville River Delta when baseline wildlife studies began in 1992 (Smith et al. 1993). In 10 years of surveys (none were conducted in 1994) and through contacts with other observers, we have located 77 fox dens between the western edge of the Colville River Delta and the western edge of the Kuparuk Oilfield (Appendix C18). In 2002, 69 (90%) of the dens in the region were classified as arctic fox dens and the remaining 8 dens (10%) were occupied by red foxes; 4 of the latter dens were former arctic fox sites that were appropriated by red foxes.

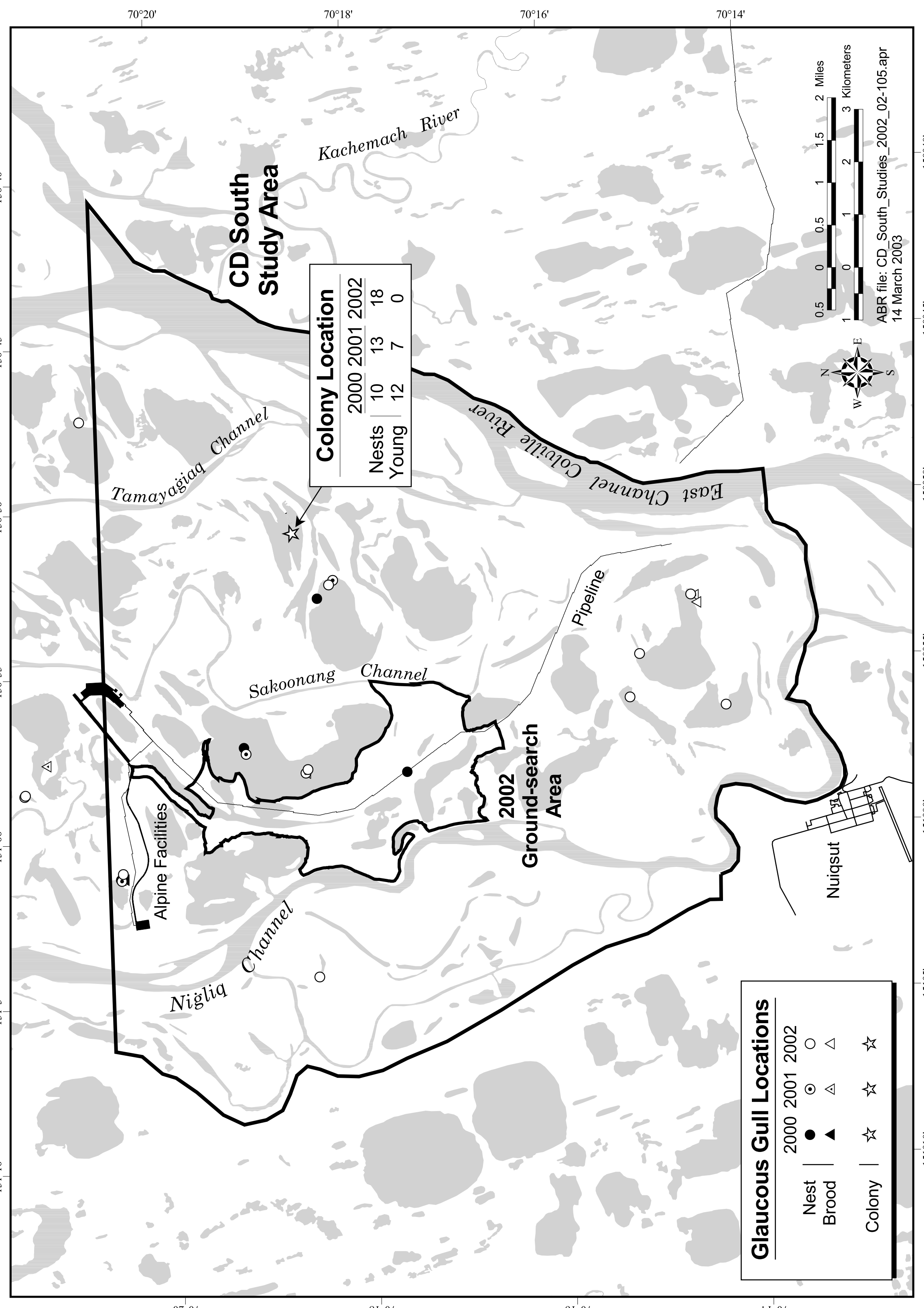

Figure 14. Distribution of Glaucous Gull nests and broods in the CD South study area, Colville River Delta, Alaska, 2000–2002.

Distribution and Abundance of Dens

To date, 9 dens have been found in the CD South study area (Figure 15): 1 each in 1992, 1993, 1997, and 2001, and 5 in 1995. Additional dens may be present in the CD South study area because of the abundance of arctic ground squirrel burrows in dune habitats, which make it difficult to distinguish fox dens. The 9 fox dens in the CD South study area included active and inactive sites of both species (Table 18), although the level of use was low in 2002. Five of the dens were arctic fox sites and 4 were red fox sites in 2002; one of the red fox sites was an arctic fox den before 1998. In marked contrast to other areas on the outer coastal plain, red fox dens are as common as arctic fox dens in the CD South study area. The annual density of active red fox dens (1–4 dens; Table 19) ranged from 1 den/39 km² to 1 den/156 km². The density of arctic fox dens active annually (0–2 dens; Table 19) was low, at 1 den/78 km² or less. In view of the aggressiveness of red foxes toward arctic foxes, it is possible that the relatively high density of red foxes in the CD South area suppresses denning activity by arctic foxes. The highest density of active dens in the CD South study area occurred in 1998, when all 4 red fox dens and 1 arctic fox den were active (Table 19), for a combined density of 1 active den/31 km².

The total density of fox dens (active and inactive for both species) in the CD South study area (156 km²) was 1 den/17 km². The densities of arctic and red fox dens were similar, at 1 den/31 km² for the former and 1 den/39 km² for the latter. In contrast, the density of red fox dens in the entire Colville River Delta area was 1 den/69 km²; comparative data are unavailable for this species from other arctic tundra areas of Alaska and Canada. The density of arctic fox dens in the CD South study area was slightly lower than the regional average of 1 den/25 km² for the combined Colville River Delta (551 km²) and Alpine Transportation Corridor (343 km²) survey areas (Johnson et al. 2003a). The density of arctic fox dens in the CD South area was similar to the 1 den/34 km² reported by Eberhardt et al. (1983) for their 1,700-km² Colville study area (which extended farther east and west than ours, but not as far inland). The density of arctic fox dens in the CD South area was near the high end of the range reported for a 1876-km² undeveloped area bordering the Prudhoe Bay Oilfield (1 den/28–72 km²), but was lower than that reported for the 805-km² developed area of the Prudhoe field (1 den/12–15 km²) (Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues et al. 1994).

Den Occupancy and Production of Young

The red fox dens in the CD South study area have had higher occupancy rates (natal, secondary, and active categories combined) each year than have the arctic fox dens. Since 1995 (no red fox dens had yet been found in 1993), 1 to 4 red fox dens (25–100%; Table 19) were active each year. The small number of arctic fox dens occupied in the CD South study area makes comparison with other areas difficult. Since 1993, the occupancy rate of arctic fox dens in the study area ranged from 0 to 50% occupied (Table 19). In their Colville study area, Eberhardt et al. (1983) reported that the percentage of arctic fox dens containing pups ranged from 6% to 55% annually over a 5-year period, whereas 56–67% showed signs of activity by adults alone. Burgess et al. (1993) estimated that between 45% and 58% of the arctic fox dens in their study area in the Prudhoe Bay Oilfield produced litters in 1992, although only 21% still were occupied by families at the time of ground visits in late July–early August. In 1993, the occupancy rate by arctic foxes at 49 natural den sites in the Prudhoe Bay Oilfield and surrounding area was 69%, and 53% of the sites were classified as natal dens (Rodrigues et al. 1994). Despite a high density of dens on Herschel Island in the northern Yukon (Smith et al. 1992), only 3–19% of a sample of 32 arctic fox dens examined over 5 years were used as natal dens in any one year (Smits and Slough 1993).

Based on brief visits at each fox den during 27–30 June 2002 and longer observations at 3 red fox dens during 11–12 July 2002, we concluded that pups were present only at 1 red fox den at which we were unsuccessful in obtaining a litter count (Table 18). Two of the arctic fox dens were judged to be potentially active but the amount and nature of fox sign at those sites was not sufficient to warrant further observations. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to obtain a complete count. Red fox

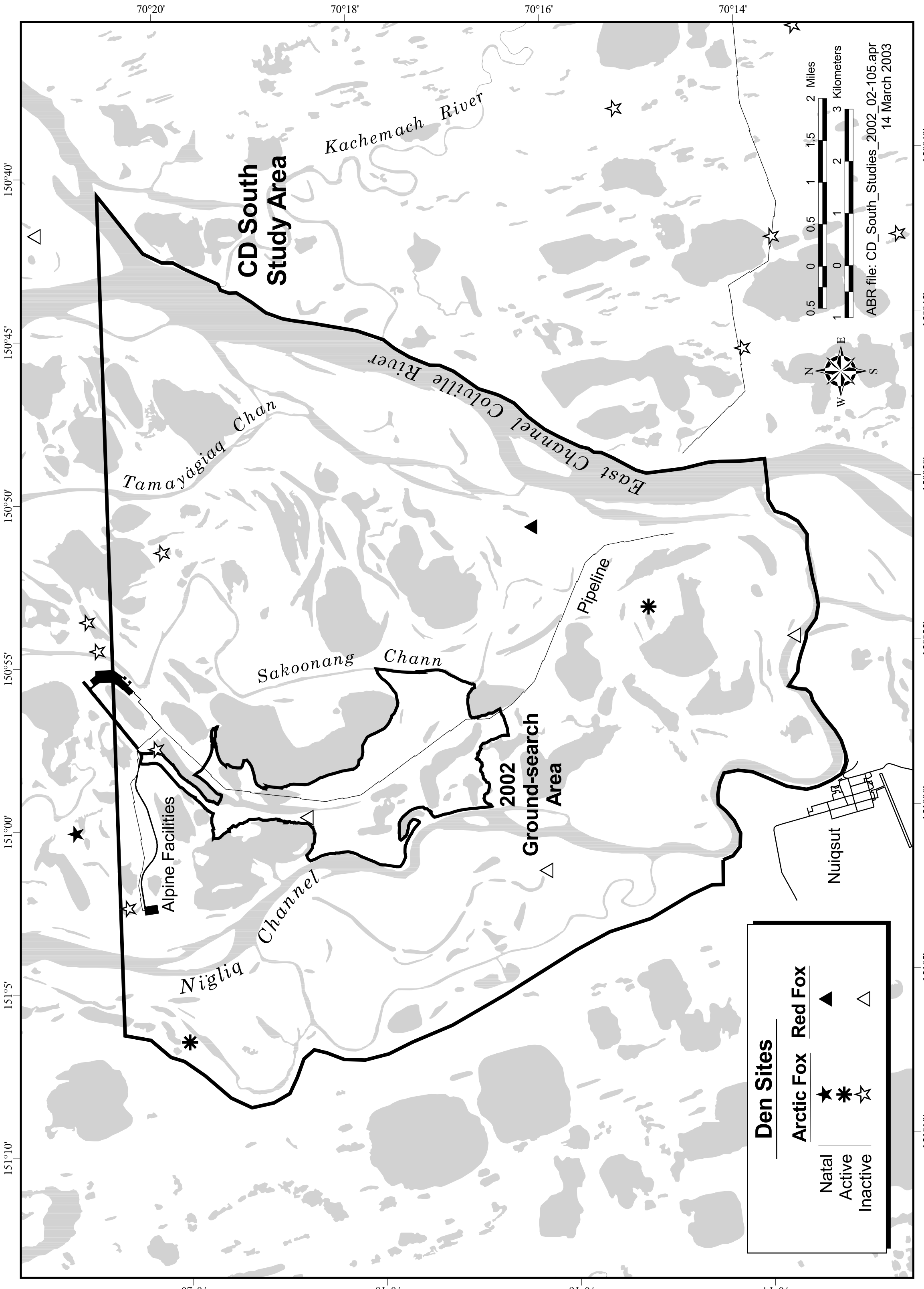

Figure 15. Distribution and status of arctic and red fox dens in the CD South study area, Colville River Delta, Alaska, 2002.

Table 18. Annual status of arctic and red fox dens in the CD South study area, Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 2000b). Numbers in parentheses indicate the number of pups observed at active dens; zeroes indicate dens were observed but no pups were seen; dashes indicate no data.

	Arctic Fox Dens					Red Fox Dens			
	Old Dune	Dune Mound	Low Ridge	Low Mound	Old Channel Bank	Dune/Lake Bank[a]	Sand Dune	Dune/River Bank	Sand Dune
1993	Natal (3)	–	–	–	–	Inactive	–	–	–
1995	Natal (–)	Inactive	Secondary? (–)	–	–	Inactive	Secondary? (0)	Natal (5)	Natal (2)
1996	Inactive	Inactive	Secondary? (5)	–	–	Inactive	Natal (2)	Natal (1)	Natal (5)
1997	Inactive?	Inactive?	Active (0)	Inactive	–	Inactive?	Active (0)	Inactive	Active? (0)
1998	Inactive	Inactive	Natal (3)	Natal? (0)	–	Active (0)	Natal (2)	Natal? (0)	Natal (6)
1999	Inactive?	Inactive	Secondary (4)	Inactive	–	Inactive?	Natal (2)	Natal? (0)	Natal (2)
2000	Active (0)	Inactive	Inactive	Inactive	–	Inactive?	Inactive	Natal (4)	Natal (1)
2001	Inactive	Inactive	Natal (4)	Inactive	Active	Inactive	Natal (3)	Active (0)	Inactive (0)
2002	Inactive	Active?	Inactive	Active?	Inactive	Inactive	Natal (? 1)	Inactive (0)	Inactive (0)

[a] Arctic fox den until 1998.

Table 19. Numbers and percentages of arctic and red fox dens that were active or inactive during each year in the CD South study area, Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 2000b).

	Arctic Fox					Red Fox			
	Natal	Secondary	Active[a]	Inactive[b]	Total	Natal	Active[a]	Inactive[b]	Total
NUMBER OF DENS									
1993	1	0	0	1	2	0	0	0	0
1995	1	0	0	2	3	2	1	0	3
1996	0	0	0	3	3	3	0	0	3
1997	0	0	0	3	3	0	2	1	3
1998	1	0	0	2	3	2	2	0	4
1999	0	1	0	2	3	2	1	1	4
2000	0	0	1	3	4	2	0	2	4
2001	1	0	1	3	5	1	1	2	4
2002	0	0	2	3	5	1	0	3	4
PERCENT OF DENS									
1993	50	–	–	50		–	–	–	
1995	33	–	–	67		67	33	–	
1996	–	–	–	100		100	–	–	
1997	–	–	–	100		–	67	33	
1998	33	–	–	67		50	50	–	
1999	–	33	–	67		50	25	25	
2000	–	–	25	75		50	–	50	
2001	20	–	20	60		25	25	50	
2002	–	–	50	50		25	–	75	

[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.

dens are more difficult to observe than arctic fox dens because they tend to be located in sand dunes having high topographic relief and tall shrubs that obscure the den entrances and activity areas. In general, our observations at dens have been most successful in obtaining pup counts during early morning and evening, when foxes tend to be most active; litters occasionally can be counted successfully even in midday, however. Estimates of pup production also can be confounded by the use of secondary dens, which may result in splitting of litters among several dens by one family (Garrott 1980, Eberhardt et al. 1983). We found no indication that litters were moved between den sites in the CD South area in 2000 or 2001, however.

Habitat Use

In the CD South study area, the habitat type used most often for denning was Riverine or Upland Shrub (7 of 9 dens, or 78%); the only other habitat type used was Patterned Wet Meadow (2 dens). In the CD South area, foxes tend to den in old dunes stabilized by vegetation, occasionally cut by lakes or river channels (Table 18). Because both arctic and red foxes have similar denning requirements and will use the same den sites in different years, we included dens used by both species to analyze habitat selection across the entire Colville River Delta (Burgess et al. 2002). Sixteen dens (70% of the delta total) were located in the Riverine or Upland Shrub type (upland shrub subtype), the only denning habitat that was preferred. Dens in the other habitats used—Barrens (eolian subtype), Moist

Sedge–Shrub Meadow, Patterned Wet Meadow, and Nonpatterned Wet Meadow—actually were located in small patches of higher microrelief that were smaller than the minimal mapping size of habitat areas. Foxes did not den in the extensive river bars and mudflats on the delta.

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have relatively deep seasonal thaw layers. Foxes locate dens on raised landforms with well-drained soil; typical locations on the Arctic Coastal Plain include ridges, dunes, lake and stream shorelines, pingos, and low mounds (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993). In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville River Delta, the latter species dens almost exclusively in sand dunes. On the Colville River Delta and adjacent coastal plain to the east, foxes den in sand dunes (mostly those stabilized by vegetation), banks of streams and lakes (including banks of drained-lake basins), ridges, and pingos (Table 18; Garrott 1980, Eberhardt et al. 1983). Those landforms are usually vegetated with upland shrubs and less commonly with riverine shrubs. Pingos are used commonly as den sites in the Prudhoe Bay area (Burgess et al. 1993), but account for only a small percentage of the known sites in the Colville area (Eberhardt et al. 1983). Chesemore (1969) reported that low mounds were used most often for den sites in the Teshekpuk Lake area of NPRA west of the Colville River Delta. These observations all confirm that the primary requirement for denning habitat is well-drained soil with a texture conducive to burrowing, conditions that occur on elevated microsites within a variety of larger habitat types.

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

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
BIRDS			
Red-throated Loon	*Gavia stellata*	Upland Sandpiper	*Bartramia longicauda*
Pacific Loon	*Gavia pacifica*	Whimbrel	*Numenius phaeopus*
Yellow-billed Loon	*Gavia adamsii*	Bar-tailed Godwit	*Limosa lapponica*
Red-necked Grebe	*Podiceps grisegena*	Ruddy Turnstone	*Arenaria interpres*
Greater White-fronted Goose	*Anser albifrons*	Semipalmated Sandpiper	*Calidris pusilla*
Snow Goose	*Chen caerulescens*	Western Sandpiper	*Calidris mauri*
Canada Goose	*Branta canadensis*	Least Sandpiper	*Calidris minutilla*
Brant	*Branta bernicla*	White-rumped Sandpiper	*Calidris fuscicollis*
Tundra Swan	*Cygnus columbianus*	Baird's Sandpiper	*Calidris bairdii*
American Wigeon	*Anas americana*	Pectoral Sandpiper	*Calidris melanotos*
Mallard	*Anas platyrhynchos*	Dunlin	*Calidris alpina*
Northern Shoveler	*Anas clypeata*	Stilt Sandpiper	*Calidris himantopus*
Northern Pintail	*Anas acuta*	Buff-breasted Sandpiper	*Tryngites subruficollis*
Green-winged Teal	*Anas crecca*	Ruff	*Philomachus pugnax*
Greater Scaup	*Aythya marila*	Long-billed Dowitcher	*Limnodromus scolopaceus*
Lesser Scaup	*Aythya affinis*	Common Snipe	*Gallinago gallinago*
Steller's Eider	*Polysticta stelleri*	Red-necked Phalarope	*Phalaropus lobatus*
Spectacled Eider	*Somateria fischeri*	Red Phalarope	*Phalaropus fulicarius*
King Eider	*Somateria spectabilis*	Pomarine Jaeger	*Stercorarius pomarinus*
Common Eider	*Somateria mollissima*	Parasitic Jaeger	*Stercorarius parasiticus*
Surf Scoter	*Melanitta perspicillata*	Long-tailed Jaeger	*Stercorarius longicaudus*
White-winged Scoter	*Melanitta fusca*	Ring-billed Gull	*Larus delawarensis*
Black Scoter	*Melanitta nigra*	Glaucous Gull	*Larus hyperboreus*
Long-tailed Duck	*Clangula hyemalis*	Sabine's Gull	*Xema sabini*
Red-breasted Merganser	*Mergus serrator*	Arctic Tern	*Sterna paradisaea*
Bald Eagle	*Haliaeetus leucocephalus*	Snowy Owl	*Nyctea scandiaca*
Northern Harrier	*Circus cyaneus*	Short-eared Owl	*Asio flammeus*
Rough-legged Hawk	*Buteo lagopus*	Common Raven	*Corvus corax*
Golden Eagle	*Aquila chrysaetos*	Horned Lark	*Eremophila alpestris*
Merlin	*Falco columbarius*	Violet-green Swallow	*Tachycineta bicolor*
Gyrfalcon	*Falco rusticolus*	American Robin	*Turdus migratorius*
Peregrine Falcon	*Falco peregrinus*	Bluethroat	*Luscinia svecica*
Willow Ptarmigan	*Lagopus lagopus*	Yellow Wagtail	*Motacilla flava*
Rock Ptarmigan	*Lagopus mutus*	Wilson's Warbler	*Wilsonia pusilla*
Sandhill Crane	*Grus canadensis*	American Tree Sparrow	*Spizella arborea*
Black-bellied Plover	*Pluvialis squatarola*	Savannah Sparrow	*Passerculus sandwichensis*
American Golden-Plover	*Pluvialis dominica*	Lapland Longspur	*Calcarius lapponicus*
Semipalmated Plover	*Charadrius semipalmatus*	Snow Bunting	*Plectrophenax nivalis*
Lesser Yellowlegs	*Tringa flavipes*	Common Redpoll	*Carduelis flammea*
MAMMALS			
Snowshoe Hare	*Lepus americanus*	Polar Bear	*Ursus maritimus*
Arctic Ground Squirrel	*Spermophilus parryii*	Ermine	*Mustela erminea*
Brown Lemming	*Lemmus sibiricus*	Wolverine	*Gulo gulo*
Collared Lemming	*Dicrostonyx rubricatus*	Spotted Seal	*Phoca largha*
Gray Wolf	*Canis lupus*	Moose	*Alces alces*
Arctic Fox	*Alopex lagopus*	Caribou	*Rangifer tarandus*
Red Fox	*Vulpes vulpes*	Muskox	*Ovibus moschatus*
Grizzly Bear	*Ursus arctos*		

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

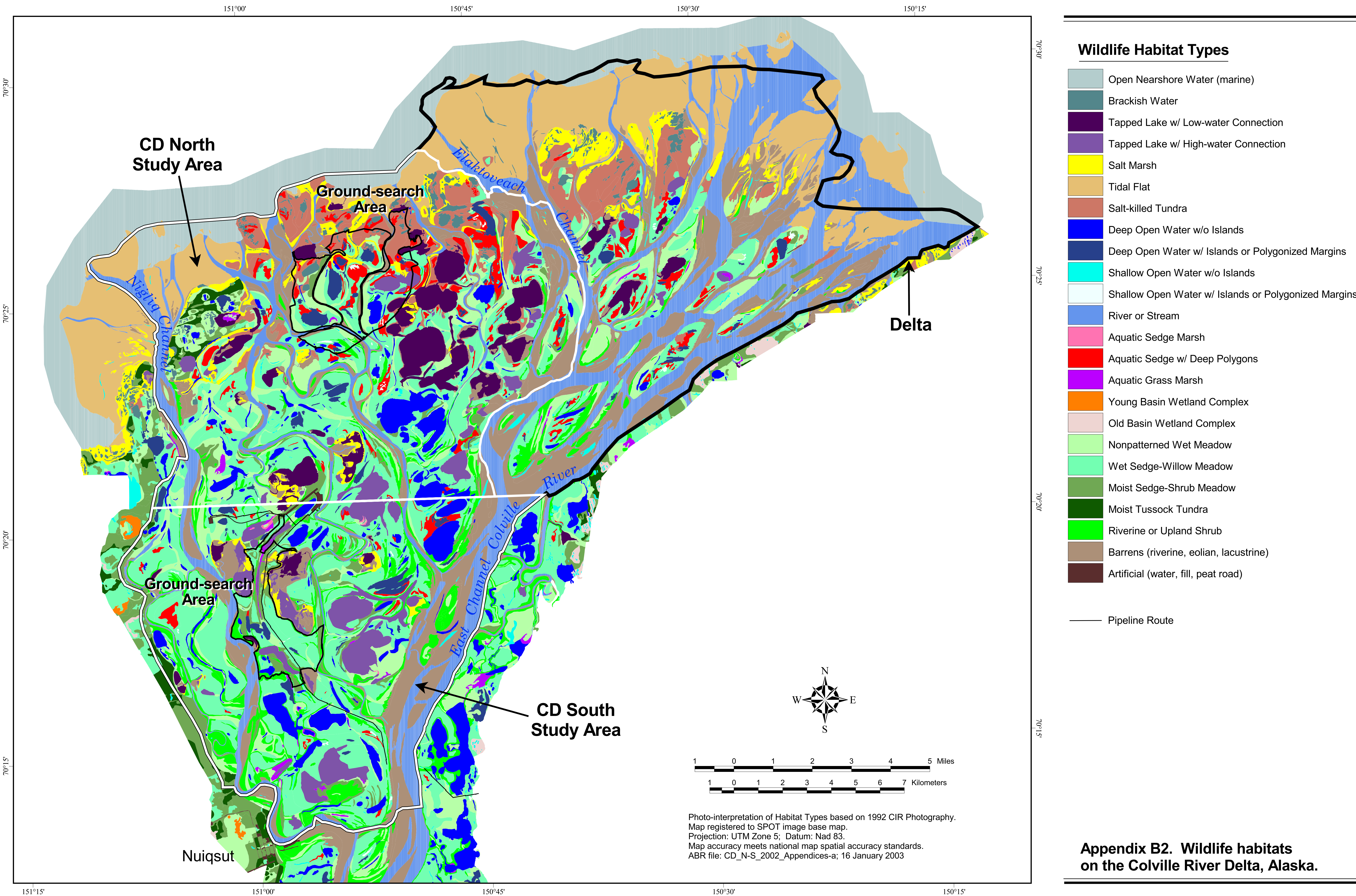
Habitat	Description
Open Nearshore Water (Estuarine Subtidal)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges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

Appendix B1. (Continued).

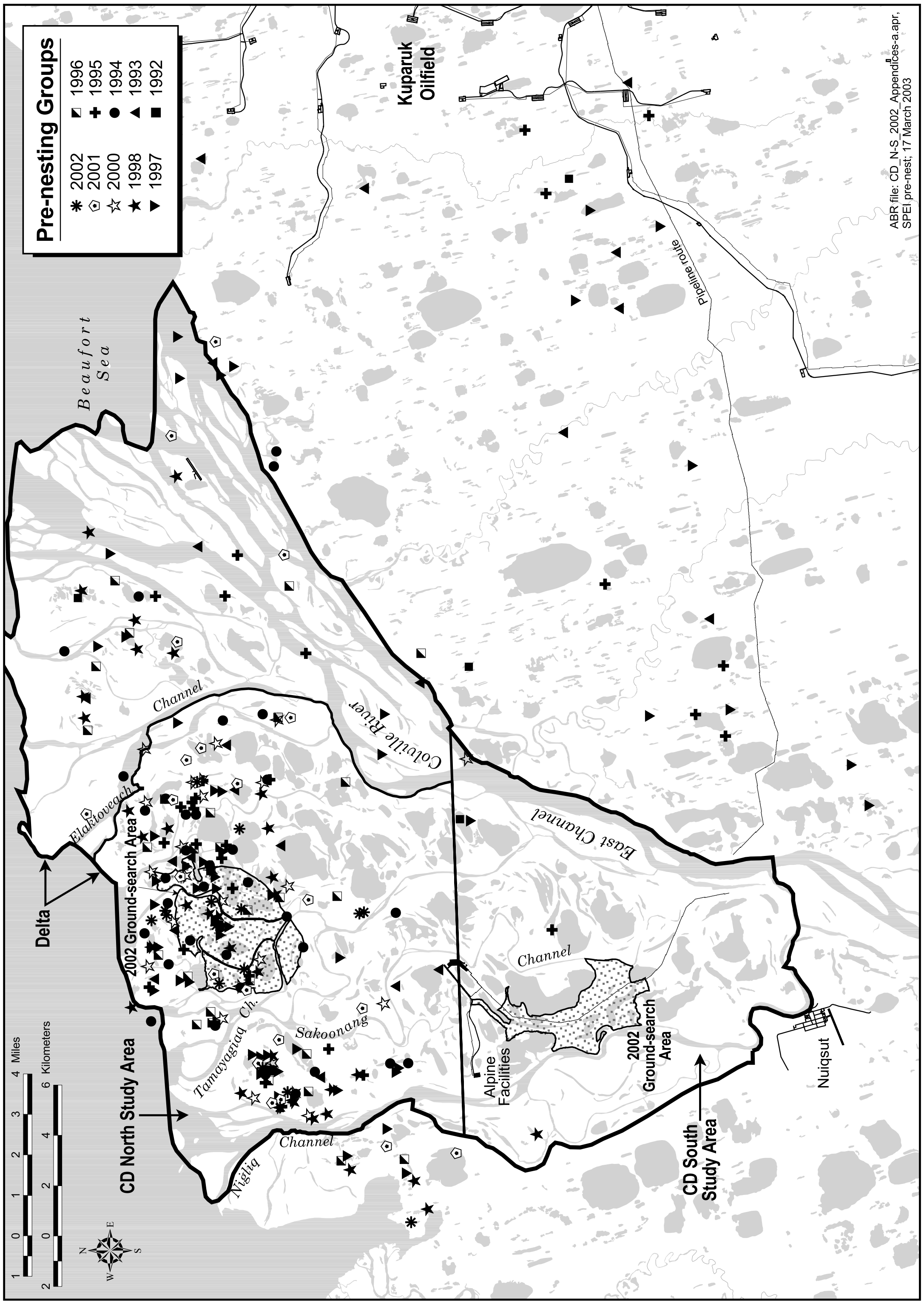
Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many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

Appendix B1. (Continued).

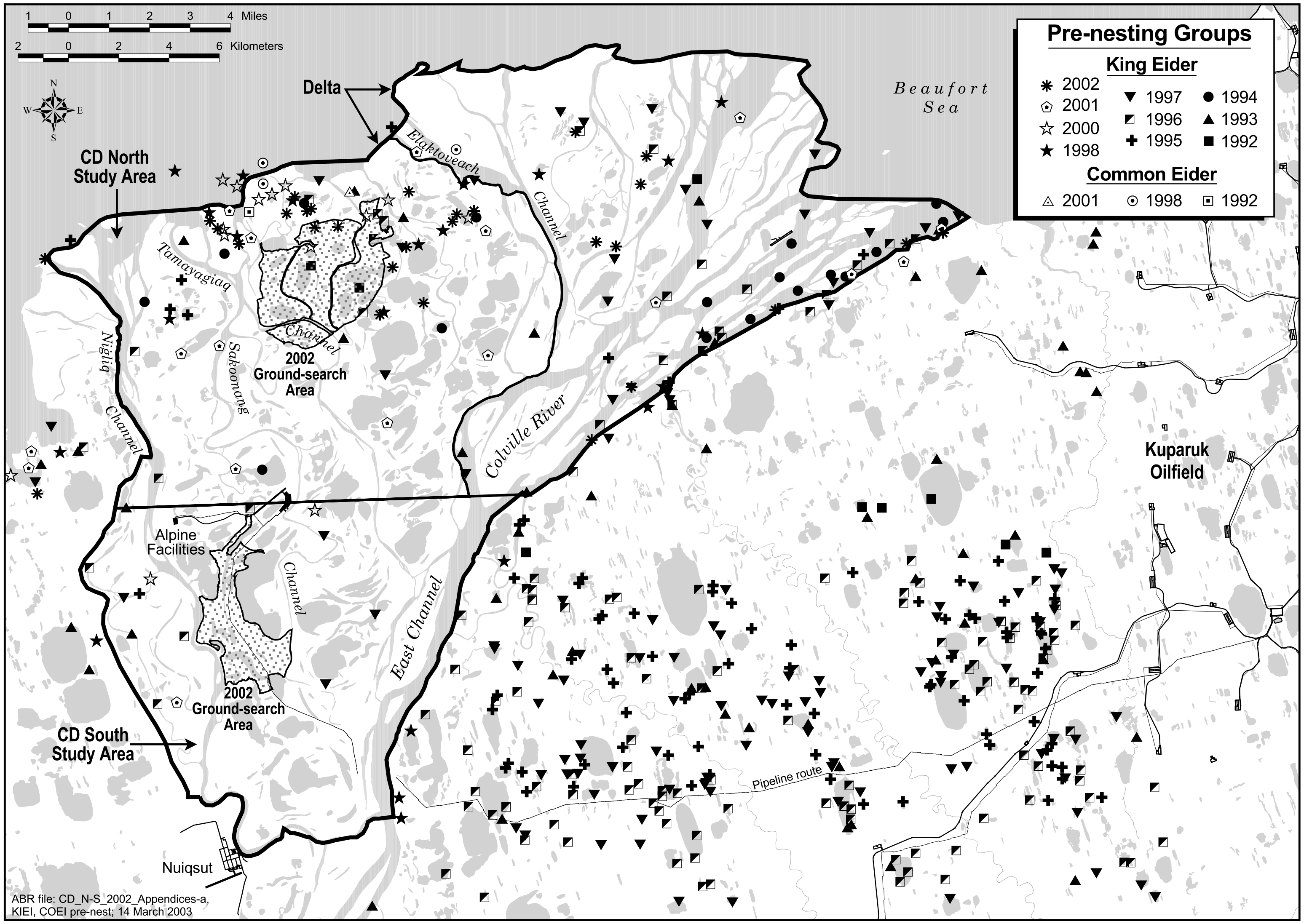
Habitat	Description
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strangmoor cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. The uninterrupted movement of water and dissolved nutrients in nonpatterned ground results in more robust growth of sedges than in polygonized habitats. *Carex aquatilis* and *Eriophorum angustifolium* usually dominate, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata, S. arctica,* and *S. planifolia*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying fine-grained silt.
Patterned Wet Meadow	Occurs in lowland areas within drained lake basins, level floodplains, and swales on gentle slopes and terraces, associated with low-centered polygons and strangmoor (undulating raised sod ridges). Water depth varies through the season (<0.3 m maximum). Polygon rims and strangmoor interrupt surface and groundwater flow, so only interconnected polygon troughs receive downslope flow and dissolved nutrients; in contrast, the input of water to polygon centers is limited to precipitation. As a result, vegetation growth typically is more robust in polygon troughs than in centers. Vegetation is dominated by the sedges, *Carex aquatilis* and *Eriophorum angustifolium,* although other sedges may be present, including *C. rotundata, C. saxatilis, C. membranacea, C. chordorriza,* and *E. russeolum*. Willows (S*alix lanata*, *S. arctica,* and *S. planifolia)* usually are abundant.
Moist Sedge–Shrub Meadow (Low- or High-relief Polygons)	Occurs on better-drained uplands between thaw basins, riverbanks, old stabilized dunes, lower slopes of pingos, and foothill slopes, generally associated with nonpatterned ground, frost scars, and high-centered polygons with low relief. Vegetation is dominated by *C. aquatilis, C. bigelowii, E. angustifolium, S. planifolia,* and *Dryas integrifolia*. The ground is covered with a nearly continuous carpet of mosses. Soils generally have a thin layer (20–30 cm) of organic matter over silt loam.
Moist Tussock Tundra	Similar to preceding type, except that the vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum*. This type tends to occur on the upper portions of slopes and in better drained conditions than Moist Sedge–Shrub Tundra.
Riverine or Upland Shrub	Both open and closed stands of low (≤1.5 m high) and tall (>1.5 m high) willows along riverbanks and *Dryas* tundra on upland ridges and stabilized sand dunes. Tall willows occur mainly along larger streams and rivers, where the vegetation is dominated by *Salix alaxensis*. Low willow stands are widespread and typically have a canopy of *S. lanata* and *S. glauca*. Understory plants include the shrubs *Arctostaphylos rubra, S. reticulata,* and *D. integrifolia,* and the forbs *Astragalus* spp., *Lupinus arcticus*, and *Equisetum* spp. *Dryas* tundra is dominated by *D. integrifolia* but may include abundant dwarf willows such as *S. phlebophylla*. Common forbs include *Silene acaulis, Pedicularis lanata,* and *Astragalus umbellatus,* and *C. bigelowii* frequently is present. In Riverine Shrub, an organic horizon generally is absent or buried due to frequent sediment deposition. In Upland Shrub, soils generally have a thin (<5 cm) organic horizon.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas resulting from riverine, eolian, or thaw-lake processes. Riverine Barrens on river flats and bars are flooded seasonally and can have either silty or gravelly sediments. The margins frequently are colonized by *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum,* and *Equisetum arvense*. Eolian Barrens generally are located adjacent to river deltas and include active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical pioneer plants include *Salix alaxensis, Elymus arenarius,* and *Deschamspia caespitosa.* Lacustrine Barrens occur along margins of drained lakes and ponds. These areas may be flooded seasonally or can be well drained. On the delta, sediments usually are clay-rich, slightly saline, and are being colonized by salt-marsh plant species. Barrens may receive intensive use seasonally by caribou as insect-relief habitat.
Artificial (Water, Fill, Peat Road)	A variety of small disturbed areas, including impoundments, gravel fill, and a sewage lagoon at Nuiqsut. Gravel fill is present at Nuiqsut, and at the Helmericks residence near the mouth of the Colville River. A peat road runs roughly north-south within the Transportation Corridor. Two Kuparuk drill sites (2M and 2K) are included, as are several old exploratory drilling pads.



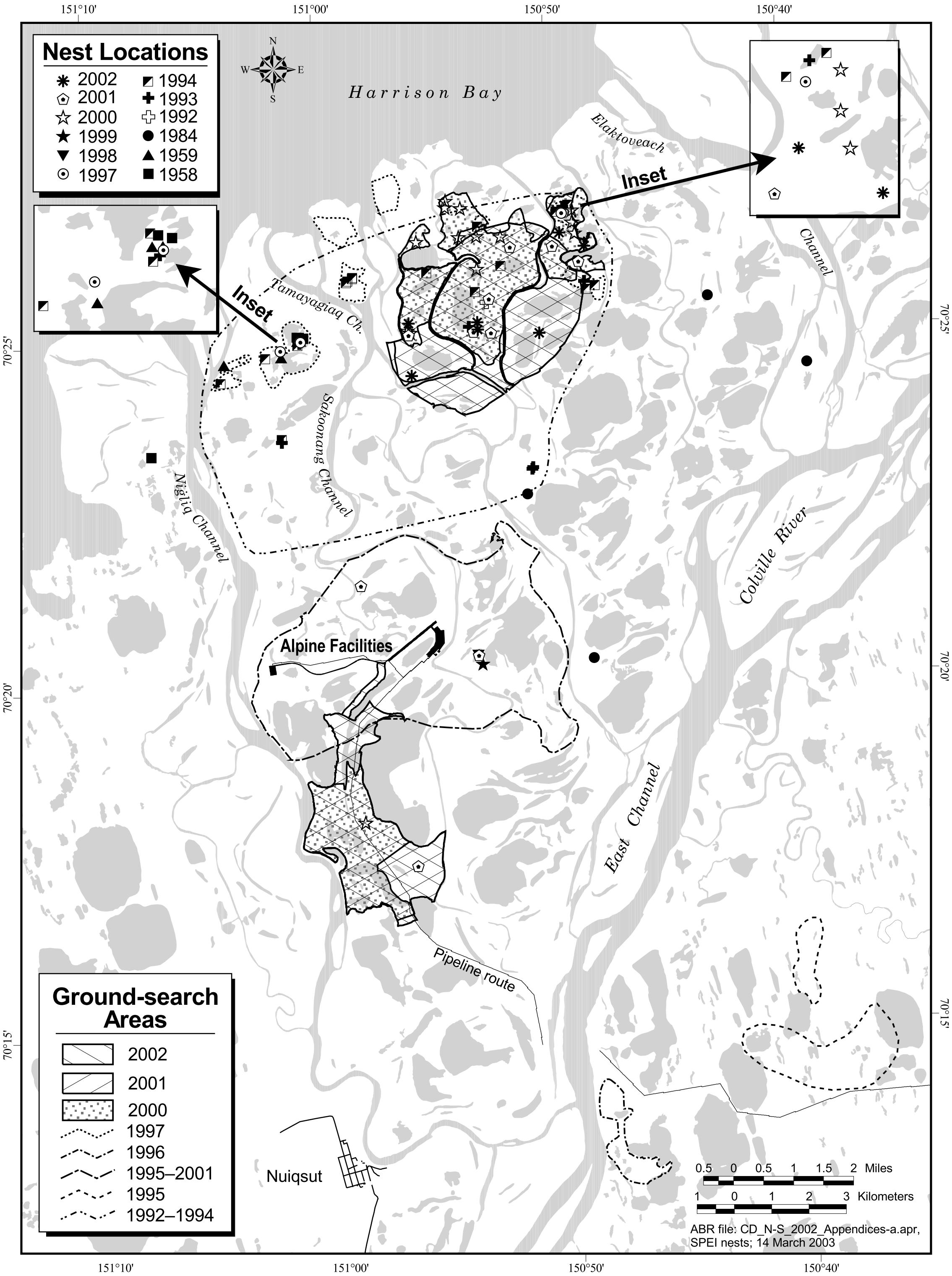
Appendix B2. Wildlife habitats on the Colville River Delta, Alaska.



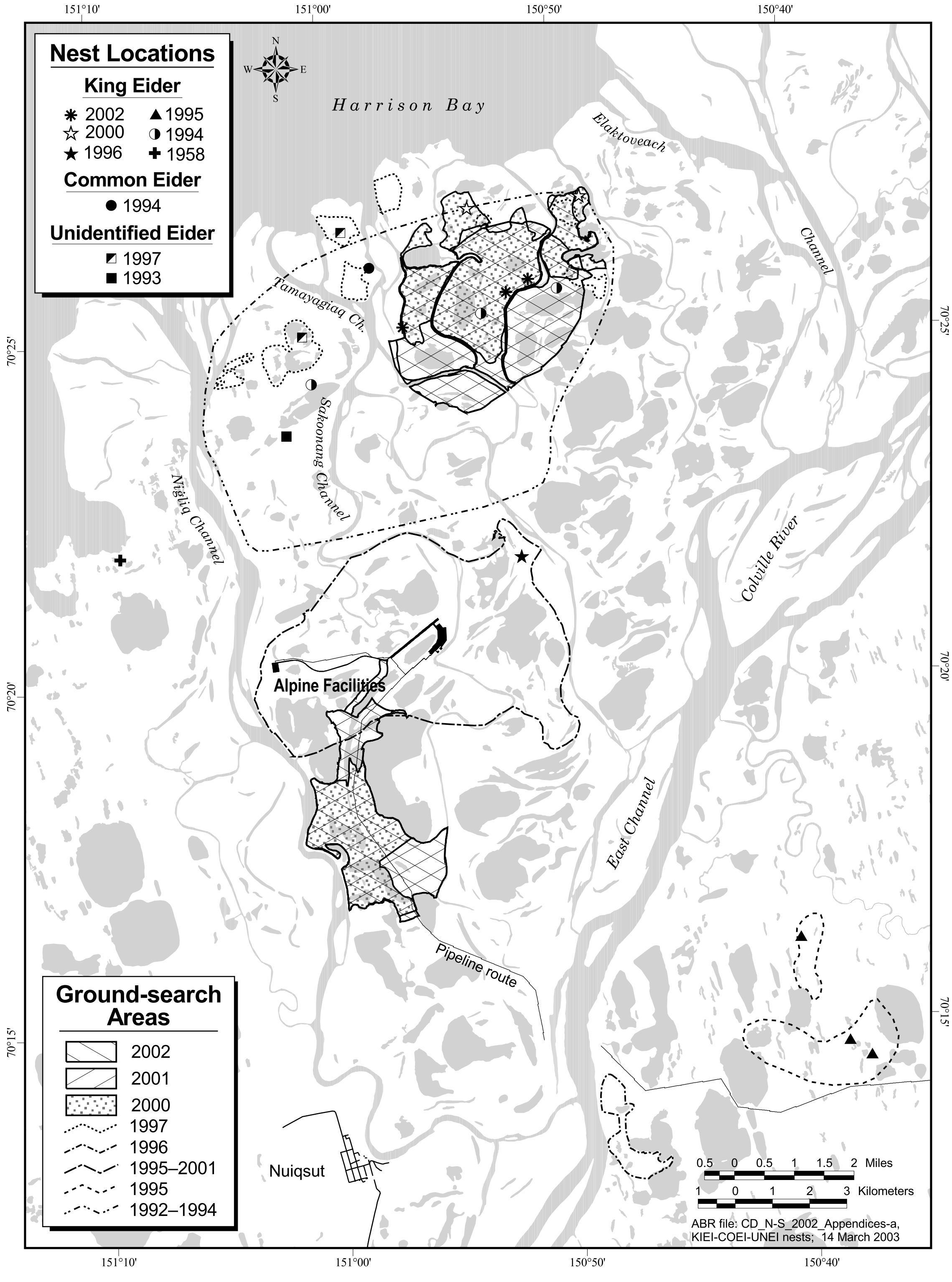
Appendix C1. Distribution of Spectacled Eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Johnson et al. 1999a).



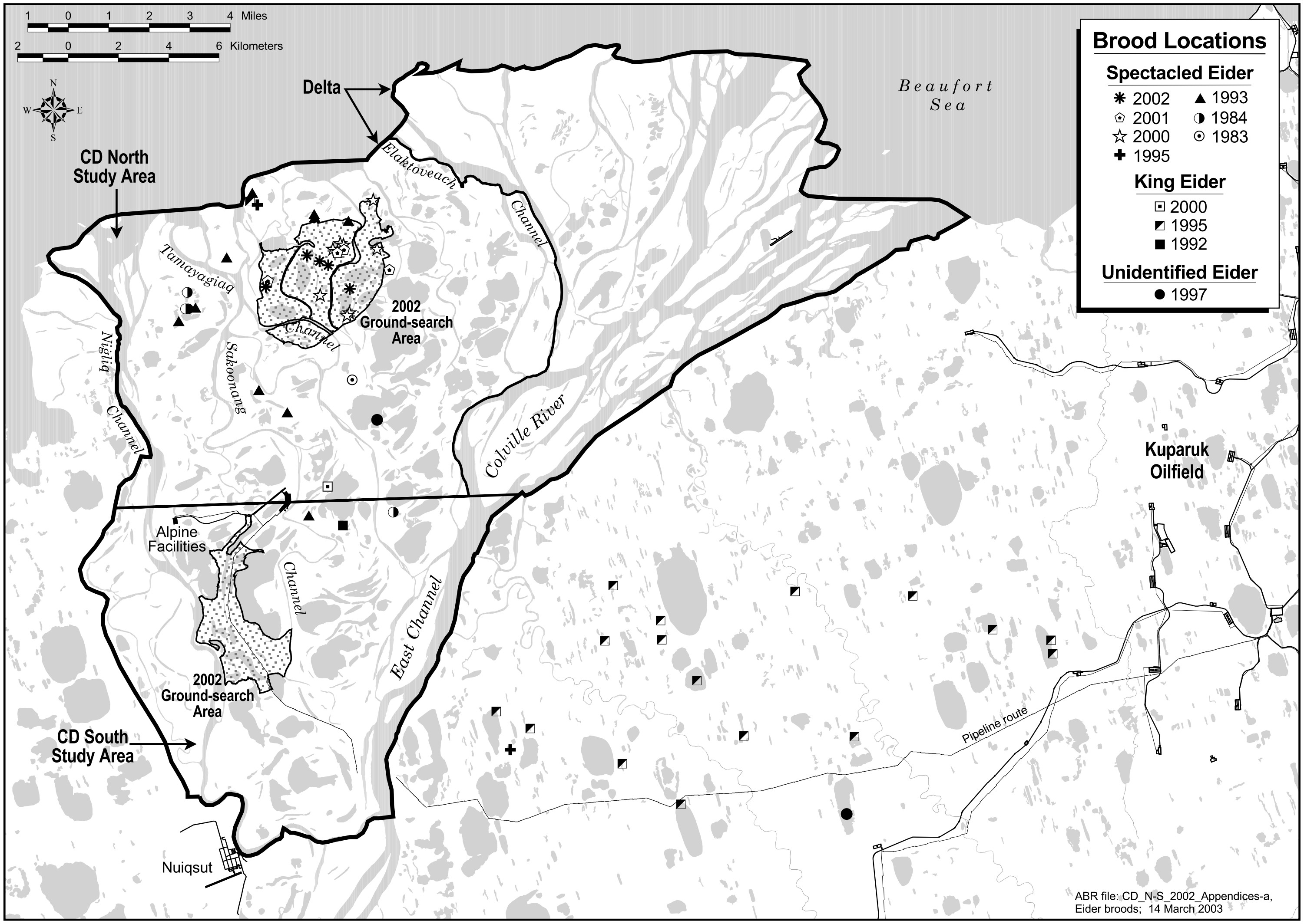
Appendix C2. Distribution of King and Common eider groups during pre-nesting aerial surveys on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Johnson et al. 1999a).



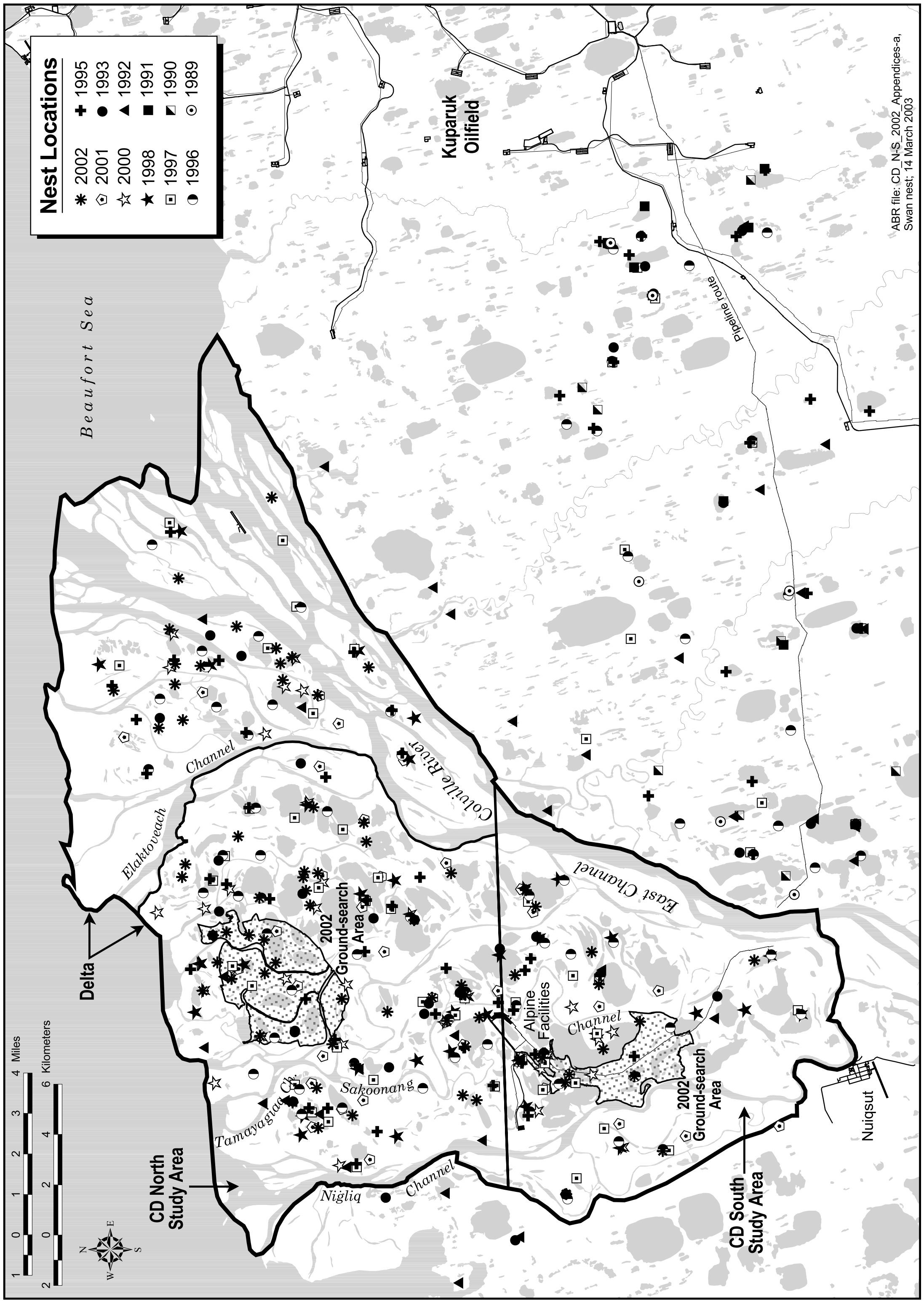
Appendix C3. Distribution of Spectacled Eider nests during ground searches on the Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–2002 (pre-2000 data from unpublished data of T. Myres [1958 and 1959] and M. North [1984]; Smith et al. 1993, 1994; and Johnson et al. 1999a, 2000b). Survey coverage was not uniform over the area portrayed.



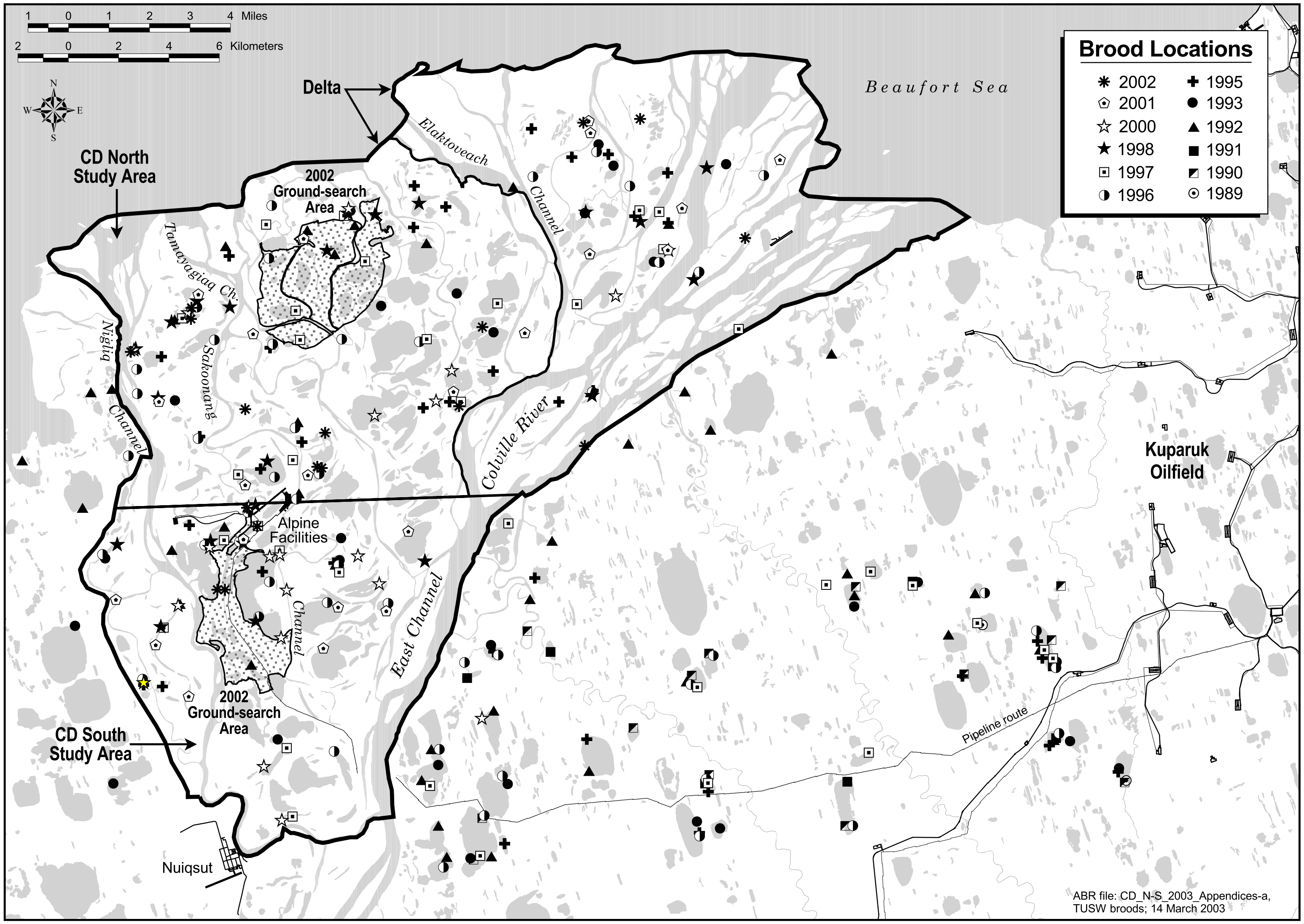
Appendix C4. Distribution of King, Common, and unidentified eider nests during ground searches on the Colville River Delta, Alaska, 1958 and 1992–2002 (pre-2000 data from unpublished data of T. Myres [1958]; Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



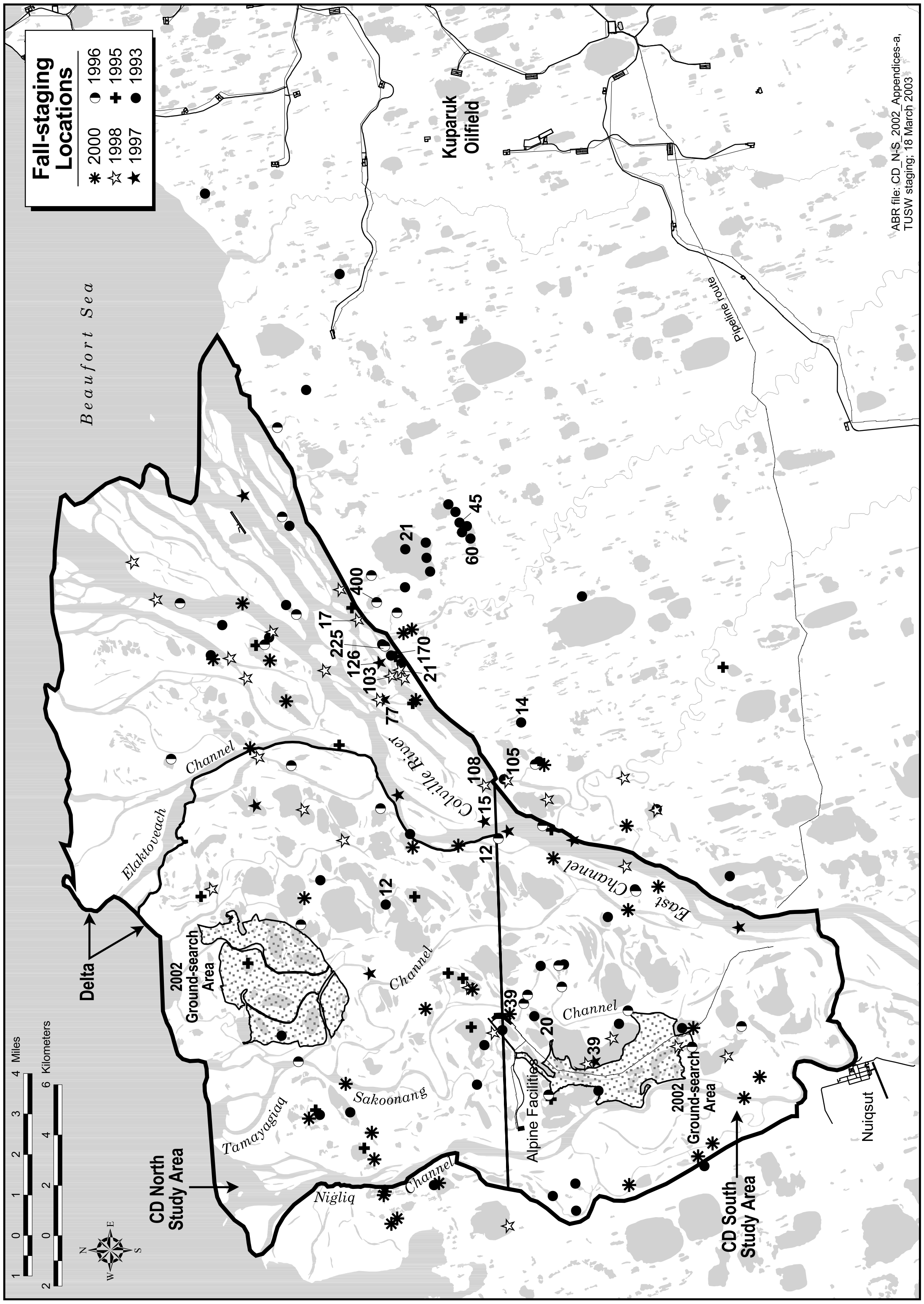
Appendix C5. Distribution of Spectacled, King, and unidentified eider broods during aerial and ground surveys of the CD North and CD South study areas, Colville River Delta, Alaska, 1983–1984 and 1992–2002 (pre-2000 data from unpublished data of M. North [1983 and 1984]; Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



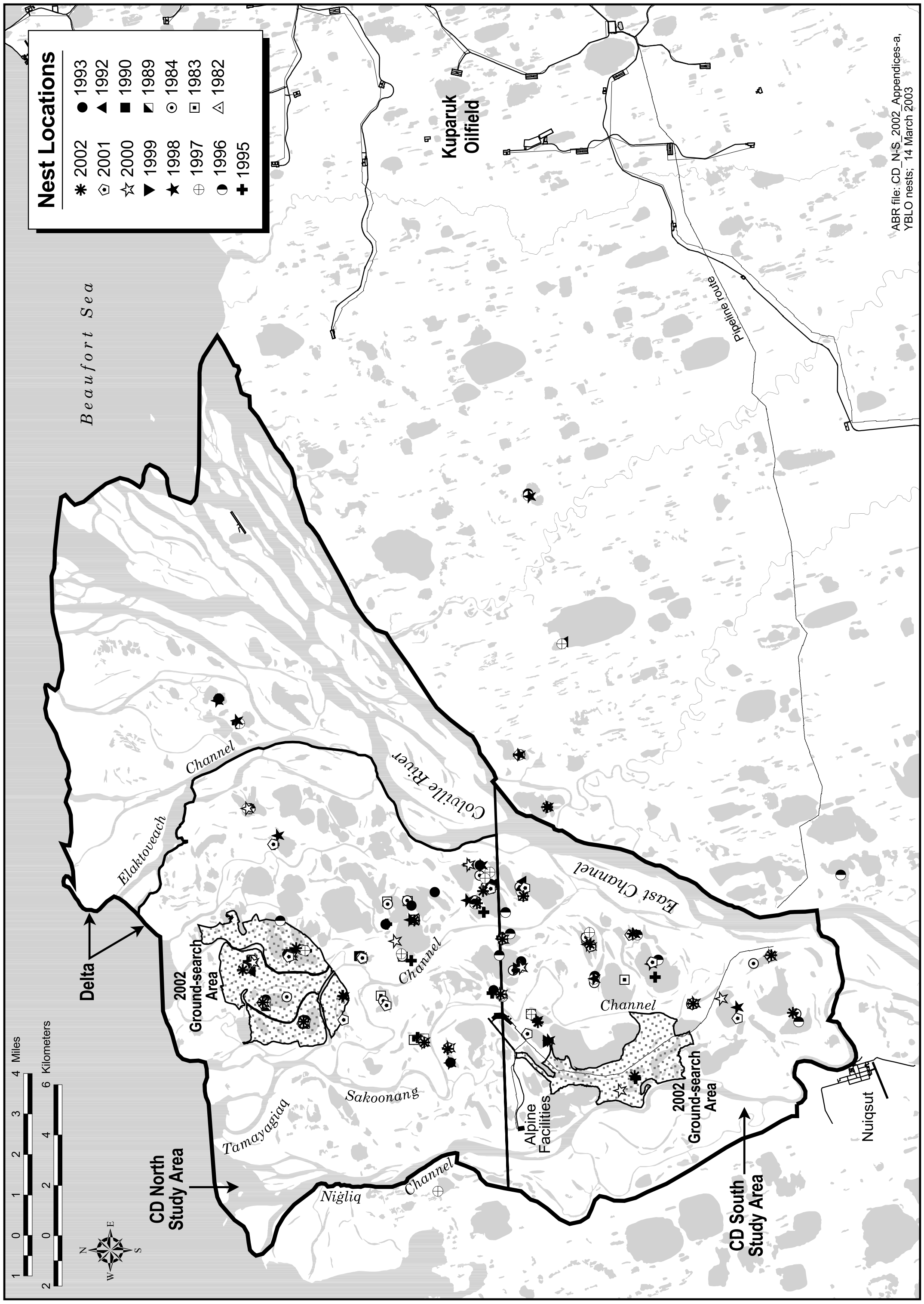
Appendix C6. Distribution of Tundra Swan nests during aerial and ground surveys on the Colville River Delta, Alaska, 1989–2002 (pre-2000 data from Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Smith et al. 1993, 1994; and Johnson et al. 1999a).



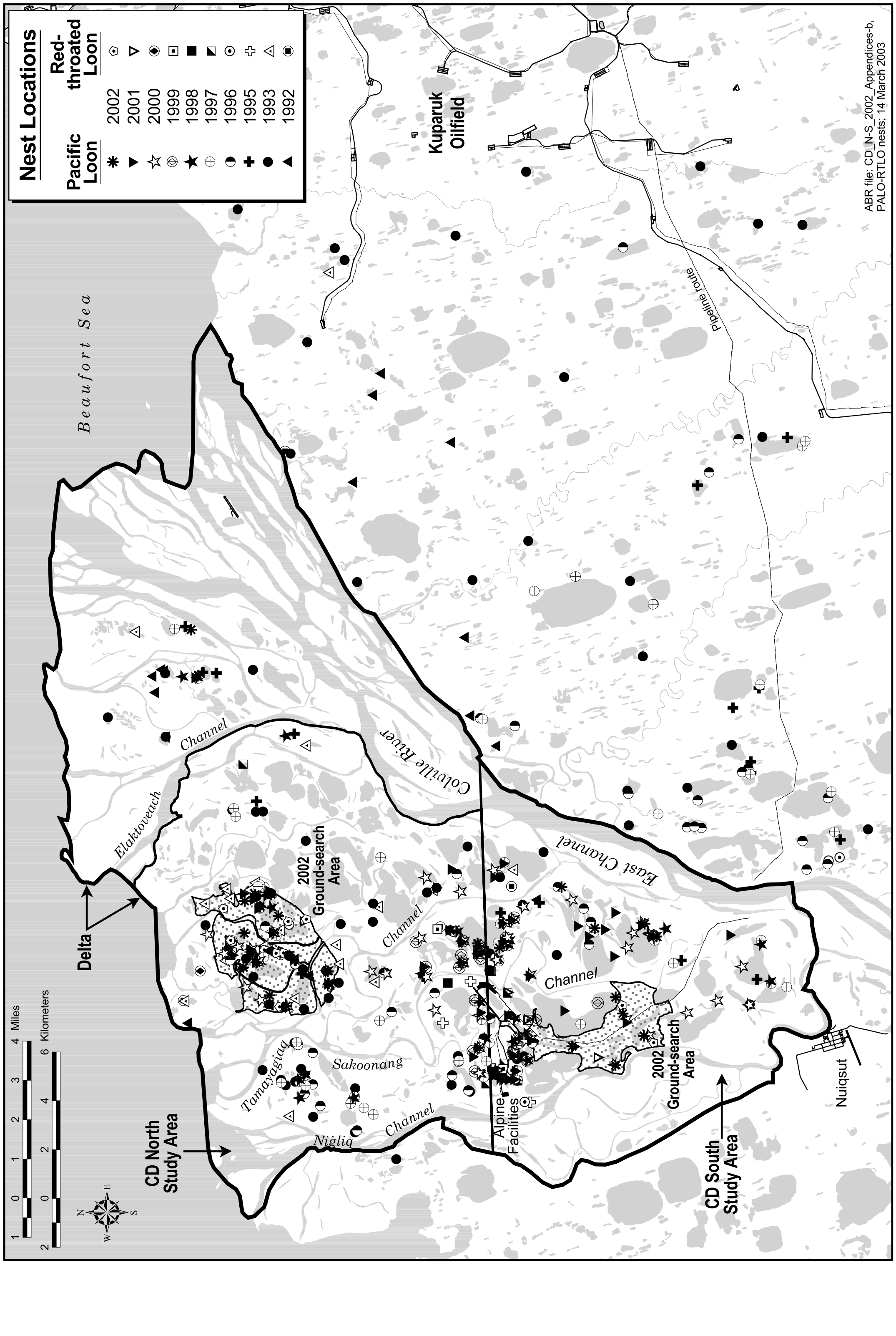
Appendix C7. Distribution of Tundra Swan broods during aerial and ground surveys on the Colville River Delta, Alaska, 1989–2002 (pre-2000 data from Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Smith et al. 1993, 1994; and Johnson et al. 1999a).



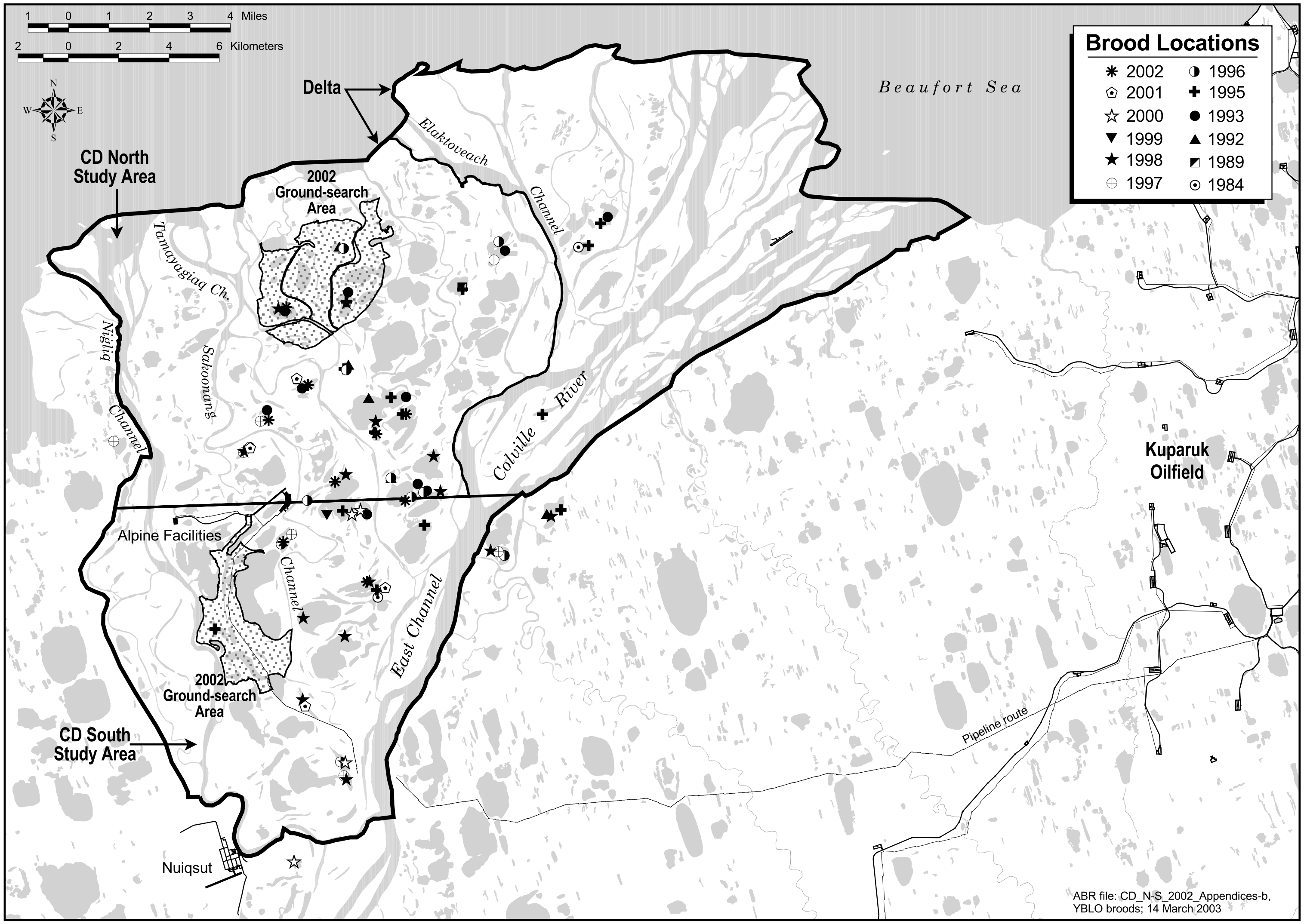
Appendix C8. Distribution of Tundra Swan fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1993–2000 (pre-2000 data from Smith et al. 1994; and Johnson et al. 1999a). Numbers indicate size of groups >10.



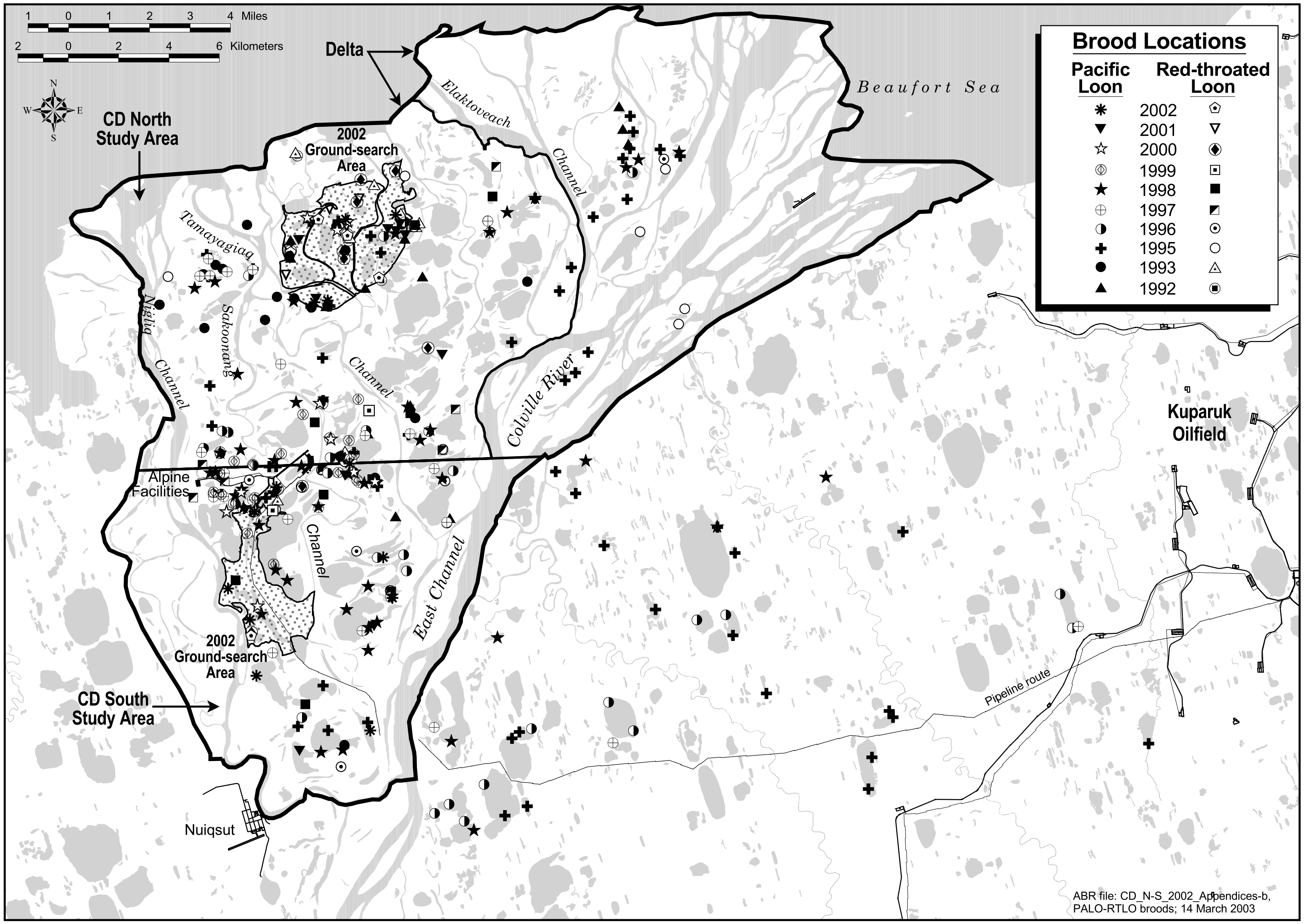
Appendix C9. Distribution of Yellow-billed Loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1982–2002 (pre-2000 data from unpublished data of M. North [1982–1984, 1989, and 1990] and S. Earnst [1995–1997]; Smith et al. 1993, 1994; and Johnson et al. 1999a).



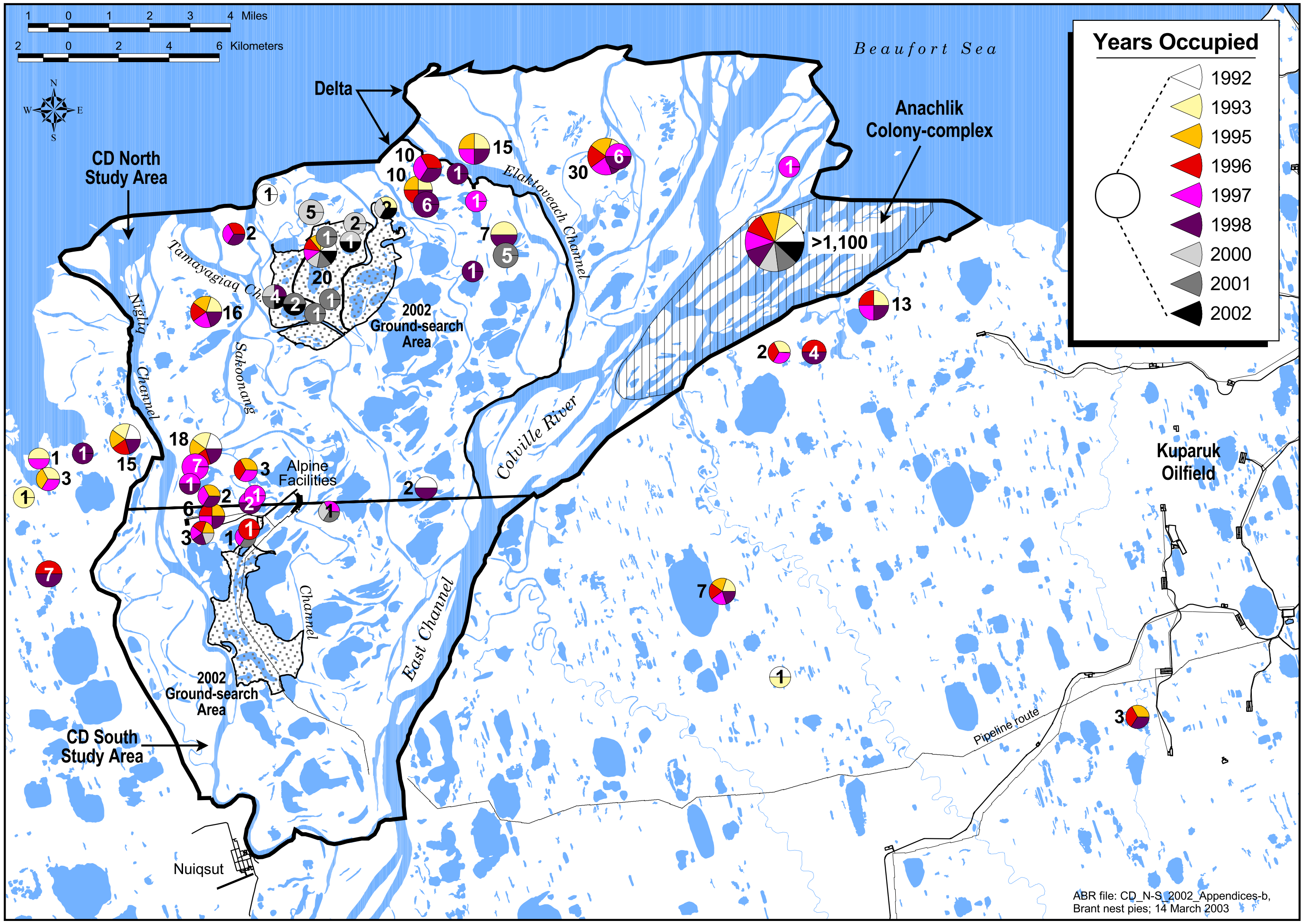
Appendix C10. Distribution of Pacific and Red-throated loon nests during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Smith et al. 1993, 1994, and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



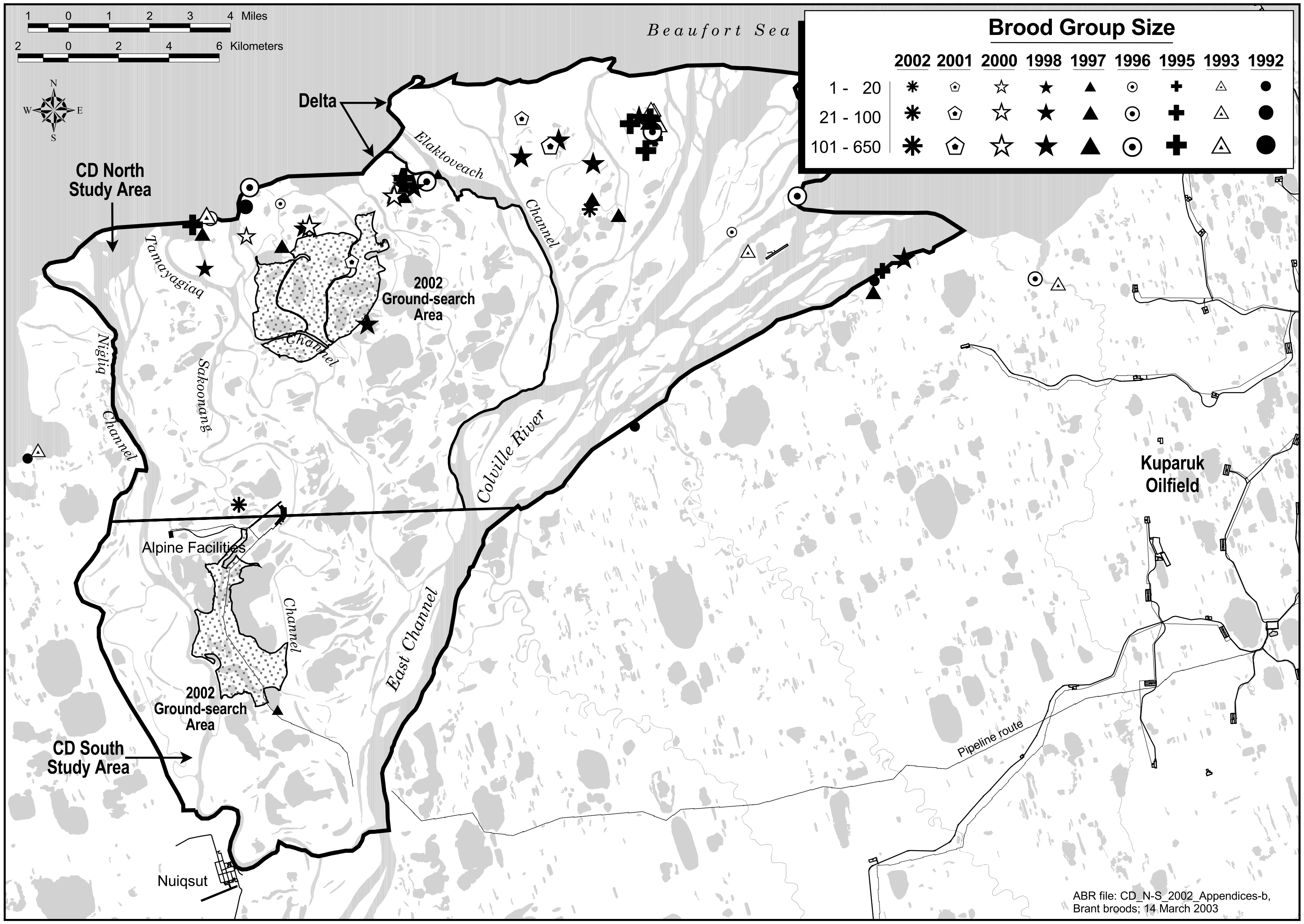
Appendix C11. Distribution of Yellow-billed Loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1984–2002 (pre-2000 data from unpublished data of M. North [1984 and 1989] and S. Earnst [1996]; Smith et al. 1993, 1994; and Johnson et al. 1999a).



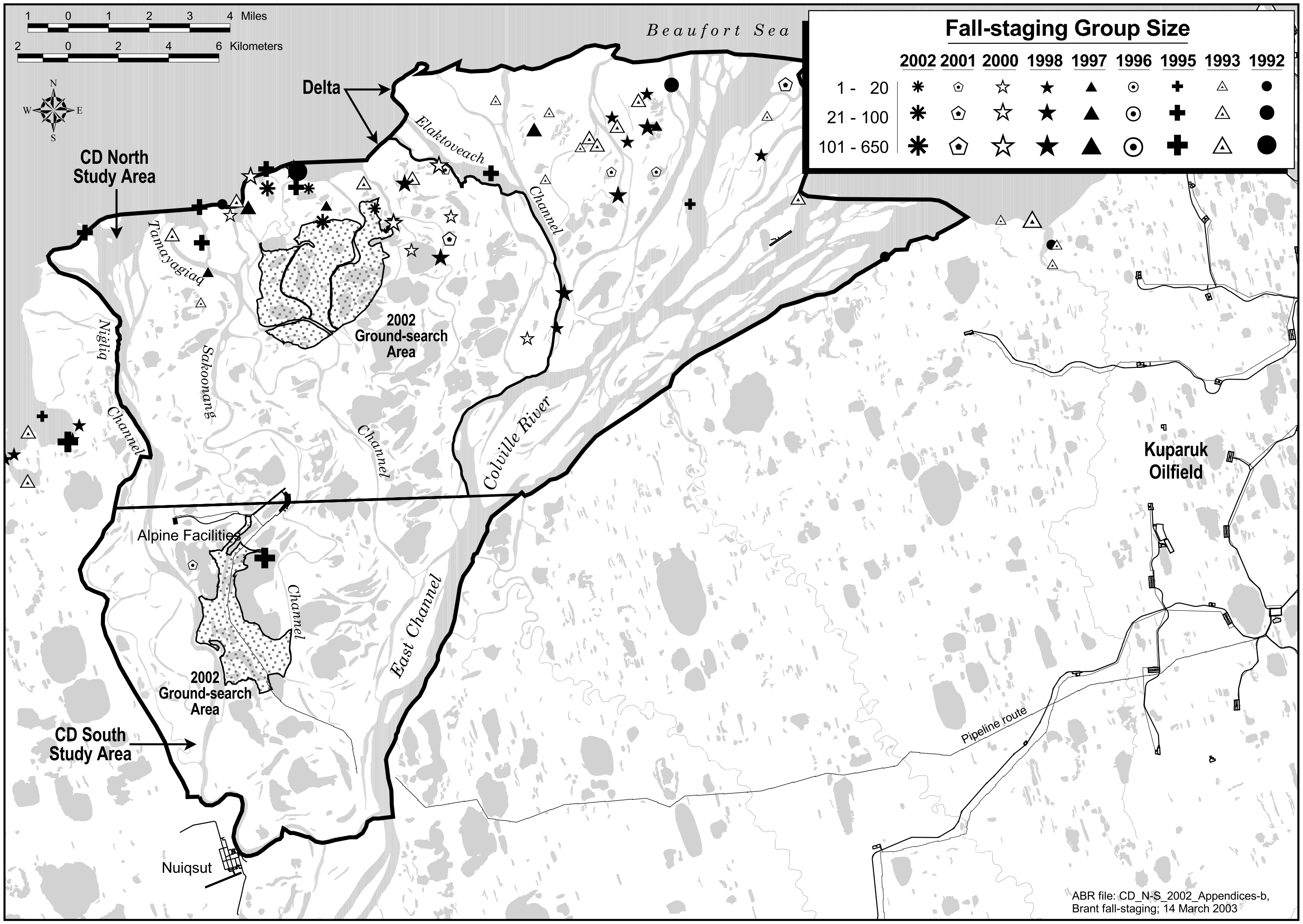
Appendix C12. Distribution of Pacific and Red-throated loon broods during aerial and ground surveys on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Smith et al. 1993, 1994; and Johnson et al. 1999a). Survey coverage was not uniform over the area portrayed.



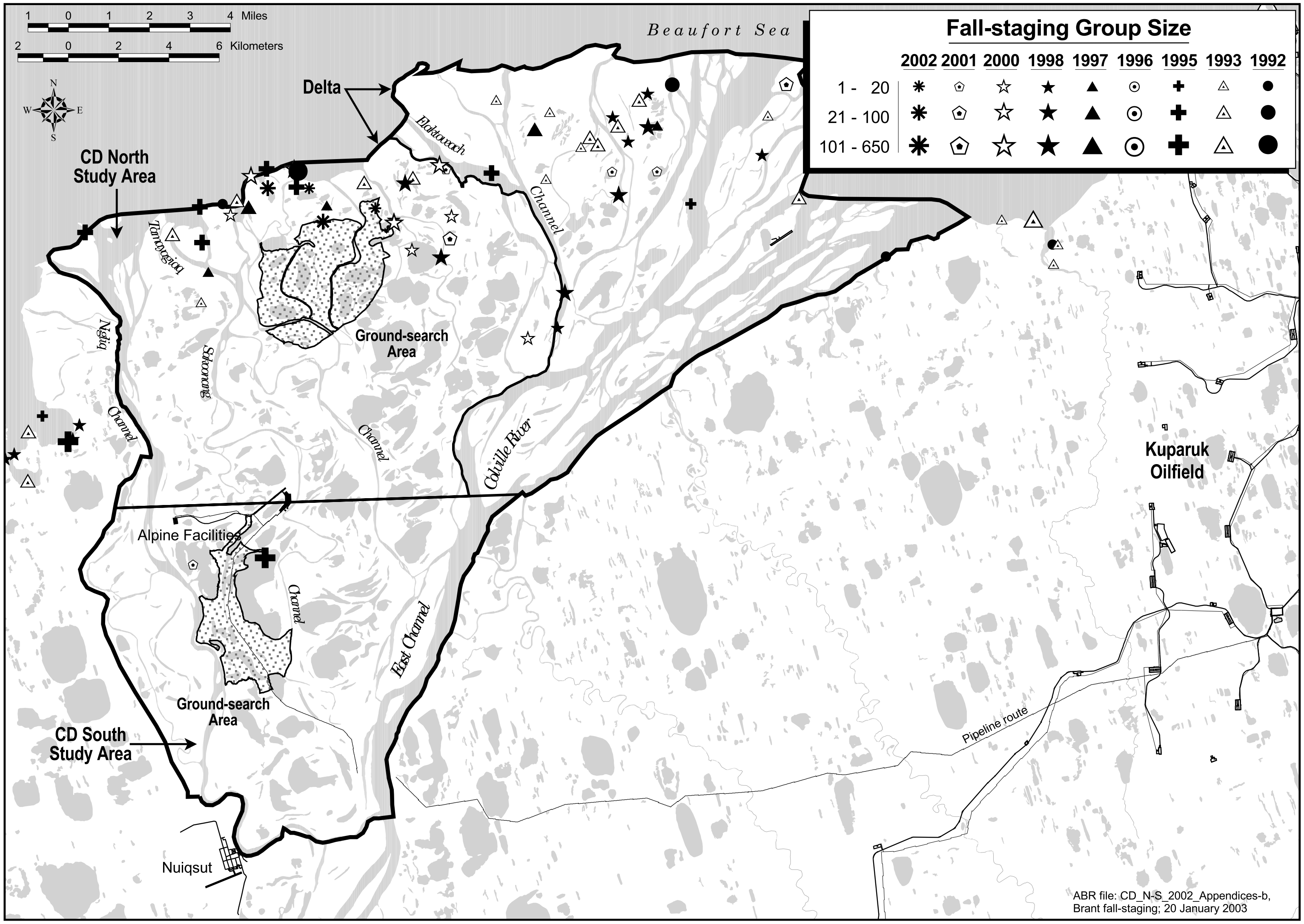
Appendix C13. Distribution and size of Brant colonies during aerial (1992–1993, 1995–1998) and ground (1995–2002) surveys on the Colville River Delta, Alaska (pre-2000 data from Johnson et al. 1999a). Numbers represent the maximal number of nests counted during surveys. Delta-wide surveys were not conducted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



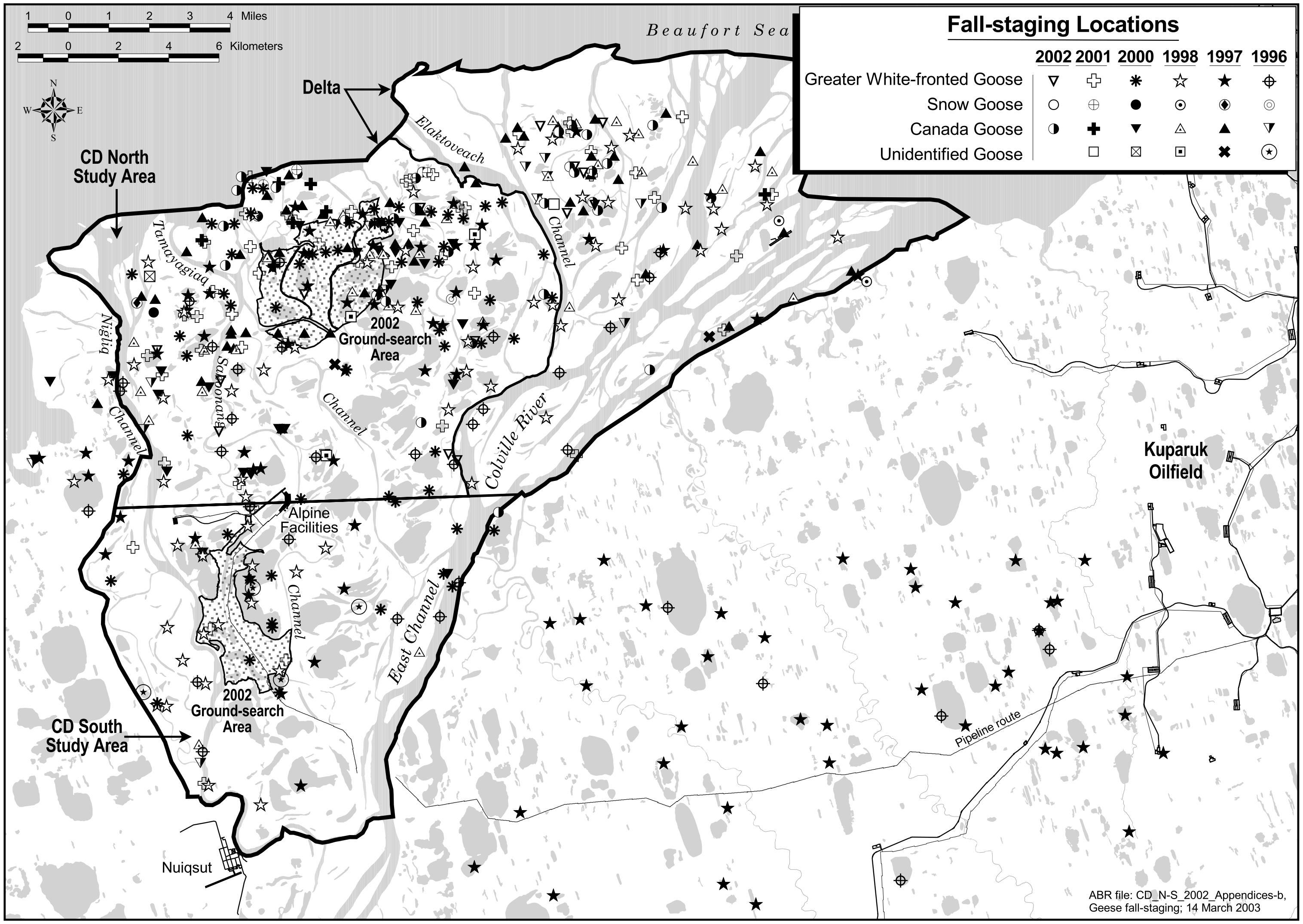
Appendix C14. Distribution and size of Brant brood-rearing groups during aerial surveys on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Smith et al. 1993, 1994; and Johnson et al. 1999a).



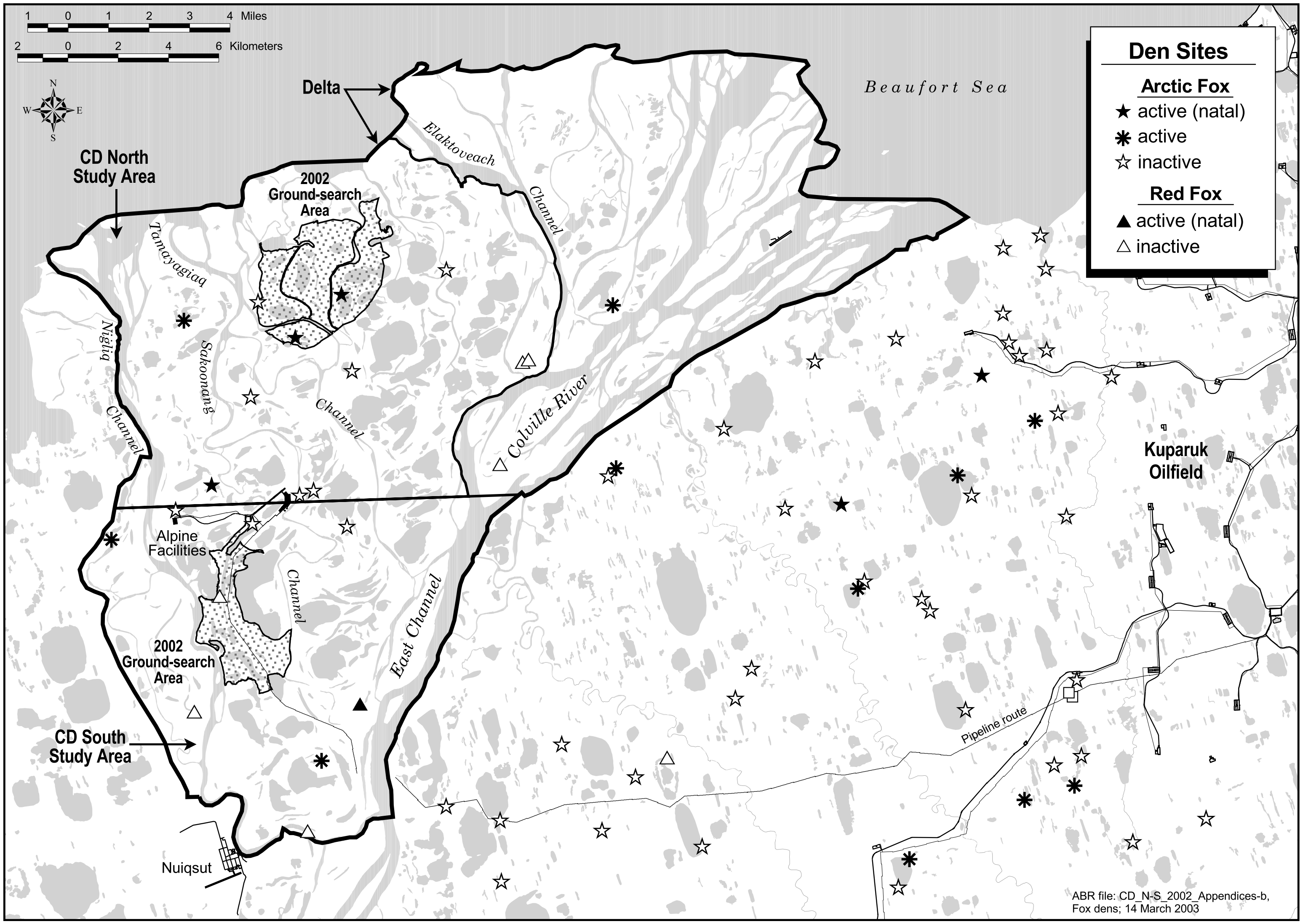
Appendix C15. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese during aerial surveys on the Colville River Delta, Alaska, 1996–2002 (pre-2000 data from Johnson et al. 1999a). Survey coverage was 25% in 1996 and 50% in subsequent years.



Appendix C16. Distribution and size of Brant fall-staging groups during aerial surveys on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Smith et al. 1993, 1994; and Johnson et al. 1999a).



Appendix C17. Distribution of fall-staging groups of Greater White-fronted, Snow, and Canada geese during aerial surveys on the Colville River Delta, Alaska, 1996–2002 (pre-2000 data from Johnson et al. 1999a). Survey coverage was 25% in 1996 and 50% in subsequent years.



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

Appendix D1. Habitat use by Spectacled Eiders and King Eiders during pre-nesting in the CD South study area, Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 1999a).

SPECIES Habitat	Total Groups	Total Adults	Use (%)
SPECTACLED EIDER			
Tapped Lake with Low-water Connection	1	2	25.0
Tapped Lake with High-water Connection	1	2	25.0
River or Stream	1	2	25.0
Aquatic Sedge with Deep Polygons	1	2	25.0
TOTAL	4	8	100
KING EIDER			
Tapped Lake with Low-water Connection	1	2	7.7
Tapped Lake with High-water Connection	2	6	15.4
River or Stream	7	19	53.9
Patterned Wet Meadow	2	3	15.4
Riverine or Upland Shrub	1	2	7.7
TOTAL	13	32	100

Appendix D2. Habitat selection (pooled among years) by Spectacled Eiders and King Eiders during pre-nesting on the Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 1999a).

SPECIES Habitat	No. Adults	No. Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
SPECTACLED EIDERS					
Open Nearshore Water	0	0	0	1.6	ns
Brackish Water	53	23	13.3	1.3	prefer
Tapped Lake with Low-water Connection	29	12	6.9	4.5	ns
Tapped Lake with High-water Connection	10	6	3.5	3.8	ns
Salt Marsh	27	13	7.5	3.3	prefer
Tidal Flat	0	0	0	7.1	avoid
Salt-killed Tundra	31	17	9.8	5.1	prefer
Deep Open Water without Islands	10	7	4.0	4.0	ns
Deep Open Water with Islands or Polygonized Margins	11	7	4.0	1.6	ns
Shallow Open Water without Islands	4	2	1.2	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	3	2	1.2	0.1	prefer
River or Stream	14	7	4.0	14.1	avoid
Aquatic Sedge Marsh	0	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	72	39	22.5	2.7	prefer
Aquatic Grass Marsh	2	2	1.2	0.2	ns
Young Basin Wetland Complex	0	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	ns
Nonpatterned Wet Meadow	37	18	8.1	8.1	ns
Patterned Wet Meadow	36	16	9.2	19.4	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.5	avoid
Moist Tussock Tundra	0	0	0	0.5	ns
Riverine or Upland Shrub	0	0	0	4.8	avoid
Barrens	4	2	1.2	15.0	avoid
Artificial	0	0	0	<0.1	ns
TOTAL	343	173	100	100	
KING EIDERS					
Open Nearshore Water	10	2	2.0	1.6	ns
Brackish Water	10	6	6.1	1.3	prefer
Tapped Lake with Low-water Connection	17	8	8.2	4.5	ns
Tapped Lake with High-water Connection	8	3	3.1	3.8	ns
Salt Marsh	4	2	2.0	3.3	ns
Tidal Flat	4	2	2.0	7.1	avoid
Salt-killed Tundra	20	10	10.2	5.1	prefer
Deep Open Water without Islands	4	1	1.0	4.0	avoid
Deep Open Water with Islands or Polygonized Margins	5	2	2.0	1.6	ns
Shallow Open Water without Islands	0	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0	0.1	ns
River or Stream	150	47	48.0	14.1	prefer
Aquatic Sedge Marsh	0	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	8	5	5.1	2.7	ns
Aquatic Grass Marsh	0	0	0	0.2	ns
Young Basin Wetland Complex	0	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	0	<0.1	ns
Nonpatterned Wet Meadow	1	1	1.0	8.1	avoid
Patterned Wet Meadow	12	7	7.1	19.4	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.5	ns
Moist Tussock Tundra	0	0	0	0.5	ns
Riverine or Upland Shrub	2	1	1.0	4.8	avoid
Barrens	1	1	1.0	15.0	avoid
Artificial	0	0	0	<0.1	ns
TOTAL	256	98	100	100	

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

Appendix D3. Habitat use by Spectacled Eiders during nesting on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Johnson et al. 1999a, 2000b). Nests were found during ground searches of selected portions of the study area.

Habitat	No. of Nests[a]	Use (%)
NEST LOCATION		
Brackish Water	6	9.7
Tapped Lake with High-water Connection	1	1.6
Salt Marsh	1	1.6
Salt-killed Tundra	15	24.2
Deep Open Water with Islands or Polygonized Margins	3	4.8
Shallow Open Water without Islands	1	1.6
Aquatic Sedge with Deep Polygons	14	22.6
Nonpatterned Wet Meadow	10	16.1
Patterned Wet Meadow	11	17.4
TOTAL	62	100
NEAREST WATERBODY [b]		
Brackish Water	23	37.1
Tapped Lake with Low-water Connection	3	4.8
Tapped Lake with High-water Connection	6	9.7
Deep Open Water without Islands	4	6.5
Deep Open Water with Islands or Polygonized Margins	18	29.0
Shallow Open Water without Islands	4	6.5
Shallow Open Water with Islands or Polygonized Margins	3	4.8
River or Stream	1	1.6
TOTAL	62	100

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

Appendix D4. Habitat use by Spectacled Eiders and King Eiders during brood-rearing on the Colville River Delta, Alaska, 1983–2002 (pre-2000 data from unpublished data of M. North [1983 and 1984], and Johnson et al. 1999a). Broods were located during both aerial and ground surveys.

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

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

Appendix D5. Numbers and densities of Tundra Swan nests and broods during aerial surveys of the Colville River Delta, Alaska, 1992–2002. Density based on survey area of 551.4 km^2 (pre-2000 data from Johnson et al. 1999a).

	Nests		Broods		Mean Brood	Nest Success[a]
Year	No.	No./km²	No.	No./km²	Size	(%)
1992[b]	14	0.03	16	0.03	2.4	114
1993	20	0.04	14	0.03	2.6	70
1995	38	0.07	25	0.05	3.7	66
1996	45	0.08	32	0.06	3.4	71
1997	32	0.06	24	0.04	2.5	75
1998	31	0.06	22	0.04	2.4	71
2000	32	0.06	20	0.04	1.9	63
2001	27	0.05	22	0.04	1.7	81
2002	55	0.10	17	0.03	3.2	31
MEAN	33	0.06	21	0.04	2.7	65

[a] Estimated percent nest success = nests/broods x 100.

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

Appendix D6. Number of Tundra Swans, swan pairs, and nesting swans during June aerial surveys of the Colville River Delta, Alaska, 1992–2002. Densities based on a survey area of 551.4 km^2 (pre-2000 data from Johnson et al. 1999a).

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

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

Appendix D7. Habitat selection (pooled among years) by Tundra Swans during nesting and brood-rearing on the Colville River Delta, Alaska, 1992–2002 (pre-2000 data from Johnson et al. 1999a).

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

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

Appendix D8. Habitat selection (pooled among years) by Yellow-billed Loons during nesting and brood-rearing on the Colville River Delta, Alaska, 1993–2002 (pre-2000 data from Johnson et al. 1999a).

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.3	avoid
Tapped Lake with High-water Connection	11	8.9	5.4	ns
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	avoid
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water without Islands	9	7.3	5.5	ns
Deep Open Water with Islands or Polygonized Margins	31	25.2	1.8	prefer
Shallow Open Water without Islands	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	1	0.8	<0.1	ns
Aquatic Sedge with Deep Polygons	6	4.9	2.9	ns
Aquatic Grass Marsh	1	0.8	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	17	13.8	8.7	ns
Patterned Wet Meadow	47	38.2	24.7	prefer
Moist Sedge–Shrub Meadow	0	0	3.5	avoid
Moist Tussock Tundra	0	0	0.7	ns
Riverine or Upland Shrub	0	0	6.5	avoid
Barrens	0	0	12.2	avoid
Artificial	0	0	<0.1	ns
TOTAL	123	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.3	ns
Tapped Lake with High-water Connection	10	21.7	5.4	prefer
Salt Marsh	0	0	2.6	ns
Tidal Flat	0	0	3.6	ns
Salt-killed Tundra	0	0	4.2	ns
Deep Open Water without Islands	27	58.7	5.5	prefer
Deep Open Water with Islands or Polygonized Margins	9	19.6	1.8	prefer
Shallow Open Water without Islands	0	0	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.6	avoid
Aquatic Sedge Marsh	0	0	<0.1	ns
Aquatic Sedge with Deep Polygons	0	0	2.9	ns
Aquatic Grass Marsh	0	0	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	0	0	8.7	avoid
Patterned Wet Meadow	0	0	24.7	avoid
Moist Sedge–Shrub Meadow	0	0	3.5	ns
Moist Tussock Tundra	0	0	0.7	ns
Riverine or Upland Shrub	0	0	6.5	ns
Barrens	0	0	12.2	avoid
Artificial	0	0	<0.1	ns
Total	46	100	100	

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

Appendix D9. Habitat selection by Greater White-fronted Geese during nesting in the CD South ground-search area, Colville River Delta, Alaska, 2000–2002.

Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Tapped Lake with Low-water Connection	0	0	<0.1	ns
Tapped Lake with High-water Connection	0	0	6.8	avoid
Salt Marsh	0	0	1.9	ns
Deep Open Water without Islands	0	0	2.6	ns
Deep Open Water with Islands or Polygonized Margins	0	0	5.0	avoid
Shallow Open Water without Islands	0	0	0.2	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
Aquatic Sedge with Deep Polygons	0	0	0.2	ns
Aquatic Grass Marsh	0	0	0.5	ns
Nonpatterned Wet Meadow	2	1.8	4.2	ns
Patterned Wet Meadow	76	69.1	40.7	prefer
Moist Sedge–Shrub Meadow	28	25.5	22.6	ns
Riverine or Upland Shrub	4	3.6	12.5	avoid
Barrens	0	0	2.8	ns
TOTAL	110	100.0	100.0	

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