WILDLIFE STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2004

SECOND ANNUAL REPORT

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INTRODUCTION

During 2004, ABR, Inc., conducted wildlife surveys for selected birds and mammals in the Colville River Delta and adjacent Northeast Planning Area of the National Petroleum Reserve—Alaska (NPRA) in support of the Alpine Satellite Development Project of ConocoPhillips, Alaska, Inc. (CPAI). The wildlife studies in 2004 were a continuation of work initiated by CPAI's predecessors, ARCO Alaska, Inc., and Phillips Alaska, Inc., in the Colville River Delta in 1992 (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b, 2000a, 2000b, 2001, 2002, 2003a, 2003b, 2004; Burgess et al. 2000, 2002a, 2003a; Lawhead 1999; Lawhead and Johnson 2000; Lawhead and Prichard 2001, 2002, 2003a) and in the northeastern NPRA in 1999 (Anderson and Johnson 1999; Murphy and Stickney 2000; Johnson and Stickney 2001; Burgess et al. 2002b, 2003b, Johnson et al. 2004). The Colville River Delta and NPRA studies augment long-term wildlife monitoring programs that have been conducted by CPAI (and its predecessors) across large areas of the central Arctic Coastal Plain since the early 1980s (see Murphy and Anderson 1993, Stickney et al. 1993, Anderson et al. 2004, Lawhead and Prichard 2003b).

The primary goal of wildlife investigations in the region since 1992 has been to describe the distribution and abundance of selected species before, during, and after construction of oil development projects. Baseline information on wildlife also is required for the permitting of development projects and, as development plans have expanded westward, wildlife survey areas also have expanded to establish pre-development baselines and to evaluate construction and operations impacts of oil development on wildlife populations. We report here the results of wildlife surveys in 2004 that were conducted in the Colville River Delta and adjacent NPRA where CPAI currently proposes oil and gas development sites (the Alpine Satellite Development Project [ASDP] [BLM 2004]): CD-3 (Fiord or CD North prospect), CD-4 (Nanuq or CD South), CD-5 (Alpine West), CD-6 (Lookout), and CD-7 (Spark) (Figure 1). Only 2004 data on the distribution and abundance of wildlife species are presented herein. Readers are directed to prior reports for background, distribution, and abundance information from previous years. Habitat selection analyses are presented for key focal species only and are based on observations from all available years of comparable data (since 1992 for some species in the Colville River Delta and since 2001 in the NPRA).

In addition to wildlife surveys, ecological land surveys (ELS) were conducted on the Colville River Delta (Jorgenson et al. 1997) and in the northeastern NPRA (Jorgenson et al. 2003, 2004) to allow integration of ecological information with project engineering approaches. The ELS described terrain units (surficial geology, geomorphology), surface forms (primarily ice-related features), and vegetation through the region and was used to develop a GIS (Geographic Information System) map of wildlife habitats. The ELS and derived habitat maps are used in this investigation to assess habitat use and habitat selection (or preferences) of wildlife species. ELS methodologies and derivation of the habitat map are presented in previous reports (Jorgenson et al. 1997, 2003, 2004; Johnson et al. 1997).

Wildlife study objectives and scopes were developed and study progress was reported through a series of agency and community scoping and planning meetings, including

- 7 March 2001—presented proposed study program to the Bureau of Land Management (BLM) and the interim Research and Monitoring Team (RMT) in Fairbanks
- 8 May 2001—met with the Kuukpik Subsistence Oversight Panel (KSOP) in Nuiqsut to discuss NPRA exploration and pre–development baseline study program
- 12 June 2001—met with BLM Subsistence Advisory Panel concerning NPRA development and summer studies
- 9 July 2001—met with KSOP concerning NPRA development and summer studies
- 16 July 2001—met with BLM Fairbanks personnel concerning NPRA issues
- 16 August 2001—met with BLM Subsistence Advisory Panel concerning NPRA development and summer studies

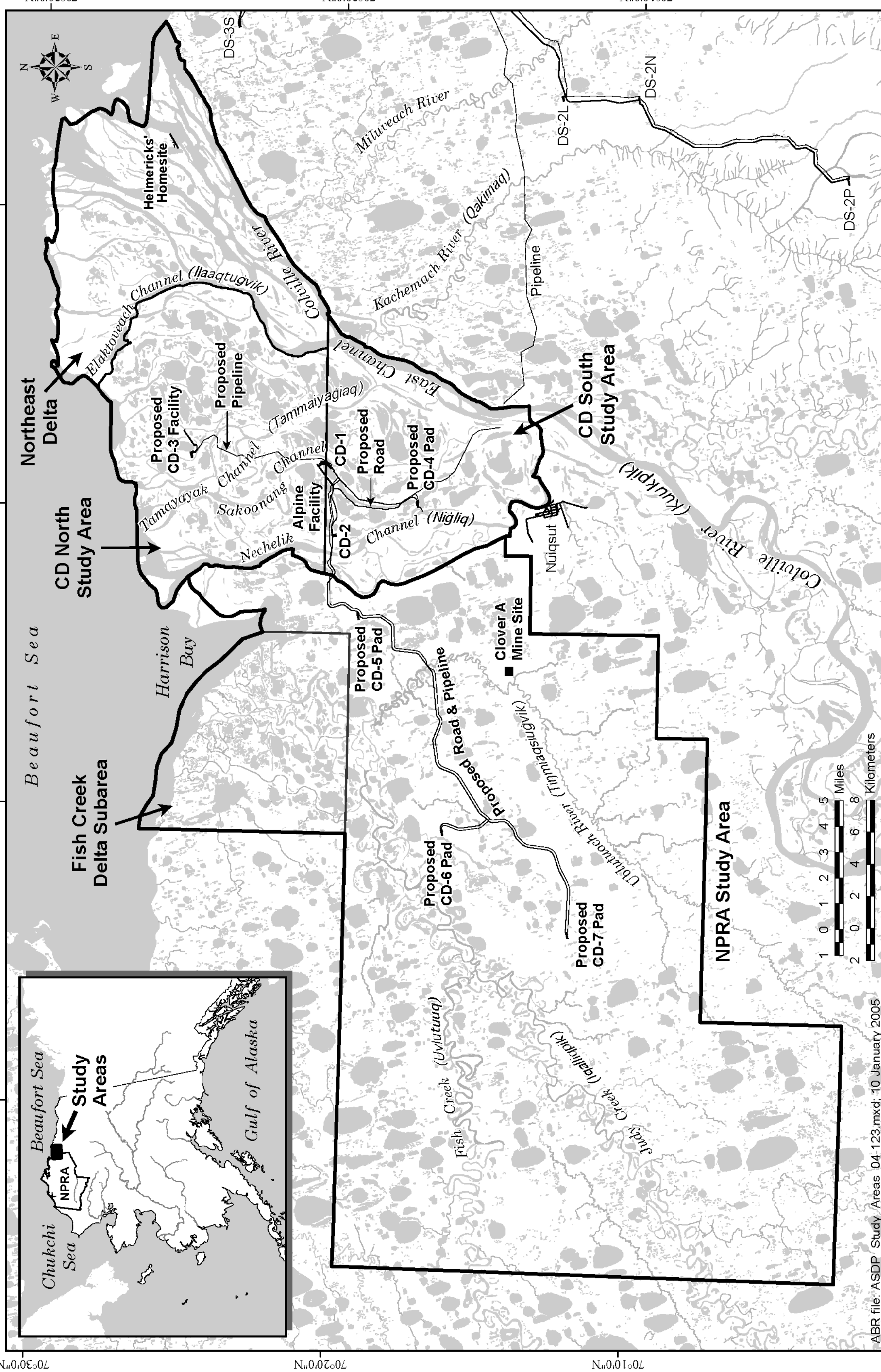

Figure 1. Wildlife study areas for the Alpine Satellite Development Project, northern Alaska, 2004.

- 28 & 29 August 2001—met with regulatory agencies in Anchorage and Fairbanks concerning plans for 2001/2002 winter exploration program
- 10 October 2001—presentation to BLM's official RMT on progress of summer studies in the NPRA
- 17 October 2001—met with BLM to discuss preliminary development plans
- 13 December 2001 and 6 June 2002—met with BLM Subsistence Advisory Panel concerning NPRA development and summer studies
- 5 March 2002—met with USFWS, Wildlife Conservation Society, and BP Exploration Alaska, Inc. to design collaborative study on tundra nesting birds
- 2 May 2002—met with KSOP to discuss 2001 study results and plans for 2002 studies in the NPRA
- 23 October 2002—met with BLM to discuss the status of environmental studies conducted through summer 2002 in the NPRA and proposed studies for 2003
- 27–28 January 2003—presented results of previous studies to regulatory agencies, Kuukpik Corporation representative, and BLM's EIS consultant during pre-scoping meeting for ASDP environmental impact statement preparation
- 18 February 2003—publication of the Notice of Intent for the Alpine Satellite Development Plan Environmental Impact Statement (ASDP EIS)
- 5 March 2003—presented results of NPRA and Colville avian studies to members of the North Slope Borough Fish and Game Management Committee
- 30 April 2003—formal request was made to the USFWS for a list of threatened and endangered species in the ASDP area
- 15 May 2003—met with KSOP and residents of Nuiqsut to discuss findings from past environmental studies and plans for 2003 studies
- 27 May 2003—formal response of the USFWS to the request for a list of species was issued
- 21 May 2003—presented plans for summer 2003 environmental studies program to Kuukpik Board of Directors
- 26–27 June 2003—provided a tour of the Alpine facilities to the North Slope Borough Planning Commission
- 17–20 August 2003—provided a tour of proposed satellite facilities to agency members
- 29 September 2003— permit pre-application meeting for ASDP EIS in Fairbanks in Anchorage
- 14 October 2003—permit pre-application meeting for ASDP EIS in Fairbanks
- 20 October 2003—met with Kuukpik Board of Directors to discuss findings of environmental studies
- 18–20 November 2003—a workshop on arctic cisco was convened in Nuiqsut by Minerals Management Service
- 2 February 2004—permit post-application meeting for ADSP EIS in Anchorage
- 12 May 2004—met with Kuukpik Board of Directors and presented findings of 2003 environmental studies and plans for 2004 summer studies
- 18 May 2004—met with KSOP and residents of Nuiqsut to present plans for summer 2004 environmental studies program
- 26 May 2004—met with agencies to present update on ASDP and summer 2004 environmental studies program
- 27 May 2004—USFWS received the biological assessment and the request for formal consultation under section 7 of the Endangered Species Act from BLM
- 28 September 2004—biological opinion on Spectacled and Steller's eiders was issued
- 8 November 2004—Record of Decision for the ASDP EIS was issued.

To facilitate public involvement in development planning and to ensure that interested parties were kept well informed, the wildlife surveys were planned with input from North Slope Borough (NSB), state and federal agencies, and Nuiqsut residents. On 8 May 2001, CPAI held a science fair in Nuiqsut to discuss exploration and development in the NPRA, as well as the environmental studies scheduled for 2001. On 9 May 2001, CPAI and ABR scientists met with Nuiqsut elders to discuss NPRA activities and solicit input on traditional use areas. Input from these meetings was used to optimize survey schedules and to avoid conflict with subsistence activities in the area. In addition, CPAI published "NPRA Update," a newsletter on NPRA activities, as an insert in the “Arctic Sounder” newspaper each year since December 2001. The newsletter discussed summer field studies, subsistence representatives and ice-road monitors, public meetings, and other information. On 15 May 2003, an open house was held in Nuiqsut to allow residents to visit with CPAI biologists and other scientists to discuss information on and concerns for resources in the Delta and NPRA areas. Mark Ahmakak and Doreen Nukapigak, representing the KSOP, participated in wildlife surveys in 2003, and Mark participated again in 2004. In September 2003, two groups of Nuiqsut elders were flown to the proposed 2004 exploration sites and CPAI study locations to solicit their input on potential issues associated with development or exploration activities. In 2003, CPAI visited subsistence cabins with Joeb Woods and Ruth Nukapigak. Presentations on birds and caribou were given by ABR biologists to Nuiqsut residents on 8 and 14 July 2004 to provide current information from ongoing studies and to provide a forum for residents to share their knowledge and concerns with biologists. CPAI provided KSOP executive director Cornelia Sovalik and chairman Leonard Lampe on 29 July 2004 with equipment to be used by KSOP field representatives. This equipment included GPS units, digital cameras, and ground-to-air radios. The primary purpose for the ground-to-air radios was for subsistence hunters to contact aircraft pilots (primarily in helicopters) when aircraft potentially could interfere with subsistence hunting.

Wildlife species were selected by CPAI and ABR for investigation using the following criteria (these criteria were endorsed first by the U.S. Fish and Wildlife Service [USFWS] and later by the BLM in pre-application meetings, beginning in 1992) to identify species of interest: 1) threatened or sensitive status (Spectacled and Steller’s eiders), 2) suspicion of declining populations (King Eiders), 3) restricted breeding range (Yellow-billed Loons), 4) concern of regulatory agencies for development impacts (Brant, Tundra Swans, shorebirds, and passerines), 5) nest predators (foxes and Glaucous Gulls), or 6) subsistence species (caribou and geese). During surveys, additional information was collected opportunistically on Pacific Loons, Red-throated Loons, Sabine’s Gulls, Arctic Terns, muskoxen, brown (grizzly) bears, and other mammals (common and scientific names of wildlife are listed in Appendix A). Additional studies on the use of the proposed development area by grizzly bears were conducted for CPAI by the Alaska Department of Fish and Game (ADFG) in 2002–2004. CPAI also supported the Polar Bear Conservation Program (U.S. Geological Survey) in its efforts to capture, mark, and monitor polar bears in the central Beaufort Sea. Data on den locations for polar and grizzly bears are used by CPAI to avoid den areas during winter exploration and ice-road construction.

Surveys in the Colville River Delta and in the northeastern NPRA in 2004 were designed to provide baseline information on the distribution, abundance, and habitat use of 8 focal species: Spectacled Eider, King Eider, Tundra Swan, Yellow-billed Loon, Glaucous Gull, caribou, and arctic and red foxes. In addition to these focal species, surveys were conducted to collect information on geese during brood-rearing and fall staging (because of their importance as subsistence species) and on nesting shorebirds and passerines (the most abundant nesting birds in the region). Studies on shorebirds and passerines are part of a region-wide collaborative study (with USFWS, Wildlife Conservation Society, Manomet Center for Conservation Sciences, and BP Exploration [Alaska], Inc.) on factors affecting nesting success of tundra-nesting birds. Required state and federal permits were obtained for authorized survey activities, including a Scientific and Educational

Permit (Permit Nos. 04-087 and 04-096) from ADFG and a Federal Fish and Wildlife Permit—Threatened and Endangered Species (Permit No. TE012155-0). The 2004 surveys are detailed in Table 1 (avian surveys) and Table 2 (mammal surveys) and described individually in methods. Results for birds and mammals are summarized by focal species (i.e., species accounts), except for the results of ground-based searches, which describe differences in avian communities between specific areas. The focal species accounts incorporate nesting and habitat use data from ground searches with data from aerial surveys for an integrated discussion of seasonal abundance, distribution, and habitat use for each species.

Six specific objectives were identified for wildlife surveys in the Colville River Delta and northeastern NPRA in 2004:

1. describe the distribution, abundance, and productivity of selected species of waterfowl, loons, and gulls;
2. calculate nest density, nesting success, and habitat use of shorebirds and passerines in representative portions of the study area;
3. evaluate habitat use and habitat preferences of key wildlife species, using the habitat classification and maps of Jorgenson et al. (1997, 2003, 2004);
4. describe the distribution and abundance of caribou during the pre-calving, calving, and post-calving periods and during late summer and fall;
5. document the distribution, abundance, and occupancy of fox dens and the production of young foxes; and
6. record the locations and numbers of muskoxen, grizzly bears, and other mammals encountered opportunistically during surveys.

STUDY AREA

The place names used throughout this report are those depicted on U.S. Geological Survey (USGS) 1:63,360-scale topographic maps, because they are the most widely available published maps of the region. The corresponding local Iñupiaq names for drainages also are provided in parentheses at the first usage in text and on the study area maps (see Figures 1). Iñupiaq names are presented out of respect for local residents, to facilitate clear communication with Iñupiaq speakers, and because they pre-date the English names used on USGS maps. We acknowledge that the Iñupiaq names presented are not comprehensive and we understand that the published USGS names for some streams (notably the Ublutuoch and Tingmeachsiovik rivers) do not correctly reflect local usage. The Iñupiaq names we use for Fish and Judy creeks in northeastern NPRA are taken from the *Iñupiat–English Map of the North Slope Borough* (NSB Planning Department, Barrow, Alaska, May 1997). Additional information was supplied to CPAI in recent years by Nuiqsut elders. Ruth Nukapigak and Sarah Kunaknana provided the name of Ulamniġiaq channel (Figure 4), which is not named on USGS maps, on the outer Colville River Delta (S. Geddes, CPAI, pers. comm.). Even in cases where USGS attempted to use the correct Iñupiaq names, the anglicized spellings are outdated and so have been corrected to the modern Iñupiaq spellings through consultation with Emily Ipalook Wilson and Dr. Lawrence Kaplan of the Alaska Native Language Center (ANLC) at the University of Alaska Fairbanks. Marjorie Kasak Ahnupkanna and Archie Ahkiviana were consulted to confirm the names of other channels on the Colville River Delta (E. Wilson, ANLC, pers. comm.). Efforts to update Iñupiaq names on maps of the study area are ongoing.

The climate in the region is arctic maritime (Walker and Morgan 1964). Winter lasts ~8 months and is cold and windy. The thaw period lasts only about 90 days during summer (1 June–31 August) and the mean summer air temperature is 5º C (43º F; Kuparuk Oilfield records: National Oceanic and Atmospheric Administration, unpubl. data), ranging from –10° C in mid-May to +15° C in July and August (North 1986), with a strong gradient of increasing temperatures with increasing distance from the coast. Mean summer precipitation is under 8 cm, most of which falls as rain in August. The soils are cold and underlain by permafrost, and temperature of the active layer of thawed soil above permafrost ranges from 0º to 10º C (32º–50º F) during the growing season. Spring is brief,

Table 1. Avian surveys conducted in the CD North, CD South, and NPRA study areas, Alaska, 2004.

SURVEY METHOD Survey Type	Season	Survey Dates: CD North and CD South	Survey Dates: NPRA	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
LARGE WATERBIRD GROUND-SEARCHES[b]								
Pad search areas[c]	Nesting	19–30 June	15–27 June	–	–	–	–	CD-3=18.0 km²; NPRA sites=23.9 km²
	Brood-rearing	15–18 July	13–18 July	–	–	–	–	Includes loon nest search
	Brood-rearing	24–25 August	–	–	–	–	–	Primarily for loons in CD North
NPRA road corridors	Nesting	–	15–27, 30 June	–	–	–	–	
	Brood-rearing	–	13–18 July					Includes loon nest search
NPRA BREEDING-BIRD PLOTS[d]	Nesting	–	5 June–15 July	–	–	–	–	24 plots (2.4 km² total)
AERIAL SURVEYS[e, f]								
Eider surveys	Pre-nesting	14–15 June	–	C185	0.4	0.4–0.8	30–35	50–100% coverage
	Pre-nesting	–	11, 15 June	C185	0.4	0.8	30–35	50% coverage
Yellow-billed Loon surveys[g]	Nesting	23 June	23–25 June	206L	–	–	60	All lakes ≥10 ha
	Brood-rearing	21 August	21–23 August	206L	–	–	60	Lakes with nests
Tundra Swan surveys	Nesting	21–23 June	22–24 June	C206	1.6	1.6	150	100% coverage
	Brood-rearing	19-23 August	20–25 August	C206	1.6	1.6	150	100% coverage
Goose surveys	Brood-rearing	–	27–28 July	C185	0.8	1.6	90	50% coverage
	Fall staging	–	24–25 August	C206	0.8	1.6	90	50% coverage

[a] C185 = Cessna 185 fixed-wing airplane; C206 = Cessna 206 fixed-wing airplane; PA18 = Piper "Super Cub" fixed-wing airplane; 206L = Bell "Long Ranger" helicopter
[b] Large waterbirds included loons and grebes, waterfowl, gulls, terns, jaegers, ptarmigan, and large shorebirds (Whimbrel, Bar-tailed Godwit, and Wilson's Snipe)
[c] Large waterbird ground-searches were conducted in the pad areas at CD-3, but not in CD-4
[d] Nest searches included all avian species, but plot design targeted shorebirds and passerines
[e] Each aerial survey covered all or most of the 2003 CRD and NPRA study areas; see text for details on aerial survey coverage
[f] Glaucous Gull nests were recorded during surveys for Yellow-billed Loons and Tundra Swans
[g] Pacific and Red-throated loons and colonies of Sabine's Gulls were recorded incidentally

Table 2. Mammal surveys conducted in the NPRA and Colville River Delta[a] survey areas, Alaska, 2004.

SURVEY TYPE Season	Survey Area	Date	Aircraft[b]	Transect Strip Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Area Sampled (km^2)[c]
CARIBOU STRIP-TRANSECTS							
Pre-calving	NPRA	18 May	C206	1.6	3.2	150	654
Insect season	NPRA	25 June	C206	1.6	3.2	150	654
Insect season	Delta	25 June	C206	1.6	3.2	150	247
Insect season	NPRA	10 August	C206	1.6	3.2	150	654
Insect season	Delta	11 August	C206	1.6	3.2	150	247
Fall	NPRA	15 September	C206	1.6	3.2	150	654
Fall	NPRA	18 October	C206	1.6	3.2	150	654
FOX DEN STATUS CHECK							
Denning	Delta	28–29 June	206L	–	–	60–90	–
Denning	NPRA	29–30 June	206L	–	–	60–90	–
FOX DEN OBSERVATIONS[d]							
Denning		9–12 July	206L	–	–	–	–

[a] The Colville River Delta comprises the CD North and CD South study areas and the northeast delta
[b] C206 = Cessna 206 fixed-wing airplane; 206L = Bell “Long Ranger” helicopter
[c] 50% coverage of 1,310-km² survey area in NPRA and 494-km² survey area on Colville River Delta
[d] Principally ground-based observations that relied on helicopter access

lasting ~3 weeks in late May and early June, and is characterized by the flooding and breakup of rivers. In late May, water from melting snow flows both over and under the ice on the Colville River, resulting in flooding on the delta 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 weather is characterized by low precipitation, overcast skies, fog, and persistent, predominantly northeast winds. The less common westerly winds often bring storms that are accompanied by high wind-driven tides and rain (Walker and Morgan 1964). Summer fog is more common in coastal areas and on the delta than it is in the more inland NPRA study area.

Wildlife surveys were conducted in the Colville River Delta and in the NPRA study area (Figure 1). The Colville River Delta was delineated for aerial survey purposes into 3 areas based on potential development scenarios: the CD North and CD South study areas, and the northeastern delta. The Colville River Delta (or Colville Delta) includes the Alpine Development (CD-1 and CD-2, at present, the only producing oilfield on the Colville Delta) and 2 proposed development sites, CD-3 and CD-4 (located in the CD North and CD South study areas, respectively). The CD-3 development is proposed as a roadless development that would be accessed via a landing strip (see BLM 2004 for complete descriptions and maps of these sites). A road is proposed to connect the CD-4 development to the Alpine Development, and the entire road corridor was included in the CD South study area. The NPRA study area includes 4 proposed development sites, CD-5, CD-6, CD-7, and Clover A (potential gravel mine site). A proposed road connects these 3 proposed pads and also connects the CD-5 pad to the Alpine Development at CD-2.

COLVILLE RIVER DELTA

As used in this report, the Colville Delta (552 km²) comprises the CD North and CD South study areas and the northeastern delta, an area that was included in some aerial surveys (Figure 1). Together these 3 areas encompass the entire delta from the east bank of the East Channel to the west bank of the westernmost distributary of the Nechelik (Niġliq) Channel and inland to the juncture of these channels. The Colville Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. Two permanent human settlements occur on the Colville Delta—the Iñupiat village of Nuiqsut and the Helmericks' family home site. Both rely heavily on the abundant fish and wildlife resources.

The Colville River (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 Colville have created a large, dynamic delta system, which includes a diversity of lakes and aquatic and terrestrial habitats. The Colville River has 2 main distributaries in the delta, the Nechelik Channel and the East Channel (Figure 1). 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, Tamayayak (Tammaiyaġiaq), Nechelik, and other channels are shallow in places and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta's channels, with the depth of the river at freeze-up being the main factor determining the inland extent of this intrusion (Walker 1983). For its entire length, the Colville River flows through land that is underlain by continuous permafrost. This extensive permafrost, combined with freezing of the upper layer of surface water in winter, influences the volume, timing, and character of river flow and erosion within the delta (Walker 1983).

Landforms, vegetation, and wildlife habitats in the Colville Delta were described in the Ecological Land Survey (Jorgenson et al. 1997), and the resulting habitat map was updated in 2004 to unify it with similar mapping of the surrounding Coastal Plain (Figure 2). Three new habitats were identified on the Colville Delta for a total of 27 habitats, and 5 others were renamed in 2004 (Table 3). The 3 new habitats were Moist Halophytic Shrub, which was formerly a constituent of Salt Marsh, and Moist Low Shrub and Dry Dwarf Shrub, both of which were formerly combined into Riverine or Upland Shrub. Tidal Flat was renamed Tidal Flat Barrens, Aquatic Sedge Marsh and Aquatic Grass Marsh were simplified to Sedge Marsh and Grass Marsh, Aquatic Sedge with Deep Polygons is now Deep Polygon Complex, and Artificial was renamed Human Modified. The definition and composition of each renamed habitat are unchanged from the previous classification (see Appendix B for all habitat descriptions).

Coastal and riverine landforms dominate the delta. Fluvial processes predominate, although eolian and ice-aggradation processes are important to landscape development, as are lacustrine and basin-drainage processes. Of the 27 wildlife habitat types identified on the delta, 4 habitats are clearly dominant (Figure 2, Table 3): Patterned Wet Meadow (19% of the entire delta), River or Stream (15%), Barrens (14%), and Tidal Flat Barrens (11%). No other habitats comprised more than 8% of the delta. Four habitats occur only in trace amounts (<0.1%) and an additional 6 habitats each occupied <1% of the total area. Aquatic habitats are a major component of the delta, comprising 32% of the total delta. Coastal salt-affected habitats—Tidal Flat Barrens, Salt-killed Tundra, Salt Marsh, Moist Halophytic Dwarf Shrub, Open Nearshore Water, and Brackish Water—together comprise 21% of the total area and contribute greatly to avian biodiversity. Tapped lakes (Tapped Lake with Low-water Connection and Tapped Lake with High-water Connection) are unique to the delta environment and also are important to the physical and biological diversity of the delta, although they occupy slightly less than 8% of the total area. Other important habitats for birds are those that contain emergent aquatic vegetation (Deep Polygon Complex, Grass Marsh, and Sedge Marsh) and waterbodies with islands and polygonized margins (Deep Open Water with Islands or Polygonized Margins and Shallow Open Water with Islands or Polygonized Margins),

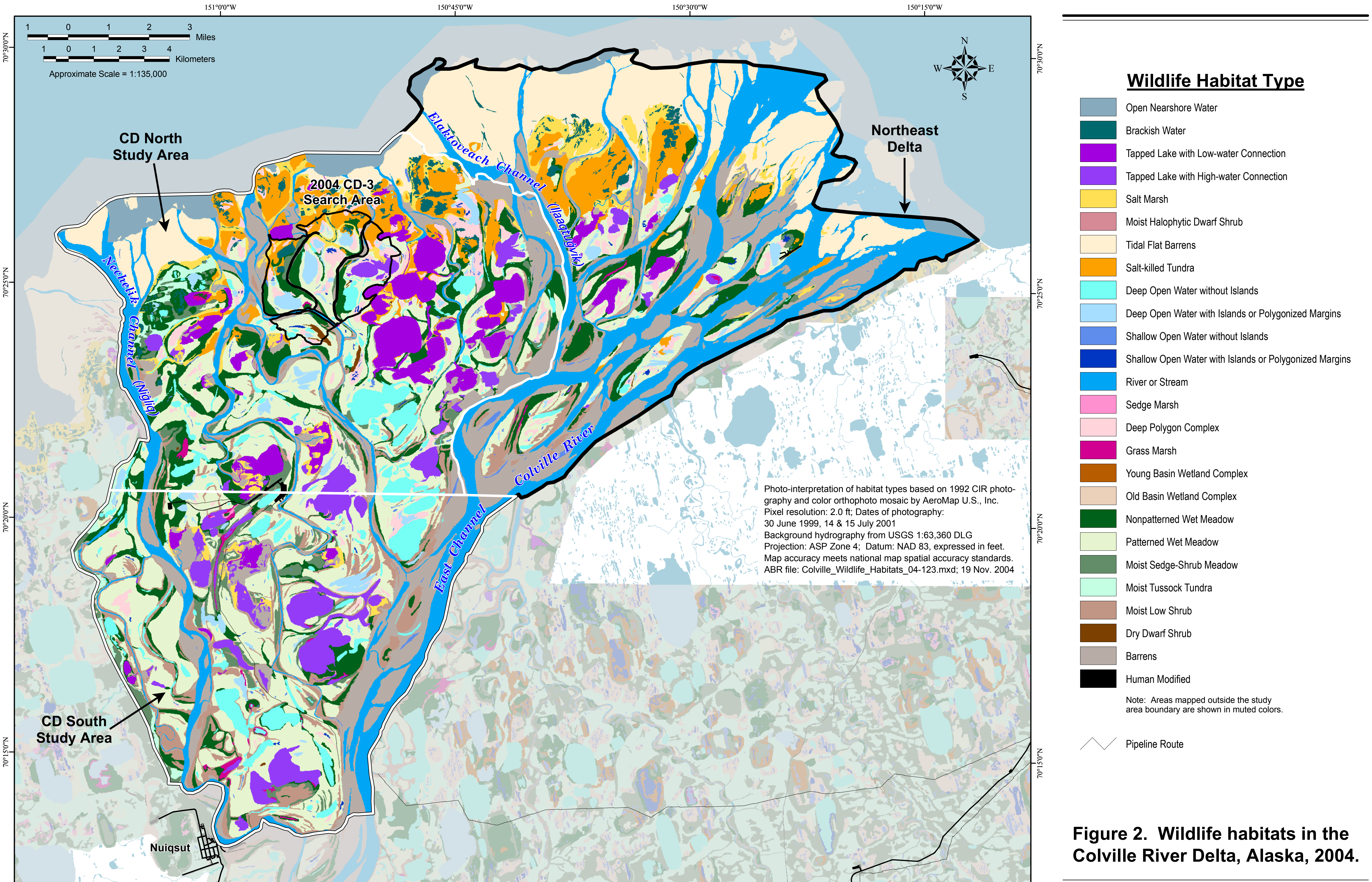

Figure 2. Wildlife habitats in the Colville River Delta, Alaska, 2004.

Table 3. Habitat availability in the Colville River Delta[a] and NPRA study area, Alaska, 2004.

	Colville River Delta		NPRA Study Area	
Habitat	Area (km²)	Availability (%)	Area (km²)	Availability (%)
Open Nearshore Water	10.12	1.8	22.32	2.7
Brackish Water	6.55	1.2	9.46	1.1
Tapped Lake with Low-water Connection	21.73	3.9	8.47	1.0
Tapped Lake with High-water Connection	20.77	3.8	2.55	0.3
Salt Marsh	16.31	3.0	16.51	2.0
Moist Halophytic Dwarf Shrub	0.14	<0.1	0.44	0.1
Dry Halophytic Meadow	0	0	0.21	<0.1
Tidal Flat Barrens	58.42	10.6	16.63	2.0
Salt-killed Tundra	25.63	4.6	6.49	0.8
Deep Open Water without Islands	20.72	3.8	50.59	6.1
Deep Open Water with Islands or Polygonized Margins	7.78	1.4	42.13	5.1
Shallow Open Water without Islands	2.01	0.4	7.76	0.9
Shallow Open Water with Islands or Polygonized Margins	0.56	0.1	13.24	1.6
River or Stream	82.79	15.0	10.28	1.2
Sedge Marsh	0.13	<0.1	13.52	1.6
Deep Polygon Complex	13.18	2.4	0.35	<0.1
Grass Marsh	1.44	0.3	2.47	0.3
Young Basin Wetland Complex	<0.01	<0.1	2.66	0.3
Old Basin Wetland Complex	0.14	<0.1	63.90	7.7
Riverine Complex	0	0	2.81	0.3
Dune Complex	0	0	8.07	1.0
Nonpatterned Wet Meadow	41.54	7.5	24.21	2.9
Patterned Wet Meadow	102.58	18.6	90.09	10.9
Moist Sedge–Shrub Meadow	12.29	2.2	172.93	20.9
Moist Tussock Tundra	3.24	0.6	203.83	24.7
Moist Tall Shrub	0	0	1.02	0.1
Moist Low Shrub	27.12	4.9	10.68	1.3
Moist Dwarf Shrub	0	0	4.77	0.6
Dry Tall Shrub	0	0	1.71	0.2
Dry Dwarf Shrub	0.47	0.1	7.25	0.9
Barrens	76.11	13.8	8.66	1.0
Human Modified	0.41	0.1	0	0
Subtotal (total mapped area)	552.19	100	826.03	100.0
Unknown (unmapped areas)	0		404.68	
Total	552.19		1,230.72	

[a] The Colville River Delta comprises the CD North and CD South study areas and the northeast delta

which account for a combined total of <5% of the delta. A strong north-south gradient occurs across the delta in the distribution of many of these habitats, with coastal habitats, Tapped Lakes with Low-water Connections, Deep Polygon Complex, and Nonpatterned Wet Meadow decreasing in abundance with increasing distance from the coast, whereas Tapped Lakes with High-water Connections, Sedge Marsh, Grass Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadow, and the non-halophytic shrub types are more prevalent away from the coast. These patterns of habitat distribution have strong effects on the distribution and abundance of various wildlife species in the delta.

As mentioned above, lakes and ponds are dominant physical features of the Colville 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. Lakes >5 ha in size cover 16% of the delta's surface (Walker 1978) and some of these lakes are deep (to 10 m), freezing only in the upper 2 m during winter and retaining floating ice until the first half of July (Walker 1978). Several other types of lakes occur on the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, thaw lakes, and tapped lakes (Walker 1983). Tapped lakes 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 Colville Delta supports a wide variety 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 highly variable numbers of 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. Grizzly (brown) bears occur regularly, and the delta has been used occasionally for denning by brown bears and less often by polar bears (see reviews in BLM 2004 and Johnson et al. 1999).

NPRA STUDY AREA

The 2004 NPRA study area (1,231 km²) abuts the western edge of the Colville Delta and encompasses 6 exploratory sites that were drilled during winter 1999–2000 and 2000–2001 (Clover A, Lookout 1, Spark 1A, Rendezvous A, Rendezvous 2, and Moose's Tooth C; see Figure 1 in Burgess et al. 2002b) and 4 proposed development sites (CD-5, CD-6, and CD-7 and the Clover A gravel mine site; Figure 1), which are part of the ASDP. The NPRA study area and the included ASDP development sites are located in the northeastern section of the NPRA, 6–39 km west of the village of Nuiqsut and 1–43 km west and southwest of the Alpine facilities (Figure 1). A proposed road and pipeline links the 3 proposed pad sites with the existing Alpine facilities on the Colville Delta (BLM 2004). In 2004, the study area was expanded northward in its easternmost corner to encompass what is known as the Fish Creek Delta (Figure 1), to provide data on wildlife and an ecological land classification (Jorgenson et al. 2004) for oil spill contingency planning. The ELS for NPRA was updated in 2004 for the expansion of the map to the Fish Creek Delta (Jorgenson et al. 2004), and the habitat classification was updated so that the NPRA and Colville Delta could be merged with similar mapping of the surrounding area.

Three major streams flow through the NPRA study area (Figure 1). On USGS topographic maps (Harrison Bay 1:63,360 series, 1955), these drainages are labeled as Fish Creek, Judy Creek, and the Ublutuoch River, but are commonly known by other names by Iñupiat residents: Fish Creek is called Uvlutuuq, Judy Creek is called Iqalliqpik, and the Ublutuoch River is called Tiŋmiaqsiuġvik (Figure 1).

Landforms, vegetation, and wildlife habitats in the northeastern NPRA were described in the recent Environmental Impact Statement for the lease area (BLM 1998) and in the Ecological Land Survey (ELS; Jorgenson et al. 2003, 2004) and are similar to those of the Colville Delta, western Kuparuk Oilfield and the Alpine Transportation Corridor (Johnson et al. 1997, Jorgenson et al. 1997). Coastal plain and riverine landforms dominate the northeastern section of the NPRA. Coastal landforms also are present but limited to northeast corner of the study area (i.e., the Fish Creek Delta; Figure 1). On the coastal plain, lacustrine processes, basin drainage, and ice aggradation are the primary geomorphic factors that modify the landscape. In riverine areas along Fish and Judy creeks, fluvial processes predominate, although eolian and ice-aggradation processes also contribute to ecological development (Jorgenson et al. 2003).

Of the 31 wildlife habitats identified in the NPRA study area (based on vegetation, surface form, and geomorphology), 7 were newly defined and 4 were renamed (Figure 3, Table 3). New habitats were Moist Halophytic Dwarf Shrub, Dry Halophytic Meadow (formerly partially vegetated areas in Tidal Flat Barrens), and 5 shrub types which were formerly grouped by physiographic associations—Moist Tall Shrub, Moist Low Shrub, Moist Dwarf Shrub, Dry Tall Shrub, and Dry Dwarf Shrub. The habitats that were renamed in NPRA were the same ones renamed on the Colville Delta, above. Three habitats dominated the NPRA landscape: Moist Tussock Tundra (25% of area), Moist Sedge–Shrub Meadow (21%), and Patterned Wet Meadow (11%; Table 3). Two habitats occurred only in trace amounts (<0.1%), and another 11 habitats each occupied <1% of total area. Aquatic habitats comprised 23% of the study area. Although the NPRA study area includes some coastal habitats with the addition of the Fish Creek Delta, they are much less abundant than in the adjacent Colville Delta (Table 3). Riparian habitats also are much less common in the NPRA than they are on the Colville Delta. Other habitats appear to be distributed throughout the study area with no discernable north-south gradient in the occurrence of habitat types.

Like the Colville Delta, the NPRA also is an important area for wildlife and for subsistence harvest. The northeastern NPRA supports a wide array of wildlife, providing breeding habitat for geese, swans, passerines, shorebirds, gulls, and predatory birds, such as jaegers and owls. The Fish Creek and Judy Creek drainages in the NPRA study area are a regionally important nesting area for Yellow-billed Loons, annually supporting a larger number of nesting pairs than does the Colville Delta (Burgess et al. 2003b, Johnson 2004). The NPRA study area is used by caribou from 2 adjacent herds: the Teshekpuk Herd, primarily, and the Central Arctic Herd, secondarily (BLM 1998, Prichard et al. 2001, Arthur and Del Vecchio 2003).

METHODS

LARGE WATERBIRD GROUND-SEARCHES

PAD SITES

In 2004, search areas (defined as areas where intensive ground-based surveys were conducted for nests and broods) were centered on each of 4 proposed pad sites: CD-3, CD-5, CD-6, and CD-7. The CD-4 pad site was not searched in 2004. To reduce disturbance of nesting birds, the study plan developed with USFWS consultation included the contingency for searching the CD-4 area on the ground for nests only if Spectacled Eiders or Steller's Eiders were observed there during pre-nesting aerial surveys. Because Spectacled Eiders were not observed in the CD-4 vicinity during the pre-nesting aerial survey, and because previous studies (Burgess et al. 2000, 2002a, 2003a) were judged to have provided adequate baseline data on the distribution and abundance of nesting birds in that area, ground surveys were not conducted in 2004.

The CD-3 search area, located within the larger CD North study area on the Colville Delta, encompassed 18.0 km² in 2004 (Figure 4) and had boundaries that were similar in 2001–2003 (Johnson et al. 2003b, 2004). The search area boundaries were selected to encompass conservatively the area of potential disturbance by aircraft landings and takeoffs (approximately 1.9 km from the proposed airstrip location) and were based on noise contours originally estimated for the Alpine Development landing strip (see Johnson et al. 2003a). The CD-5, CD-6, and CD-7 search areas were located in the NPRA study area (Figure 5) and each comprised an area circumscribed by a 1-km radius around the pad footprints (4.1 km² minimum). The CD-7 search area was located in a basin wetland and the boundaries of that area were expanded to include the entire basin (5.5 km²). Each of these sites was searched in 2002 and 2003, and the 2004 search areas overlap these previous search areas, but the boundaries shifted somewhat as the locations of potential development were refined by CPAI.

Ground-based nest and brood searches were conducted to determine the diversity and abundance of large waterbirds and to estimate nesting success of waterfowl. These searches employed the same techniques used in the CD South search area in 2000–2002, the CD-3 search area in 2000–2003, and the NPRA search areas in 2001–2003 (Burgess et al. 2000, 2002a, 2002b, 2003a, 2003b; Johnson et al. 2000a, 2002, 2003b, 2004). These techniques were originally developed in the Colville wildlife studies in 1996–1998 and used in the Alpine project area in 1999–2001 (Johnson et al. 1997, 1998, 1999a, 1999b, 2000b, 2001, 2003a).

Nest searches were conducted between 15 and 30 June (Table 1) by 5–15 observers walking a regular search pattern throughout each search area with ~10-m spacing between adjacent observers. Each team member thoroughly searched all dry ground (non-aquatic) between themselves and adjacent observers for nests of all large birds, including ducks, geese, swans, ptarmigan, loons, jaegers, gulls, terns, and raptors. Nests of larger shorebirds, such as Whimbrel, Bar-tailed Godwits, and Wilson's Snipe were recorded incidentally, although it should be noted that the survey method was not comprehensive for these species. The following data were recorded for each nest found: species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. In the field, all nest locations were plotted on color photomosaics (~1:14,000–1:18,000 scale) and recorded as waypoints on handheld global positioning systems (GPS). Observers attempted not to flush birds from nests but, when a bird was flushed, the observer counted the eggs, collected a small sample of down (including contour feathers, if present), and covered the eggs with down and vegetation (except for loon, gull, and shorebird eggs, which were left uncovered) before leaving the site. When necessary (for example, when nests were unattended by an adult bird at discovery), down and contour feather samples were used to identify nests to species. We used classification of color patterns on contour feathers for unidentified nests of eiders (Anderson and Cooper 1994), and for other waterfowl nests we compared feathers with those from known nests or with descriptions contained in Bowman (2004).

Nest checks (to determine fate), additional nest searches for loons, and brood surveys were conducted simultaneously between 13 and 18 July (Table 1). Each nest site recorded in June was revisited and examined for evidence of nest fate. Waterfowl and ptarmigan nests were classified as successful if thickened egg membranes were found that had detached from the eggshells. If no membranes were found at a nest of those species, the nest was classified as failed. All nests were examined for evidence of predation, such as crushed egg remnants or blood, yolk, and albumin on the egg shells. Nearly all waterfowl and ptarmigan nests could be classified as successful or failed. Nest fate for other bird species could not be consistently evaluated, because they typically remove egg shells and membranes from their nests after hatching and other evidence of fate—observations of young at the nest, direct observations of a predation event, or other clear evidence of predation—was observed for a minority of nests. For these species, unbiased estimates of nesting success were not possible. During the nest checks, all shorelines, lakes, and islands were searched for loon nests and for the presence of broods of other large waterbirds. Loon nests were recorded as described above. Brood

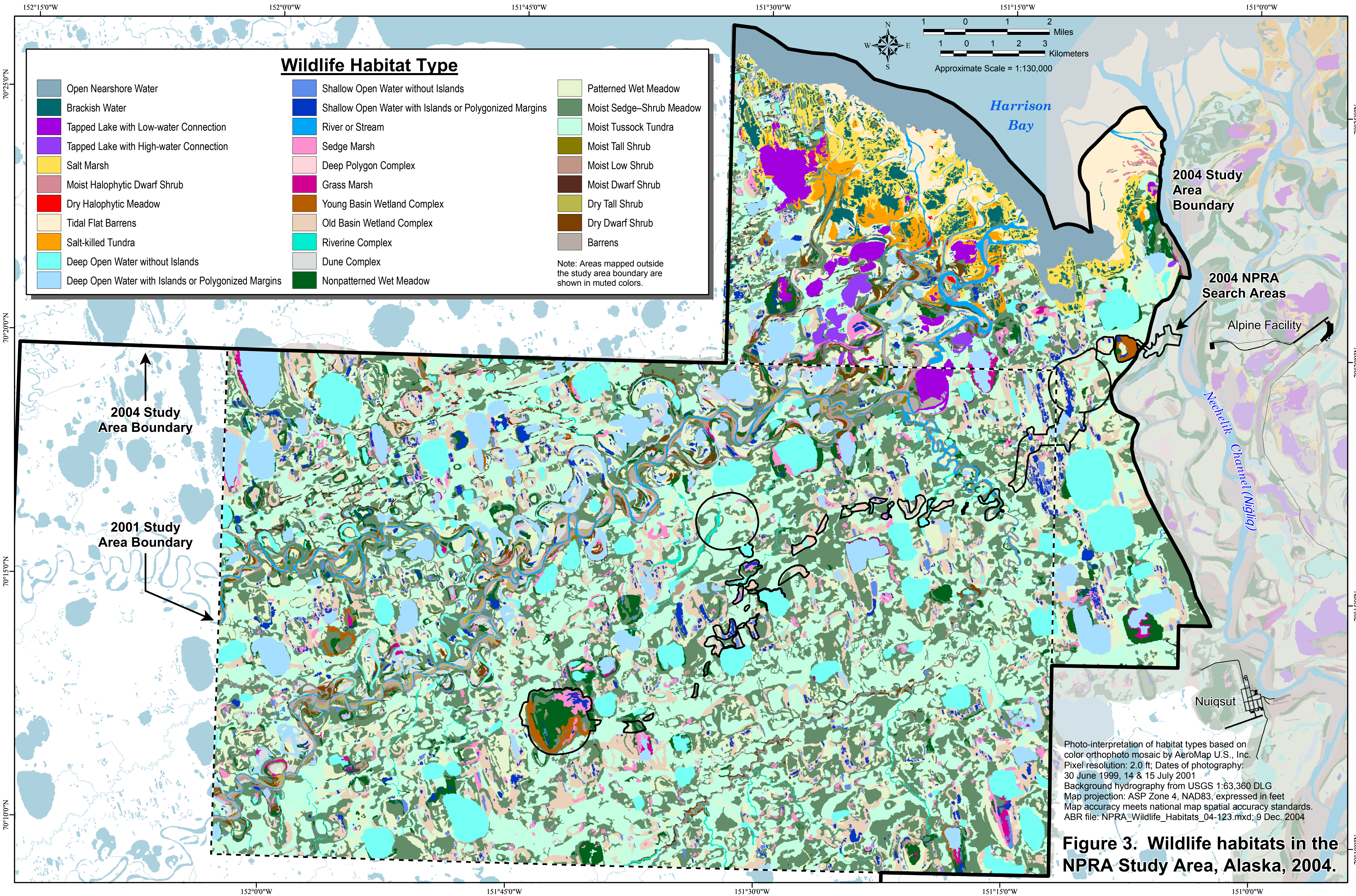

Figure 3. Wildlife habitats in the NPRA Study Area, Alaska, 2004.

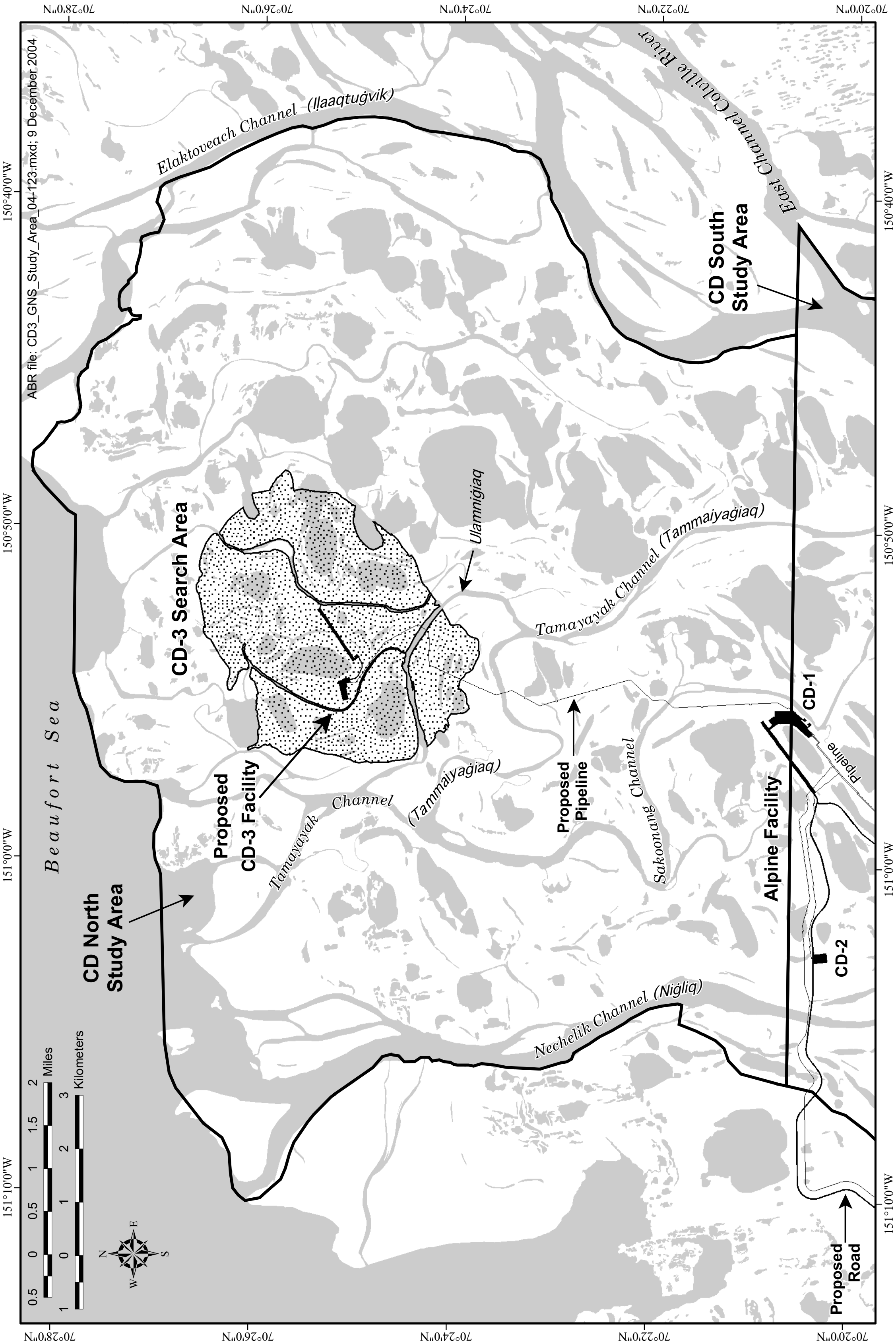

Figure 4. Ground-search area for large waterbird nests and broods in the CD North study area, Colville River Delta, Alaska, 2004.

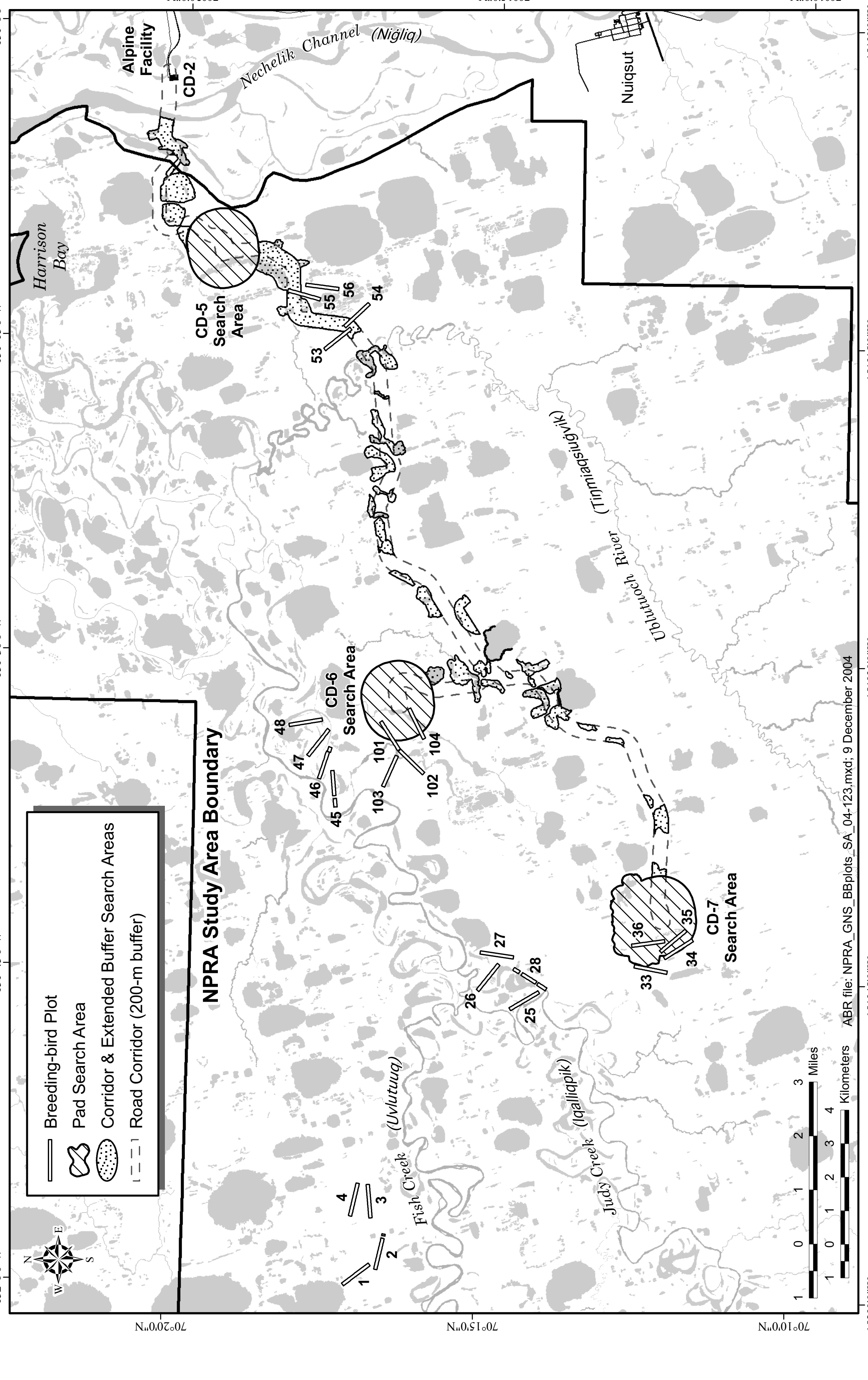

Figure 5. Ground-search areas for large waterbird nests and broods and breeding-bird plots in the NPRA study area, Alaska, 2004.

locations were plotted on color photomosaics, and the numbers of adults and young were recorded.

The CD-3 search area was revisited again between 24 and 25 August and all waterbodies greater than about 25 m long were searched for loon broods. Loon nests were classified as successful if a brood was observed on the nesting lake (or an adjacent lake associated with the nest site). Data collected were similar to that collected during the July nest fate and brood survey.

Despite the intensive nature of the ground-based search effort, additional nests of Tundra Swans and loons occasionally were found in the search areas during aerial surveys. These birds typically flush at great distances and can be missed by ground observers. For comprehensive treatment, we have included all known nests (from either aerial or ground searches) in summaries for the search areas.

NPRA ROAD CORRIDOR

Ground-based nest searches also were conducted along the proposed NPRA road route using the same methods as in the pad search areas, except that we selected areas of primarily aquatic and wet habitats, yielding many disjunct, small search areas (Figure 5). These habitats were prioritized (and broad areas of Moist Tussock Tundra were excluded) in discussions with the USFWS, to focus efforts on the habitats most frequently used by focal species, because the entire road route was too extensive for a complete ground-based nest search. Boundaries of search areas along the NPRA road route were identified prior to conducting nest searches by plotting the road corridor (200 m on both sides of the centerline) on the wildlife habitat map and selecting aquatic and wet habitats that were intersected by the corridor (Figure 3).

Two areas, distinguished by their proximity to the proposed road route, were searched. The “corridor search area” included aquatic and wet habitats within 200-m of the road centerline (Figure 5). Where the 400-m-wide corridor intersected waterbodies or wetland basins, we continued our nest searches at least another 400 m (up to 1,250 m, maximum) in “extended buffer search areas.” In addition to wetlands, extended buffer search areas included shorelines (a 25-m strip) and islands of all large waterbodies that intersected the corridor. The corridor and extended buffer search areas do not overlap the pad search areas where the road approaches the pads (Figure 5). Nests, broods, and habitats within the corridor search areas and extended buffer search areas are summarized separately. Because specific high-value habitats were selected for the corridor and extended buffer search areas, calculated densities for these areas are not strictly comparable to those computed for the pad search areas.

NPRA BREEDING-BIRD PLOTS

In 2004, 24 breeding-bird plots (arranged in 6 clusters of 4 plots each) were sampled in the NPRA study area to determine nest densities, nesting success, and habitat associations of tundra-nesting birds (Figure 5). Each cluster of plots was located to sample representative habitats in each of 3 general areas: the Fish and Judy creek floodplain, north of Fish Creek, and south of Judy Creek. The plot clusters sampled in 2004 (1–4, 25–28, 33–36, 45–48, 53–56, and 101–104) also were sampled in 2002 and 2003. All but one of these plot clusters (plots 101–104) also was sampled in 2001. Plots 65–68 (see Burgess et al. 2002b) were sampled only in 2001, and were replaced by plots 101–104 in 2002. Three plot clusters, 33–36, 53–56, and 101–104, occur near the proposed CD-7, CD-5, and CD-6 pads, respectively. The distribution of plots allows for future comparisons between plot clusters near development areas with those at greater distances from development areas.

Breeding-bird plots measured 100 m × 1,000 m (0.1 km² [10 ha]) and were marked with 1 row of survey lath that delineated 50 m × 50 m grids (40 grids/plot) (Figure 6). Each grid was subdivided into 4 quadrants. Plots were visited up to 12 times in 2004. The first visit to remark and set-up the plots occurred 5–9 June. During the next 4 visits on 10–27 June, plots were searched for new nests and known nests were checked for fate. During the remaining 7 visits from 28 June–15 July, known nests were monitored for fate. Nest searching visits were 3–6 days apart (mean = 4.5 days, SD = 1.0) and nest monitoring visits were 3 days apart. On the first and third nest-search visits, 2 people dragged a 50-m rope through each plot to flush birds from their nests. During the second and fourth nest-search visits, 1 person walked a “W”

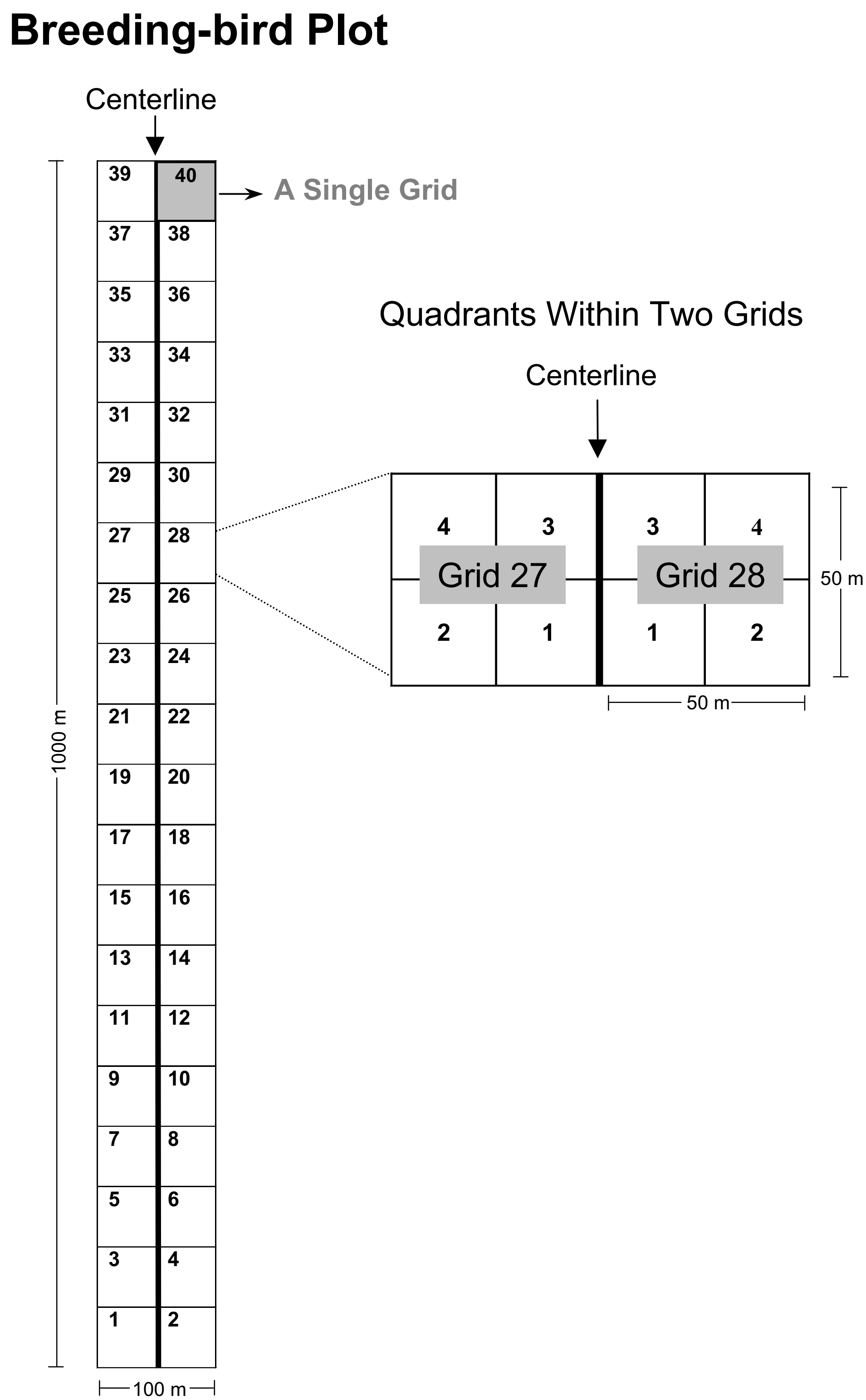

Figure 6. Typical breeding-bird plot grid system used in the NPRA study area, Alaska.

pattern through each grid. During nest-monitoring visits, the plot was not searched systematically for new nests, but new nests were marked and monitored if encountered. When a bird flushed and the nest location was not observed or known from a previous visit, the observer moved farther away or used nearby terrain features as cover until the bird returned and the nest could be located. Known nests were checked during both nest-search and nest-monitoring visits to collect data on nest age and hatching and fledging success. The number and density of nests found during plot set-up and nest-searching visits were summarized by species and plot, species and plot cluster, and species group and plot cluster. Nests found during nest-monitoring visits were reported but not included in these summaries.

To assist in locating known nests, an orange wooden stake (~2.5 × 30 cm) was placed in the ground on the plot centerline at a point where a line to the nest perpendicularly intersected the centerline. Each centerline marker was labeled with the distance to the nest location. A small wooden marker (~1.2 × 15 cm) was placed 1–3 m from the nest toward the plot centerline and placed low in vegetation so that they were visible when walking from the centerline, but concealed from other directions.

For each nest found, the observer recorded the species, the number of birds present, the status of the nest (active, inactive, unknown), the flushing distance of the incubating adult, the number of eggs or young, the estimated age of the young, and the nest location by grid number, distance from centerline, and quadrant within the grid (Figure 6). For nests found close to plot boundaries, a tape measure was used to determine whether they were on or off plot. To estimate the age of nests of shorebirds, waterfowl, loons, terns, and ptarmigan, 4 eggs from each nest (or all eggs of clutches smaller than 4) were floated in water in a plastic container. Measurements were collected on the position of the egg in the water column (i.e., on the bottom, neutrally buoyant, on the surface), the angle between the central axis of the egg and the water surface, and, if the egg was breaking the surface, the percent volume (nearest 5%) of the egg above the surface. Eggs that were cracked, starred, or pipped were noted. Eggs of shorebirds and ptarmigan were floated during each visit to a plot. If waterfowl, loons, and terns were incubating when a plot was visited, observers attempted not to flush them off their nests, but if they did flush, their eggs also were floated. Waterfowl nests were covered with down and vegetation before leaving the site.

For all species, a nest was considered successful if evidence gathered at the site suggested that at least one young fledged (i.e., hatched and survived to leave the nest). When a nest was inactive, data were collected to help determine the fate of the nest, including the presence or absence of egg membranes, broken eggs, eggshell pipping fragments (1–5 mm for shorebirds), eggshell pieces (>5 mm for shorebirds), and eggshell tops or bottoms. If adult behavior suggested the presence of a brood or if a brood was observed, distance to nest was recorded. Any evidence of predation (fox smell, fox scat, or a disturbed nest site) was noted. Habitat information was recorded at each nest, including the landform at the nest site, the terrestrial habitat within a 5-m radius of the nest and within the nest quadrant (25 m × 25 m), and the estimated percent of the nest (nearest 10%) obscured by vegetation. Summaries of habitat use by nesting birds on breeding-bird plots are not presented in this report. The location of the nest was recorded using a GPS receiver.

For shorebirds, a nest was classified as successful when at least 1 chick was observed in or near a nest scrape, when an eggshell top or bottom indicative of a hatched egg was found (Mabee 1997), or when 2 lines of supportive evidence were confirmed (e.g., eggshell fragments consistent with pipped eggs and egg flotation data indicating a nest could have hatched). Successful nests of shorebird species generally contain eggshell fragments 1–5 mm in length (Mabee 1997). The presence or absence of eggshell fragments was tallied for shorebird nests with chicks to confirm this pattern. Nest age could be determined for nests found during laying, for nests with starred or pipped eggs, and for nests with chicks, by backdating from the estimated hatch date or chick age. Incubation periods were obtained from Poole et al. 2003, with modifications from observed incubation periods. The egg flotation data from nests with known incubation periods were plotted and used to age the other nests. A shorebird nest was classified as failed when a clutch of eggs disappeared too early in incubation to have hatched (i.e., eggs at least 4 d younger than the mean incubation period for each species, as indicated by nest records or flotation data), the nest area contained indications of predation (e.g., broken eggs), or the clutch was abandoned. A nest was classified as having an unknown fate when neither success nor failure (listed above) could be confirmed.

Waterfowl and ptarmigan nests were classified as successful if thickened egg membranes were found that had detached from the eggshells. Nests of waterfowl and ptarmigan were classified as failed if such membranes were absent. Ages of passerine nests were estimated for nests found during laying and for nests containing nestlings. A passerine nest was considered successful if the age of the nestlings at the midpoint between the last date active and the first date inactive was greater or equal to the reported age at fledging (fledging periods from Poole et al. 2003). A passerine nest was considered failed if the midpoint age of the nestlings was less than the reported age at fledging or if the nest never had nestlings.

Mean daily survival rates (DSR) were calculated for species groups (i.e., shorebirds, passerines, and waterfowl) and for individual species in each plot cluster and over all plots combined. DSRs were calculated using program MARK (White and Burnham 1999). The nest survival model in MARK has its roots in the Mayfield method, so our results with MARK should be comparable to a Mayfield analysis (Mayfield 1961, 1975), in which the necessary assumptions for that method are met. For calculations of daily survival rate (DSR), the nests of unknown fate and nests that had insufficient data (e.g., found on the day of hatch or found failed) were excluded. Mean DSR was calculated for each plot cluster for species with ≥4 total nests, for species groups in each plot cluster, and for all plots together. Mean DSR also was calculated for the incubation and nestling periods of passerines, but only included those nests that hatched or were found after hatch.

During all visits to breeding-bird plots, all observations of avian and mammalian predators occurring on plot (flying over or on the ground) were recorded during the entire time observers were on plot. During some visits, timed observation counts of predators also were made. Three timed counts of 10 minutes length were conducted on each plot during the plot-marking visit, the second and fourth nest searching visits, and the third and fifth nest monitoring visits. The timed counts were conducted at centerline stakes at least 200 m apart. During each count, binoculars were used to scan for predators. Observers recorded predator species and behavior. Observations were converted to number of predators per hour for comparison of means.

EIDER AERIAL SURVEYS

Regional abundance and distribution of eiders was evaluated with data collected on aerial surveys flown during the pre-nesting period (Table 1), while male eiders (the more visible of the 2 sexes in breeding plumage) were still on the breeding grounds. The pre-nesting survey in 2004 (Figure 7) covered the same area as in 2003, with the addition of the Fish Creek Delta. The pre-nesting survey was conducted on 11, 14 and 15 June using the same methods that were used in previous years on the Colville Delta (1993–1998 and 2000–2003) and in the NPRA study area (1999–2003), although the survey areas and survey coverage differed among years (see Anderson and Johnson 1999, Murphy and Stickney 2000, Johnson and Stickney 2001, Burgess et al. 2003b, Johnson et al. 2003b, 2004). Flight altitude was 30–35 m above ground level (agl) and flight speed was approximately 145 km/h. A GPS receiver was used to navigate pre-determined east–west transect lines that were spaced 800 m apart in the NPRA study area and most of the Colville Delta and 400 m apart over the CD-3 and CD-4 areas (Figure 7). An observer on each side of the airplane (in addition to the pilot) counted eiders in a 200-m-wide transect (delimited by tape on windows and wing struts, see Pennycuick and Western 1972), thereby covering ~70% of the Colville Delta and 50% of the NPRA study area. Three areas were not surveyed on the Colville Delta: the extensive tidal flats and marine waters on the northernmost delta were not included because eiders rarely use those habitats, a 2.4-km radius circle around the Helmericks' home site was avoided to reduce disturbance to its residents, and similarly, the extreme southern delta was avoided

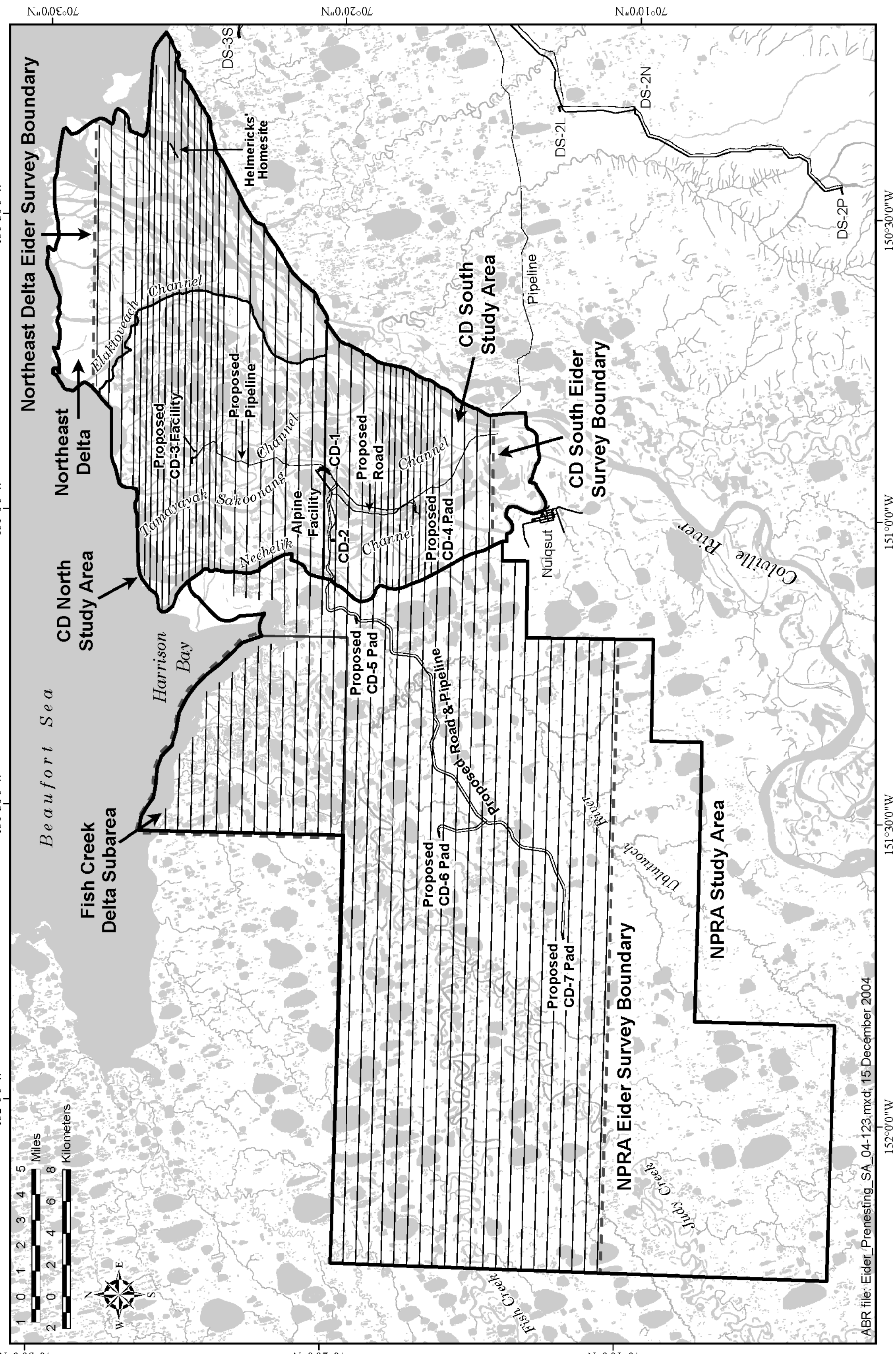

Figure 7. Transect lines and survey areas for pre-nesting eider aerial surveys, northeast delta and CD North, CD South, and NPRA study areas, Alaska, 2004.

to limit disturbance to Nuiqsut residents (Figure 7). Eider locations were recorded on color photomosaic maps (1:63,360-scale) and audio tapes were used to record transect number, species, numbers of individuals of each sex and number of identifiable pairs, and activity (flying or on the ground).

We calculated the observed number of birds, the observed number of pairs, the "indicated" number of birds, and densities (number/km²) for each study area. Following the USFWS (1987a) protocol, the total indicated number of birds was twice the number of males not in groups (defined as >3 birds of mixed sex that cannot be separated into singles or pairs) plus the number of birds in groups.

LOON AERIAL SURVEYS

Aerial surveys for nesting Yellow-billed Loons were conducted on 23–25 June 2004 and for brood-rearing loons on 21–23 August 2004 in the CD North, CD South, and NPRA study areas; the Fish Creek Delta was not included in the loon aerial surveys in 2004 (Figure 8, Table 1). The nesting survey was conducted in a helicopter flying at ~60 m agl in a lake-to-lake pattern covering most lakes ≥10 ha in size and immediately adjacent aquatic habitats, comprising the typical breeding habitats for nesting Yellow-billed Loons (Sjolander and Agren 1976, North and Ryan 1989). Tapped Lakes with Low-water Connections (lakes whose levels fluctuate with the river) were excluded because Yellow-billed Loons do not use such lakes for nesting (North 1986, Johnson et al. 2003b). During the brood-rearing survey, only lakes where Yellow-billed Loons were observed during the nesting survey were surveyed. Observations of Pacific and Red-throated loons were recorded incidentally. All locations of loons and their nests were recorded on color photomosaics (~1:30,000 scale).

The total number of adults, nests, broods, and young counted on aerial surveys were summarized by season for each species of loon. Density of adults, nests, and broods was calculated only for Yellow-billed Loons because the smaller lakes that typically are used by Pacific and Red-throated loons were not included in the survey.

TUNDRA SWAN AERIAL SURVEYS

Aerial surveys for nesting and brood-rearing Tundra Swans were flown during 21–24 June and 19–25 August 2004, respectively (Table 1). Aerial surveys covered the entire Colville Delta (CD North, CD South, and northeast delta) and the NPRA study area including the Fish Creek Delta (Figure 9). Surveys were conducted in accordance with USFWS protocols (USFWS 1987b, 1991) and the same methods were used for nesting and brood-rearing surveys on the Colville Delta in 1993, 1995–1998, and 2000–2003 (Smith et al. 1994, Johnson et al. 2003b, 2004) and in the NPRA in 1999–2003 (Anderson and Johnson 1999, Murphy and Stickney 2000, Johnson and Stickney 2001, Burgess et al. 2003b, Johnson et al. 2003b, 2004). East-west transects spaced 1.6 km apart were flown in a fixed-wing airplane that was navigated with the aid of a GPS receiver. Flight speed was 145 km/h and altitude was 150 m agl. Two observers each searched 800-m-wide transects on opposite sides of the airplane while the pilot navigated and scanned for swans ahead of the airplane, providing 100% coverage of the surveyed area. Locations and counts of swans and their nests were recorded on color photomosaics (1:63,360-scale). Each nest on the Colville Delta was photographed with a 35-mm camera for site verification.

Numbers of swans, nests, and broods were summarized and densities calculated for each season for each study area. Nesting success was estimated from the ratio of broods to nests counted during aerial surveys only. The accuracy of these estimates can be affected by several factors. First, swan broods are more likely to be detected than swan nests during aerial surveys (see Stickney et al. 1992), thus inflating the estimated nesting success. Second, some broods probably are lost to predation between hatching and the aerial survey, thus deflating estimated nesting success. In addition, swan broods are mobile and can move into or out of a survey area prior to the survey, thus biasing the estimated nesting success in either direction. Immigration and emigration of broods are less of a problem, however, for estimating nesting success in large, well-defined areas, such as the Colville Delta. Nonetheless, nesting success

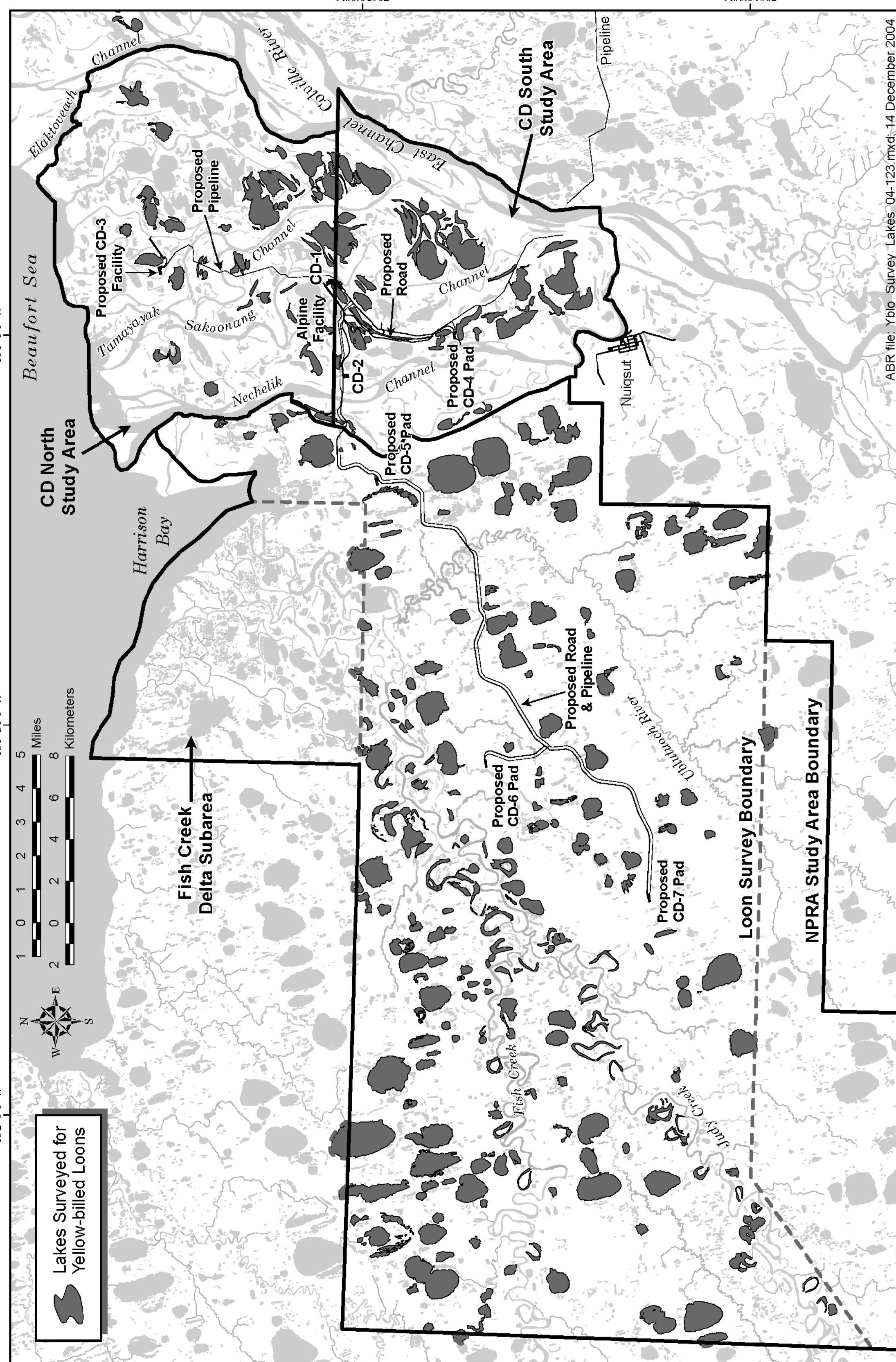

Figure 8. Lakes included in aerial surveys for nesting Yellow-billed Loons, CD North, CD South, and NPRA study areas, Alaska, 2004.

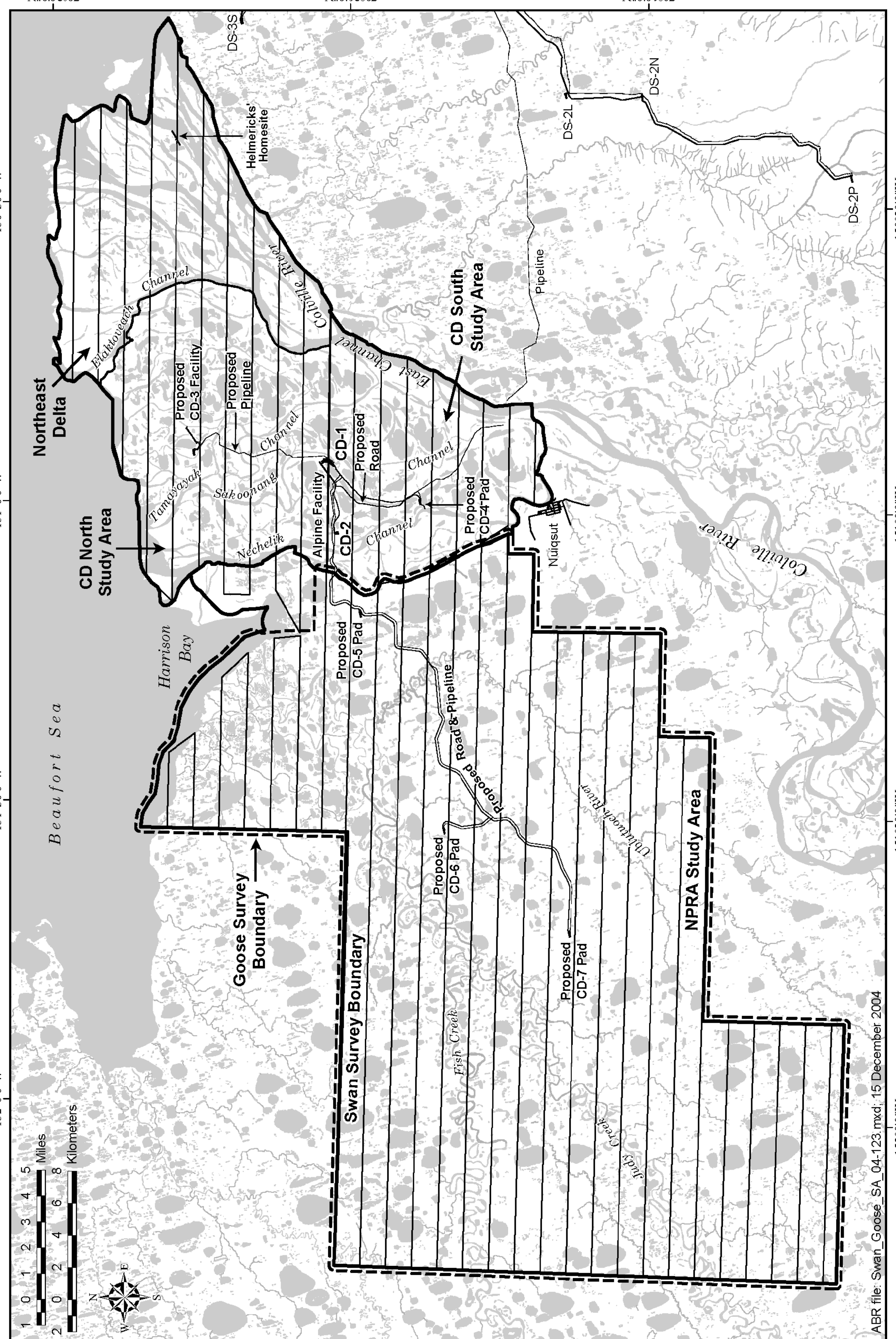

Figure 9. Transect lines and survey areas for aerial surveys of nesting and brood-rearing swans and brood-rearing and fall-staging geese, northeast delta and CD North, CD South, and NPRA study areas, Alaska, 2004.

estimates based on aerial-survey data should be considered relative indices.

GOOSE AERIAL SURVEYS

In 2004, 2 systematic aerial surveys were flown for all species of geese in the NPRA study area, including the Fish Creek Delta: brood-rearing (26–27 July), and fall staging (24–25 August; Table 1). No surveys were flown for geese on the Colville Delta in 2004. Goose surveys were flown in a Cessna 185 aircraft in July and a Cessna 206 aircraft in August. Both aircraft flew the surveys at 90 m agl and approximately 145 km/h on east–west flight lines that were 1.6 km apart, the same transects flown for the Tundra Swan surveys (Figure 9). Two observers searched 400-m-wide strips, 1 on each side of the plane, yielding 50% coverage of the survey area. The numbers of adults and young and their locations were recorded on color photomosaics (1:63,360-scale).

GULL AERIAL SURVEYS

Glaucous Gulls nests were recorded on the Colville Delta and in the NPRA study area during nesting aerial surveys for Yellow-billed Loons and Tundra Swans (see individual species sections for survey methods). Glaucous Gull broods were recorded opportunistically during brood-rearing surveys for Yellow-billed Loons. Colonies of Sabine's Gulls also were recorded during the nesting survey for Yellow-billed Loons, and the number of nests at each colony was estimated based on the number of adults observed (Sabine's Gull nests are difficult to confirm from aerial surveys). All nest and brood observations were recorded on color photomosaics (1:30,000 and 1:63,360-scale).

Additional information on the abundance of gulls was obtained from results of the ground-searches (see ground-search methods, above). The number and density of nests was calculated for Glaucous Gulls in the CD North, CD South, and NPRA study areas.

CARIBOU SURVEYS

Two aerial surveys of the Colville River Delta were conducted on 25 June and 11 August (Table 2). The Colville Delta surveys followed 10 transect lines (Figure 10) encompassing a 492-km² survey area, constituting the same area surveyed in 2002 by Lawhead and Prichard (2003a).

Five aerial surveys were conducted in the NPRA caribou survey area in 2004, beginning on 18 May and ending on 18 October (Table 2); an additional survey planned for the calving season in early to mid-June had to be canceled due to a combination of factors (lack of a qualified pilot, an aircraft equipment problem, and inclement weather). The NPRA caribou survey area sampled in 2002–2004 encompassed all of the NPRA study area except for the Fish Creek Delta and the northernmost extension along the Nechelik Channel of the Colville River (the latter area was included in the Colville Delta caribou survey area) (Figure 10). NPRA surveys followed 14 north–south-oriented transect lines and encompassed 1,310 km².

Caribou surveys of the NPRA study area and Colville Delta were conducted by 2 observers on opposite sides of a Cessna 206 airplane. A third observer recorded data. The pilot navigated the transect lines using a GPS receiver and maintained an altitude of ~150 m agl using a radar altimeter. Transect lines were spaced at intervals of 3.2 km following section lines on USGS topographic maps (scale 1:63,360). Observers counted caribou within an 800-m-wide strip on each side of the transect centerline, sampling 50% of the survey area. Therefore, the number of caribou counted was doubled to obtain the estimated number of caribou in the survey area; the standard error (SE) of the estimated number was calculated (Gasaway et al. 1986) using transects as the sampling unit. The strip width was delimited visually using tape markers on the struts and windows of the aircraft (see Pennycuick and Western 1972).

When caribou were observed within the transect strip, their perpendicular location on the transect centerline was recorded using a GPS receiver, the number of adults (including yearlings) and calves were recorded, and the perpendicular distance from the transect centerline was estimated in 200-m intervals. For plotting on maps, the midpoint of the distance interval was used (e.g., 300 m for the 200–400-m interval). Thus, the maximal mapping error was estimated to be ~100 m.

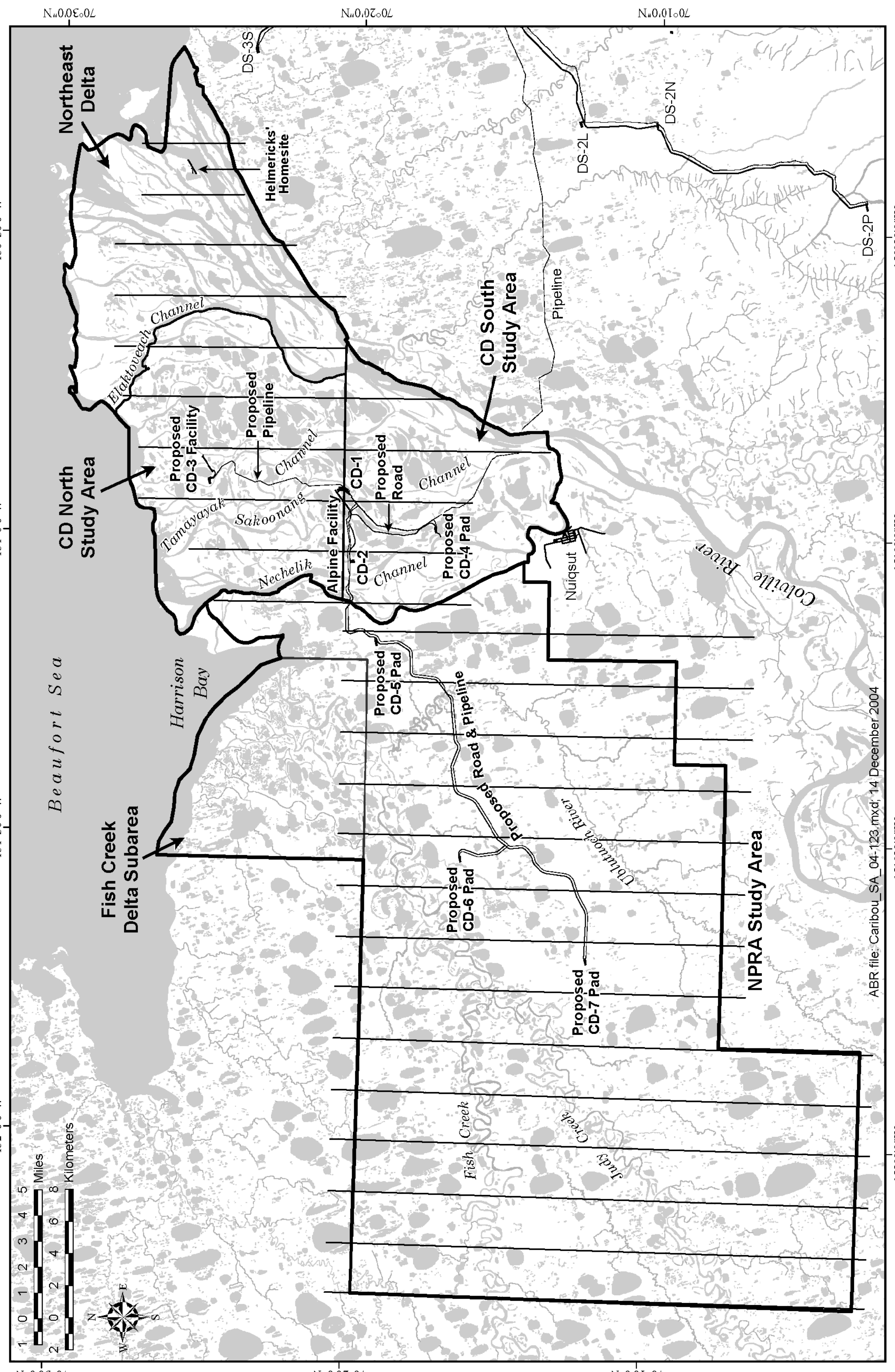

Figure 10. Transect lines and survey areas for caribou aerial surveys, northeast delta and CD North, CD South, and NPRA study areas, Alaska, 2004.

FOX SURVEYS

Aerial and ground-based surveys were used to evaluate the distribution and status of arctic and red fox dens on the Colville Delta and in the NPRA study area in 2004, using the same methods as used in previous years on the Colville Delta (Johnson et al. 2003a). A helicopter was used to search for dens and aerial observations were supplemented with reports of dens from avian nest searches conducted in June. Most of the study area was searched by helicopter in 2001, except for the northernmost portion and the riverine dunes and banks of Fish and Judy creeks. Additional search effort was expended in the latter areas in July 2002 and 2003, but little helicopter time was available for additional searching in 2004 and the Fish Creek Delta was not searched. Additional survey effort will be required to search those drainages fully, however, due to the abundance of ground squirrel burrows, which are difficult to distinguish from fox dens during aerial surveys. Soil disturbance caused by foxes digging at den sites, together with fertilization resulting from feces and food remains, results in a characteristic, lush flora that makes perennially used sites easily visible from the air after "green-up" of vegetation (Chesemore 1969, Garrott et al. 1983). Green-up occurs earlier on traditionally used den sites than on surrounding tundra, a difference that is helpful in locating dens as early as the third week of June.

Aerial surveys and ground visits in 2004 to evaluate den status were conducted on 28–29 June on the Colville Delta and 29–30 June in the NPRA study area (Table 2). Active dens were observed during 9–12 July to count pups. During ground visits, evidence of use by foxes was evaluated and the species using the den was confirmed. Following Garrott (1980), we examined the following indicators to assess den status: presence or absence of adult and pup foxes; trampled vegetation in play areas and beds; presence and appearance of droppings, diggings, and tracks; prey remains; shed fur; and signs of predation (e.g., pup remains). Dens were classified into 4 categories (derived from Burgess et al. 1993), the first 3 of which we consider to be "occupied" dens:

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

Because foxes commonly move pups from natal dens to secondary dens, repeated observations during the denning season are needed to classify den status confidently. Our efforts focused on assessing den occupancy and on counting pups at occupied sites. Based on the assessment of den activity on initial visits, dens judged to be occupied were observed ~2 weeks later to count pups. Observers were dropped off by helicopter at suitable vantage points several hundred meters from den sites, from which they conducted observations with binoculars or spotting scopes over periods of 2.5–4 h. Observations usually were conducted early and late in the day, when foxes tend to be more active.

HABITAT USE AND SELECTION ANALYSES

As described above, wildlife location data from the ground and aerial surveys were plotted on the maps of wildlife habitats (Figures 2 and 3) using map coordinates, recorded either from GPS readings taken in the field, or by plotting locations on georeferenced maps or photomosaics and subsequently deriving coordinates. By this method, a wildlife habitat was assigned to each observation (nests on breeding-bird plots were an exception, as no habitat analysis was conducted on those nests, see below). For each species, habitat use (% of observations in each identified habitat type) 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), and

3) the percent availability of each habitat in the search or survey area. Habitat use was calculated from group locations for species or seasons when birds were in flocks or broods, because we could not assume independence of location, habitat use, or habitat selection among individuals in these groups (i.e., a few large groups could bias results).

For a subset of species/surveys, a statistical evaluation of habitat selection was used to evaluate whether habitats were used in proportion to their availability. (Note that habitat availability often differed among species, because survey areas often differed, as described below). When multiple years of survey data were available, all comparable data were used in statistical evaluation of habitat selection. For this purpose, annual surveys were considered comparable only when the survey areas were similar in habitat composition, because habitat availability was calculated as by summing annual habitat availability over years.

Habitat selection was evaluated for the following species and seasons:

- pre-nesting Spectacled Eiders and King Eiders (aerial surveys, Colville Delta 1993–2004 and NPRA study area 2001–2004)
- nesting Spectacled Eiders and Pacific Loons (ground searches, CD-3 search area 2000–2004)
- nesting and brood-rearing Tundra Swans (aerial surveys, Colville Delta 1992–2004 and NPRA study area 2001–2004)
- nesting and brood-rearing Yellow-billed Loons (aerial surveys, Colville Delta 1993–2004 [nests] and 1995–2003 [broods], and NPRA study area 2001–2004)
- nesting Pacific Loons (ground searches, CD-3 search area 2000–2004)
- nesting Greater White-fronted Geese (ground searches, CD-3 search area 2000–2004 and NPRA search areas 2004)
- nesting Canada Geese (NPRA search areas 2004)
- denning arctic and red foxes (Colville Delta 1993–2004 and NPRA study area 2001–2004, all known dens irrespective of year of discovery or species, because dens may be reused by either species in subsequent years)

For other species, the number of observations of individual species from comparable annual surveys was inadequate for statistical analysis. For analysis of habitat selection, the aerial survey observations were evaluated without the additional observations of those species from the ground searches (for example, swan nests located during ground searches but not during aerial surveys were not included in the analysis of habitat selection) to avoid any possible biases for habitats in areas that were searched with greater intensity on the ground. Several habitats, based on similar composition or physiography and low areal coverage, were merged for the avian analyses to reduce the number of classes. Thus, Moist Halophytic Dwarf Shrub (≤0.1% of both study areas; Table 3) was merged with Salt Marsh, Dry Halophytic Meadow (<0.1% of NPRA) was combined into Tidal Flat Barrens, and all non-halophytic shrub types (all but one occupied <1% of each study area) were combined into Tall, Low, or Dwarf Shrub. Selection analyses for fox denning do not include aquatic habitats and Tidal Flat Barrens, which are flooded periodically, as available for fox denning, because only terrestrial habitats provide sites suitable for denning.

Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat use, and this distribution was used to compute 95% confidence intervals around the expected value of habitat use (Haefner 1996, Manly 1997). Random habitat use was based on the percent availability of each habitat 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 observed habitat use greater than the 95% confidence interval 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 observed habitat use below the 95% confidence interval of simulated random use. The simulations and calculations of confidence intervals were conducted with Microsoft® Excel.

RESULTS

CONDITIONS IN THE STUDY AREA

The 2004 season was characterized by average May, but cold early June temperatures followed by an extended period of warm temperatures in the last half of June, and extensive flooding of the Colville River that was caused by ice jams. We summarized weather records from 2 locations in the region: the Colville Village station at the Helmericks' home site, which is representative of conditions on the outer Colville Delta (including the CD-3 search area), and the Kuparuk Oilfield station, which is representative of conditions farther inland (probably comparable to much of the NPRA study area, although Kuparuk is ~55 km east). At both the Kuparuk station and at Colville Village, snow persisted through the first week of June in 2004, similar to the timing in 2003 (Johnson et al. 2004). In May 2004, the mean temperature was –5.5° C at Kuparuk and –5.0° C at Colville Village, slightly cooler than the long-term mean of –5.0° C at Kuparuk (*n* = 17 yrs) and slightly warmer than the mean of –6.0° C at Colville Village (*n* = 8 years) (NOAA: http://lwf.ncdc.noaa.gov). In June 2004, the mean temperature was 7.2° C at Kuparuk and 5.6° C at Colville Village, both of which were warmer than the long-term means for June of 4.4° C and 3.5° C for Kuparuk and Colville Village, respectively. The warmer than average June temperatures in 2004 were largely attributed to the extended warm period in the latter half of the month; Kuparuk averaged 12.6° C during this period, while Colville Village averaged 10.3° C.

Cumulative thawing degree-days were computed for the periods of bird arrival (approximately 15–31 May) and nest initiation (1–15 June) for each year of record (Figure 11). (On the Celsius scale, the value of cumulative

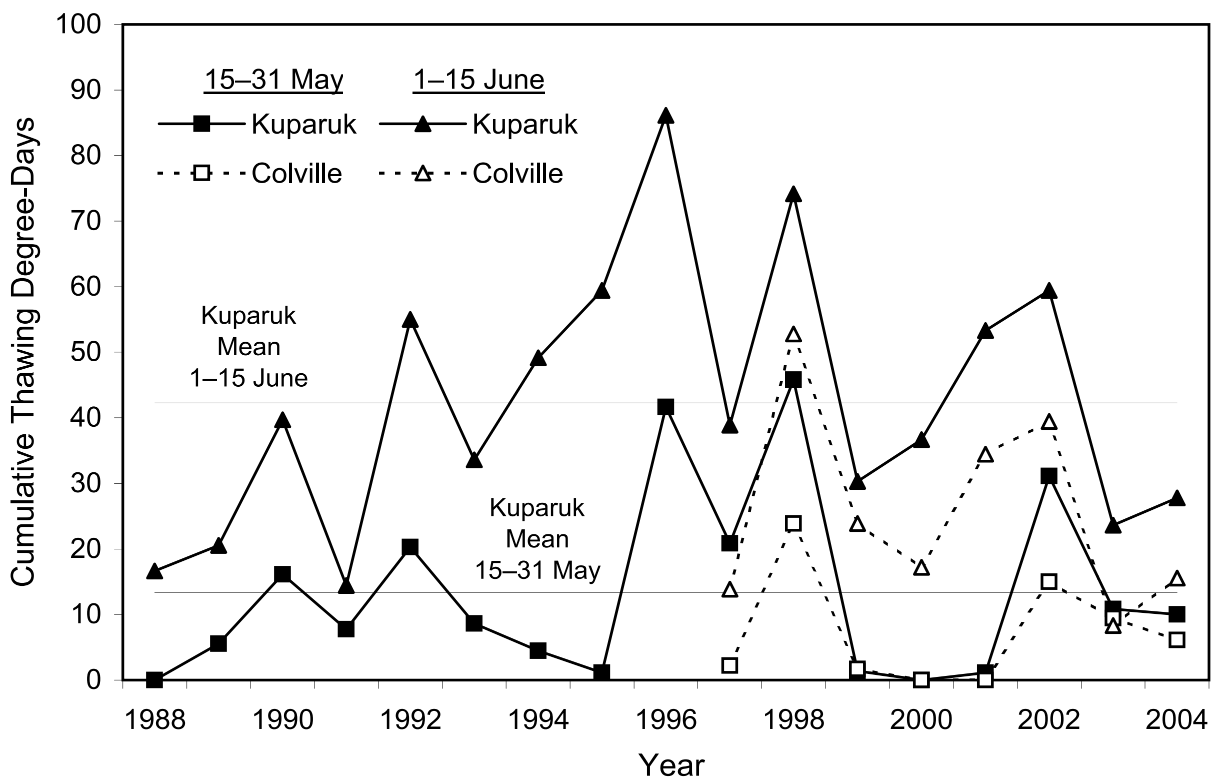

Figure 11. Cumulative number of thawing degree-days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield and Colville River Delta, Alaska. Mean values computed from Kuparuk data (*n* = 17 years).

thawing degree-days [hereafter, thawing degree-days] for any particular period is the sum of mean daily temperatures for each day of that period in which the daily mean temperature was above freezing.) At Colville Village, temperatures during bird arrival in 2004 were slightly cooler than average and ranked fourth warmest of 8 years. Similarly, at the Kuparuk station, the bird arrival period in 2004 was also slightly cooler than the 17-year mean, ranking eighth warmest overall. In contrast to the arrival period, the 2004 nest initiation period was among the coldest on record for both stations. The 2004 nest initiation period was the third coldest at Colville Village and the fifth coldest at Kuparuk (Figure 11).

Breakup of the Colville River was characterized by some of the highest water levels recorded at the Alpine facility (Michael Baker Jr., Inc. 2004). These high water levels were caused by an ice jam that blocked the entrance to the East Channel and directed flow down the Nigliq channel. Another ice jam occurred 30 river miles upstream at Ocean Point. These ice jams also caused over-bank flooding in places. Multiple peak stages occurred during the 2004 breakup, starting on 22 May, mostly caused by the effects of ice movements, rather than from high volumes of water. Peak discharge occurred on 26 May and peak elevation was recorded on 27 May. Timing of breakup in 2004 was slightly earlier than average. In early June, crews establishing the breeding bird plots observed flooding conditions on both the Ublutuoch River and Fish Creek, and lakes adjoining Fish Creek had high water levels (A. Wildman, ABR, pers. comm.).

High water in early June 2004 may have delayed nesting near rivers and associated floodplains. The warm conditions that occurred in the latter half of June were favorable for those nests that survived through mid-June or were initiated after that. The first Lapland Longspur hatchling was found on 14 June, 6 days earlier than 2003 (Johnson et al. 2004). Yet, in a pattern similar to 2003, some eiders and Long-tailed Ducks were still incubating in mid-July. Mosquitoes began to emerge in the study area on 19 June, which is relatively early, and caribou movements onto the Colville Delta in response to mosquito harassment were noted by 21 June.

LARGE WATERBIRDS AT PROPOSED PAD AND ROAD SITES

COLVILLE RIVER DELTA

Distribution, Abundance, and Nesting Success

Only the CD-3 search area was included in the ground-based field effort on the Colville Delta in 2004. (The CD-4 search area was omitted, as described above). The CD-3 search area was located in the north-central CD North study area, near the outer Colville Delta (Figure 4) in an area comprising more than 90% wet, aquatic, or salt-affected habitats (Table 4). The search area in 2004 was 18.0 km² and included 17 wildlife habitats (Table 4). Patterned Wet Meadow was the largest single component (>25% of the total area), and Nonpatterned Wet Meadow, Deep Polygon Complex, Salt-killed Tundra, and Deep Open Water with Islands or Polygonized Margins each comprised over 10% of the area. No other habitats comprised ≥5% of the search area.

In 2004, 518 nests of 17 species were recorded in the CD-3 search area (Figures 12 and 13, Table 5), which was greater than in previous years (245–404 nests). Overall nest density in 2004 was 29 nests/km², which also was higher than the density observed in previous years (range 16.7–22.5 nests/km², 2000–2003). No additional nests were found in the search area during aerial surveys for loons or swans in 2004.

More than half of the nests in the CD-3 search area in 2004 belonged to geese, with most belonging to Greater White-fronted Geese (330 nests) and smaller numbers to Brant (23 nests), Canada Geese (4 nests), and Snow Geese (3 nests) (Figure 12, Table 5). The density of Greater White-fronted Goose nests (18 nests/km²) was higher than in any previous year in CD-3 (Johnson et al. 2003b). The density of Brant nests (1 nest/km²) was within the range of densities for this area. The densities of duck nests were the highest recorded in all years, with Long-tailed Duck (32 nests), Spectacled Eider (18 nests), and Northern Pintail (11 nests) the most common nesting species. Eight Tundra Swan nests were found in the CD-3 search area, yielding a nest density of 0.4 nests/km², which was comparable to the densities in previous years.

Table 4. Habitat availability in the CD-3, CD-5, CD-6, and CD-7 search areas, CD North and NPRA study areas, Alaska, 2004.

Habitat	CD-3 Area (km²)	CD-3 Availability (%)	CD-5 Area (km²)	CD-5 Availability (%)	CD-6 Area (km²)	CD-6 Availability (%)	CD-7 Area (km²)	CD-7 Availability (%)
Brackish Water	0.51	2.8	0	0	0	0	0	0
Tapped Lake with Low-water Connection	<0.01	<0.1	0	0	0	0	0	0
Tapped Lake with High-water Connection	0.88	4.9	0	0	0	0	0	0
Salt Marsh	0.80	4.4	0	0	0	0	0	0
Salt-killed Tundra	1.92	10.6	0	0	0	0	0	0
Deep Open Water without Islands	0.82	4.6	0	0	<0.01	<0.1	0	0
Deep Open Water with Islands or Polygonized Margins	1.82	10.1	0	0	0	0	0	0
Shallow Open Water without Islands	0.07	0.4	<0.01	0.1	0	0	0.04	0.7
Shallow Open Water with Islands or Polygonized Margins	0.15	0.8	0.34	8.4	<0.01	0.1	0.23	4.3
River or Stream	<0.01	<0.1	0	0	0	0	0	0
Sedge Marsh	0	0	0.06	1.5	0.06	1.5	0.70	12.7
Deep Polygon Complex	2.22	12.3	0	0	0	0	0	0
Grass Marsh	0.04	0.2	0	0	0	0	0.01	0.2
Young Basin Wetland Complex	0	0	0	0	0	0	1.09	19.9
Old Basin Wetland Complex	0	0	0.79	19.2	0.12	3.0	0	0
Riverine Complex	0	0	0	0	0.18	4.4	0	0
Nonpatterned Wet Meadow	2.67	14.8	0.06	1.4	0	0	1.89	34.3
Patterned Wet Meadow	4.73	26.2	1.18	28.7	0.49	11.8	0.18	3.3
Moist Sedge–Shrub Meadow	0.44	2.4	0.79	19.1	0.82	19.9	0.94	17.1
Moist Tussock Tundra	0	0	0.90	21.8	2.43	59.1	0.32	5.9
Tall, Low, or Dwarf Shrub	0.27	1.5	0	0	<0.01	0.1	0.09	1.7
Barrens	0.70	3.9	0	0	0	0	0	0
Total	18.02	100	4.12	100	4.12	100	5.51	100

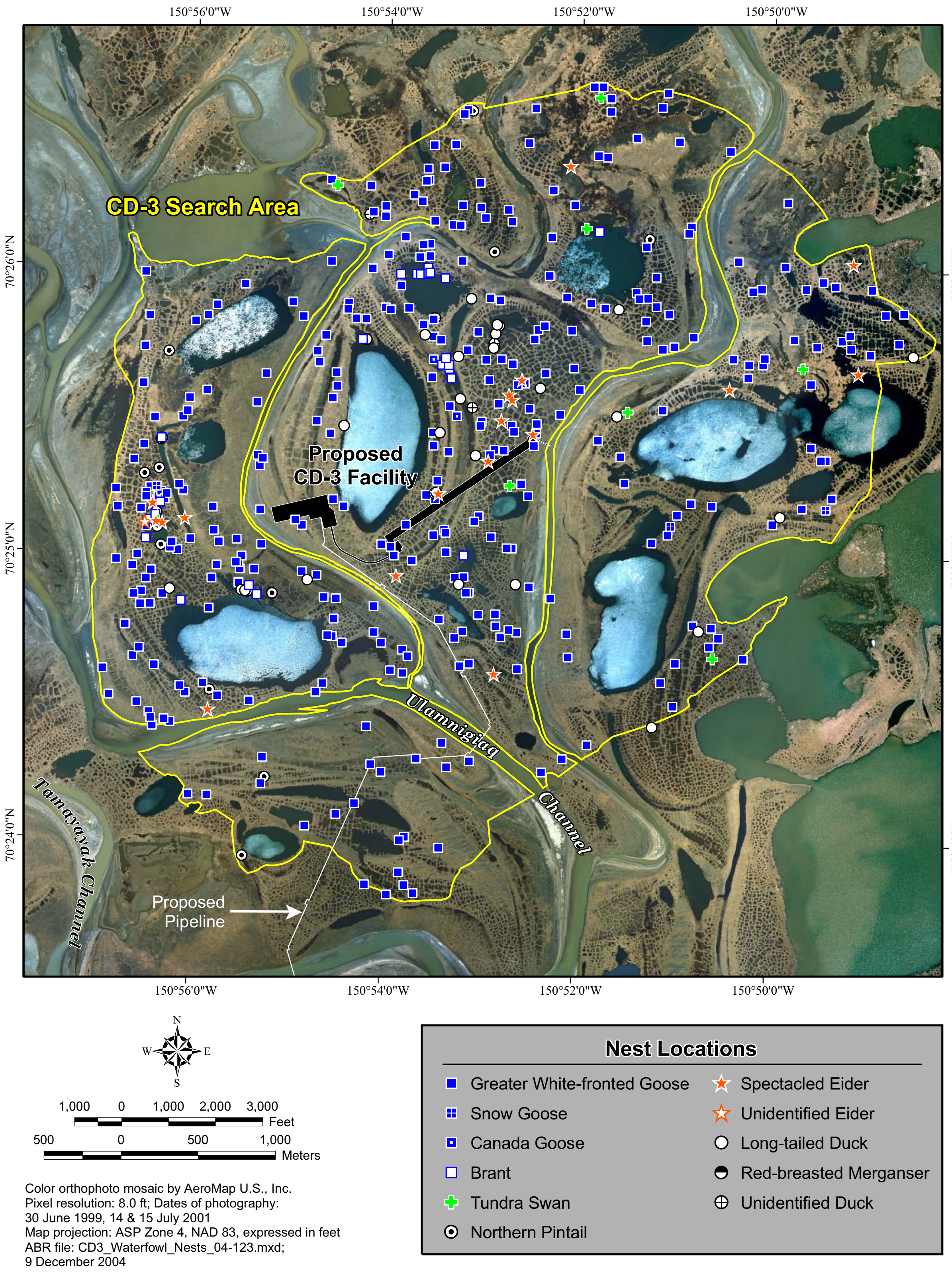

Figure 12. Waterfowl nests in the CD-3 search area, Colville River Delta, Alaska, 2004.

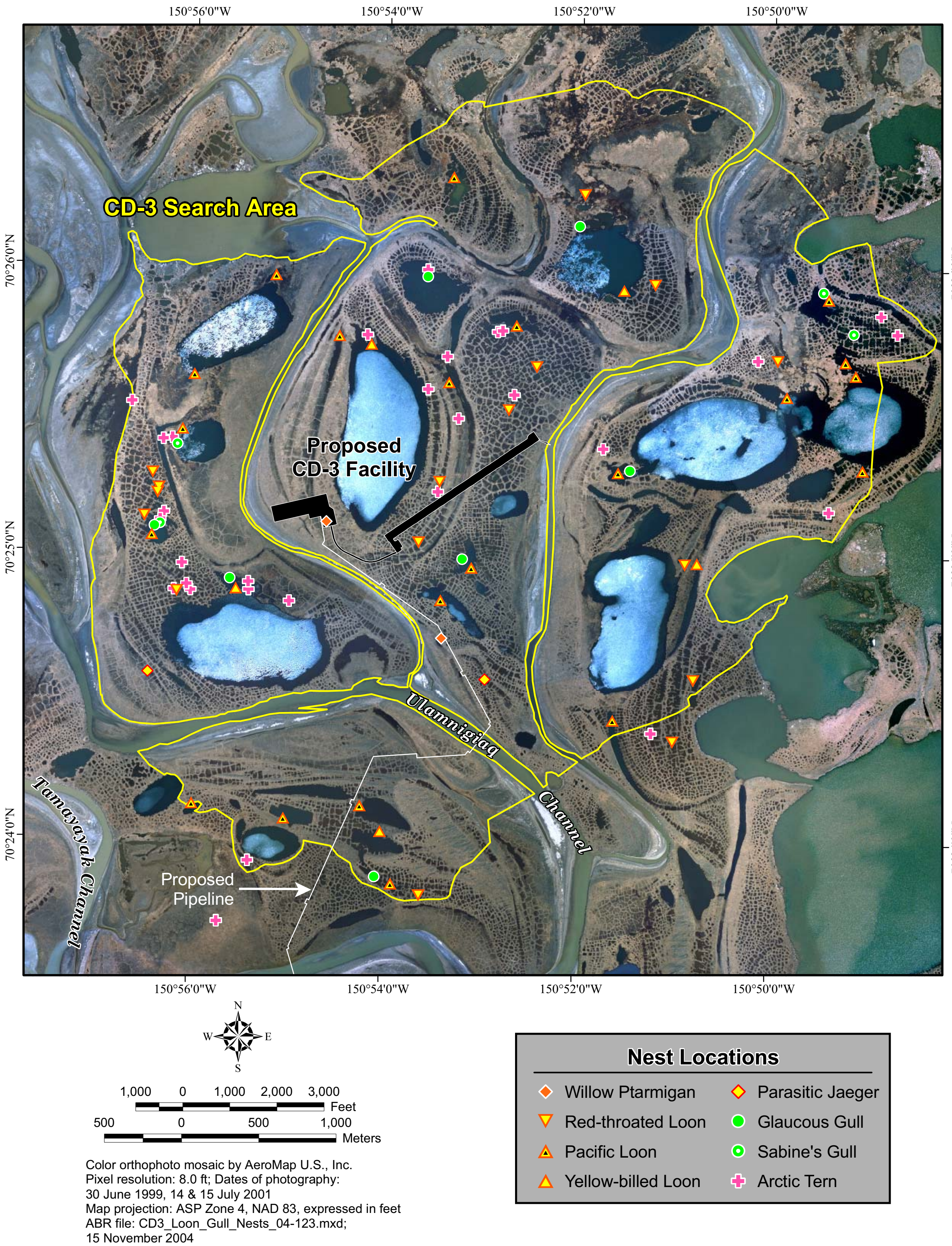

Figure 13. Loon, gull, and other bird nests in the CD-3 search area, Colville River Delta, Alaska, 2004.

Table 5. Number and density of nests and nesting success of birds in the CD-3 search area, Colville River Delta, Alaska, 2004.

Species	Number of Nests				Success[a] (%)	Density[b] (nests/km²)
	Total	Successful	Failed	Unknown		
Greater White-fronted Goose[c]	330	216	107	7	67	18.3
Snow Goose	3	2	1	0	67	0.2
Canada Goose	4	2	1	1	67	0.2
Brant[c]	23	11	9	3	55	1.3
Tundra Swan	8	5	3	0	63	0.4
Northern Pintail[c]	11	1	8	2	11	0.6
Spectacled Eider[c]	18	9	9	0	50	1.0
Unknown eider	1	0	1	0	0	0.1
Long-tailed Duck[c]	32	9	21	2	30	1.8
Red-breasted Merganser	1	1	0	0	100	0.1
Unknown duck	4	0	4	0	0	0.2
Willow Ptarmigan	2	1	0	1	–	0.1
Red-throated Loon[d]	16	5	1	10	–	0.9
Pacific Loon	20	8	2	10	–	1.1
Yellow-billed Loon	5	4	0	0	–	0.3
Parasitic Jaeger	2	2	0	0	–	0.1
Glaucous Gull	7	4	1	2	–	0.4
Sabine's Gull	4	1	0	3	–	0.2
Arctic Tern	26	8	0	18	–	1.4
Total	518	289	168	60	61	28.7

[a] Estimates are provided only for waterfowl, as explained in text; nest success = no. successful / (no. successful + no. failed) × 100
[b] Density calculations based on a search area of 18.0 km²
[c] Includes nests identified to species from down and feather characteristics
[d] Includes 1 nest that was presumed present from the presence of a brood observed during August

All 3 species of loons nested in the CD-3 search area in 2004, with Pacific Loons being most common (20 nests), followed by Red-throated Loons (16 nests), and Yellow-billed Loons (5 nests) (Figure 13, Table 5). Loon nest density is typically low and, in 2004, densities were generally comparable to those of prior years (Johnson 2003b, 2004). Gulls and terns also nested in the CD-3 search area in 2004, with Arctic Tern nests more common (26 nests) than either Glaucous Gull nests (7) or Sabine's Gull nests (4). Two Parasitic Jaeger nests and 2 Willow Ptarmigan nests were found in the CD-3 search area in 2004.

In general, nesting success of geese was high and comparable to prior years, as approximately 67% of Greater White-fronted, Snow, and Canada geese were successful (Table 5). As is typical for Brant, their nesting success (55%) was lower than that of other geese in 2004, but was within the range of values from prior years (10–62%). Sixty-three percent of all Tundra Swan nests hatched, which was within the range of values from previous years (25–100%). Nesting success of ducks is typically poor by comparison with geese and swans and, over all species, only 32% of duck nests of known fate hatched.

During nest-fate checks and ground searches for broods in 2004, 53 brood-rearing groups of 12 species were recorded in the CD-3 search area (Figure 14, Table 6). Broods of all 3 species of loons were observed in the search area, but only broods of 1 species of goose (Greater

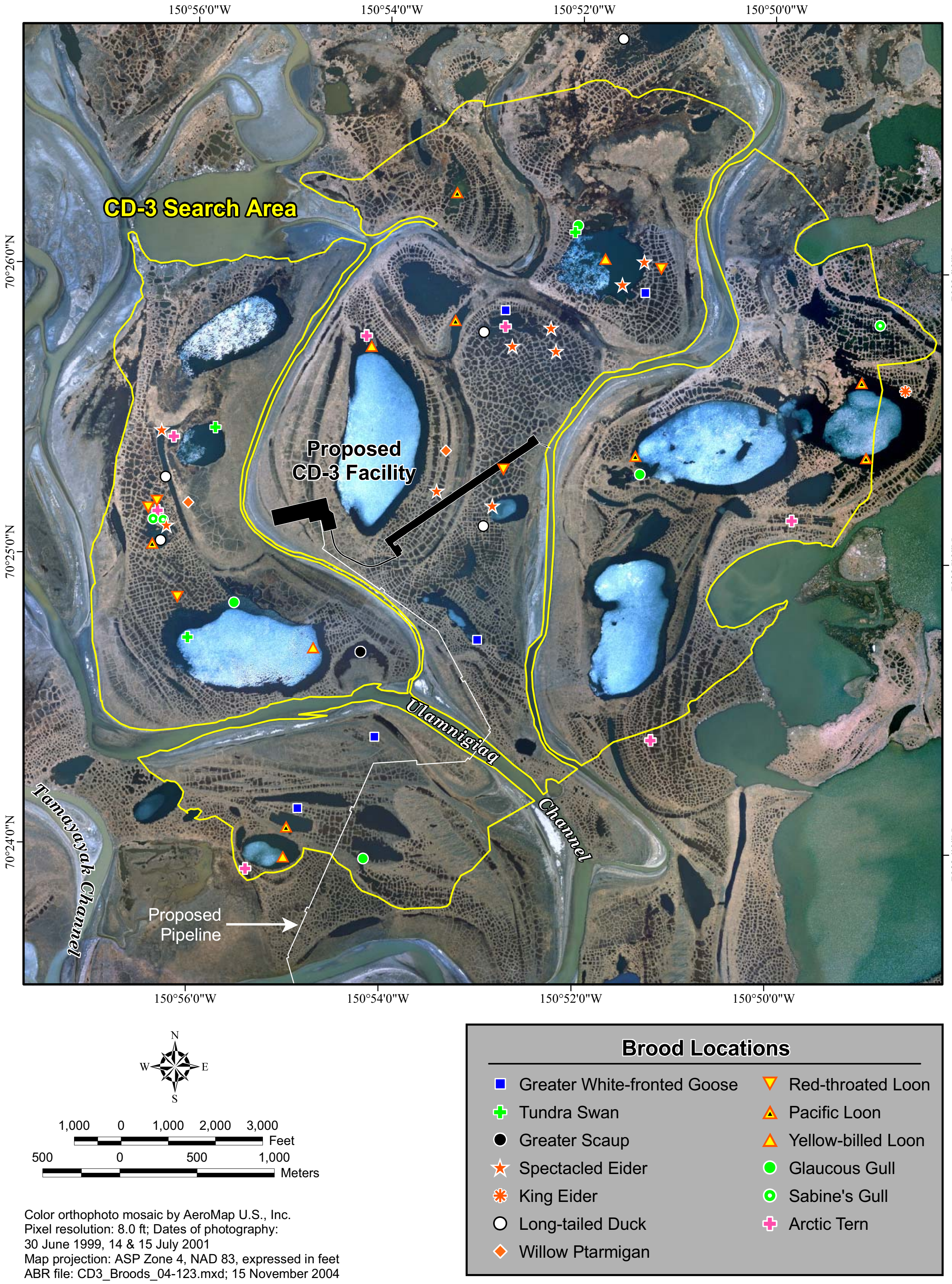

Figure 14. Large waterbird broods in the CD-3 search area, Colville River Delta, Alaska, July and August 2004.

Table 6. Number of brood-rearing adults and young in the CD-3 search area, Colville River Delta, Alaska, July and August 2004.

Species	Adults	Young	Broods or Groups
Greater White-fronted Goose	20	23	5
Tundra Swan	5	9	3
Greater Scaup	1	5	1
Spectacled Eider	9	35	9
Long-tailed Duck	5	29	4
Willow Ptarmigan	2	2	2
Red-throated Loon	5	6	5
Pacific Loon	12	8	7
Yellow-billed Loon	8	6	4
Glaucous Gull	9	7	4
Sabine's Gull	8	5	3
Arctic Tern	15	7	6
Total	100	142	53

White-fronted Goose) were recorded. Two Tundra Swan broods were seen during the July visit, but only 1 during the August visit. Broods of Long-tailed Ducks and Spectacled Eiders were observed during both visits, and a Greater Scaup brood was observed during August, although no nests of this species had been found in the area in 2004. Broods of Arctic Terns and Sabine's Gulls were observed only during July, while Glaucous Gull broods were observed in the search area during both months. Broods were undoubtedly undercounted, because young of many species are cryptic and use vegetation to hide; thus, numbers reported here are minimal counts.

Habitat Use

Habitats with polygonal surface forms contained the highest numbers of nests in the CD-3 search area in 2004. Patterned Wet Meadow contained 170 nests (33% of the total) while Deep Polygon Complex contained 131 nests (26%) (Table 7). Other habitats that contained ≥10% of all nests included Nonpatterned Wet Meadow and Deep Open Water with Islands or Polygonized Margins. Patterned Wet Meadow had the highest species richness for nests (15 species) followed by Deep Open Water with Islands or Polygonized Margins (11 species) and Deep Polygon Complex (10 species). All other habitat types had less than 10 nesting species. Only 1 habitat type was used considerably more for nesting (proportionally) than its availability; Deep Polygon Complex contained 26% of all nests, but occupied 12% of the total area.

Most (66%) broods and/or brood-rearing groups were observed in aquatic habitats, including both types of Deep Open Lakes (44% of all groups), Shallow Open Water with Islands or Polygonized Margins (8%), and Tapped Lake with High-water Connection (8%; Table 8). Species richness was greatest in Deep Open Water with Island or Polygonized Margins (9 species). Three habitat types were used in substantially greater proportion than their availability: Deep Open Water with Islands or Polygonized Margins (36% of broods, 10% of total area), Deep Polygon Complex (23% of broods, 12% of total area), and Shallow Open Water with Islands or Polygonized Margins (8% of broods, 1% of total area).

Table 7. Habitat use (%) during nesting in the CD-3 search area, Colville River Delta, Alaska, 2004.

Habitat	Greater White-fronted Goose[a]	Snow Goose	Canada Goose	Brant[a]	Tundra Swan	Northern Pintail[a]	Spectacled Eider[a]	Unknown eider	Long-tailed Duck[a]	Red-breasted Merganser	Willow Ptarmigan	Red-throated Loon[b]	Pacific Loon	Yellow-billed Loon	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Number of Nests	Number of Species[c]
Brackish Water	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	<1	1	1
Tapped Lake with High-water Connection	0	0	0	0	0	0	6	0	0	0	0	0	20	0	0	14	0	0	1	6	3
Salt Marsh	3	0	0	0	13	0	0	0	3	0	0	7	0	0	0	0	0	0	3	13	4
Salt-killed Tundra	10	0	0	0	13	27	6	0	0	0	0	7	10	0	0	0	25	12	9	44	8
Deep Open Water without Islands	0	0	0	4	0	0	6	0	6	0	0	0	20	0	0	0	0	4	2	10	5
Deep Open Water with Islands or Polygonized Margins	0	0	25	74	25	0	11	100	22	100	0	0	30	60	0	86	25	27	11	55	11
Shallow Open Water without Islands	1	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	<1	3	2
Shallow Open Water with Islands or Polygonized Margins	1	0	25	4	0	0	0	0	9	0	0	13	5	0	0	0	0	8	2	12	7
Deep Polygon Complex	27	0	0	13	25	27	33	0	22	0	0	47	5	0	0	0	25	42	26	131	10
Nonpatterned Wet Meadow	17	0	25	0	0	0	0	0	3	0	0	0	0	0	50	0	0	4	12	59	5
Patterned Wet Meadow	40	67	25	4	25	36	39	0	31	0	100	27	5	40	50	0	25	4	33	170	15
Moist Sedge–Shrub Meadow	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	5	2
Tall, Low, or Dwarf Shrub	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	2	1
Barrens	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	1	1
Number of nests	330	3	4	23	8	11	18	1	32	1	2	15	20	5	2	7	4	26		512	

[a] Includes nests identified to species from feather and down samples
[b] Excludes 1 nest whose exact location was unknown, but whose presence was presumed due to the observation of a brood
[c] The total number of species nesting at CD-3 was 17

Table 8 . Habitat use (%) during brood-rearing in the CD-3 search area, Colville River Delta, Alaska, 2004.

Habitat	Greater White-fronted Goose	Tundra Swan	Greater Scaup	Spectacled Eider	Long-tailed Duck	Willow Ptarmigan	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Number of Groups	Number of Species[a]
Brackish Water	0	33	0	0	0	0	0	0	0	0	0	0	2	1	1
Tapped Lake with High-water Connection	0	0	0	0	0	0	0	43	0	25	0	0	8	4	2
Salt-killed Tundra	0	0	0	0	0	0	0	0	0	0	0	17	2	1	1
Deep Open Water without Islands	0	0	0	11	25	0	0	14	25	0	0	0	8	4	4
Deep Open Water with Islands or Polygonized Margins	20	33	0	44	25	0	0	43	75	75	67	17	36	19	9
Shallow Open Water without Islands	0	0	0	0	0	0	0	0	0	0	0	17	2	1	1
Shallow Open Water with Islands or Polygonized Margins	0	0	0	0	0	0	40	0	0	0	0	33	8	4	2
Deep Polygon Complex	20	0	0	44	50	50	60	0	0	0	33	0	23	12	6
Grass Marsh	0	0	100	0	0	0	0	0	0	0	0	0	2	1	1
Nonpatterned Wet Meadow	0	0	0	0	0	50	0	0	0	0	0	0	2	1	1
Patterned Wet Meadow	60	33	0	0	0	0	0	0	0	0	0	17	9	5	3
Number of Groups	5	3	1	9	4	2	5	7	4	4	3	6		53	

[a] The total number of species observed at CD-3 during brood-rearing was 12

NPRA STUDY AREA

Distribution and Abundance

Proposed Pad Sites

CD-5—The search area for the proposed CD-5 pad site was located in the northeast corner of the NPRA study area (Figure 5) in an area dominated by moist and wet polygonal habitats (Figure 3, Table 4). Four habitat types occupied most of the CD-5 search area: Patterned Wet Meadow (29%), Moist Tussock Tundra (22%), Old Basin Wetland Complex (19%), and Moist Sedge–Shrub Meadow (19%). No other habitat type comprised >9% of the total area.

Eighty-one nests of 12 species were located in the CD-5 search area in 2004 (Figure 15, Table 9). Three-fourths of these nests belonged to geese, including Greater White-fronted Goose (33 nests), Canada Goose (20 nests), and Brant (8 nests). All other species had ≤4 nests in the study area. The total nest density in the CD-5 search area was 20 nests/km² (Table 9). CD-5 has had higher nest densities than the other 2 pad search areas in the NPRA in all 3 years nest searches have been conducted in these areas (Burgess et al. 2003b, Johnson et al. 2004). Overall nest density in CD-5 in 2004 was lower than that observed in the CD-3 search area (Table 5). Nests in CD-5 are concentrated in a mixed-species nesting colony located in a wetland basin with complex shorelines and many small islands (Figure 15). All Canada Goose, Brant, Pacific Loon and gull nests, and most of the duck nests in the CD-5 search area were located in this wetland basin.

The Greater White-fronted Goose was the most abundant large waterbird nesting in the CD-5 search area followed by Canada Goose and Brant (Table 9). Although the density of Greater White-fronted Goose nests at CD-5 (8 nests/km²) was the highest among all the NPRA search areas, the nest density for this species at CD-5 was less than half that found in the CD-3 search area in 2004. Canada Goose nests, however, occurred at a markedly higher density at CD-5 (5 nests/km²) than at CD-3 (0.2 nests/km²) in 2004.

Three species of ducks nested in the CD-5 search area in 2004. Of 9 total duck nests at CD-5, 4 belonged to King Eiders, 4 to Long-tailed Ducks, and 1 belonged to a Northern Pintail (Figure 15, Table 9). Overall nesting density of ducks (2.2 nests/km²) in CD-5 was higher than in the other NPRA search areas in 2004.

Pacific Loon nests were found at CD-5 in 2004, and although no Red-throated Loon nests were found in 2004, they have been found there in past years (Burgess et al 2003b, Johnson et al. 2004). Four Glaucous Gull and 2 Arctic Tern nests also were found at CD-5 in 2004.

Four broods were observed in the CD-5 search area in July 2004 (Figure 16). Parasitic Jaegers and Glaucous Gulls each had a brood, and Arctic Terns had 2 broods (Table 10).

CD-6—In 2004, the search area for the proposed CD-6 pad site was located in the north-central portion of the NPRA study area (Figure 5) and comprised 4.1 km² of primarily Moist Tussock Tundra (59% of the area; Figure 3, Table 4). Permanent waterbodies in the CD-6 search area were limited to a beaded stream (Riverine Complex) and the northern tip of a large lake (Deep Open Water without Islands). Eight habitat types occurred in the CD-6 search area, and in addition to Moist Tussock Tundra, only Moist Sedge–Shrub Meadow (20% of the area) and Patterned Wet Meadow (12%) comprised >5% of the search area. Aquatic habitats comprised ~6% of the CD-6 search area.

The CD-6 search area had the lowest density of nests and species diversity of all the NPRA search areas. Fourteen nests of 7 species were found in the CD-6 search area in 2004 (Figure 17, Table 9). Northern Pintail (4 nests) were the most common nesting species followed by Greater White-fronted Geese (3 nests). All other species had ≤2 nests. One Yellow-billed Loon nest and 1 Red-throated Loon nest also were found in 2004. Nest density for all species combined was 3.4 nests/km² in the CD-6 search area in 2004, which was ~17% of the density observed in the CD-5 search area.

Only 1 brood was observed in the CD-6 search area (Figure 18, Table 10) and that brood belonged to an Arctic Tern. Low numbers of waterbird broods would be expected for an area such as CD-6, which had low densities of nests and few waterbodies for rearing broods.

CD-7—The search area (5.5 km²) for the proposed CD-7 pad site was the most southwestern search area in the NPRA study area (Figure 5). In contrast to the more upland CD-6 search area, the

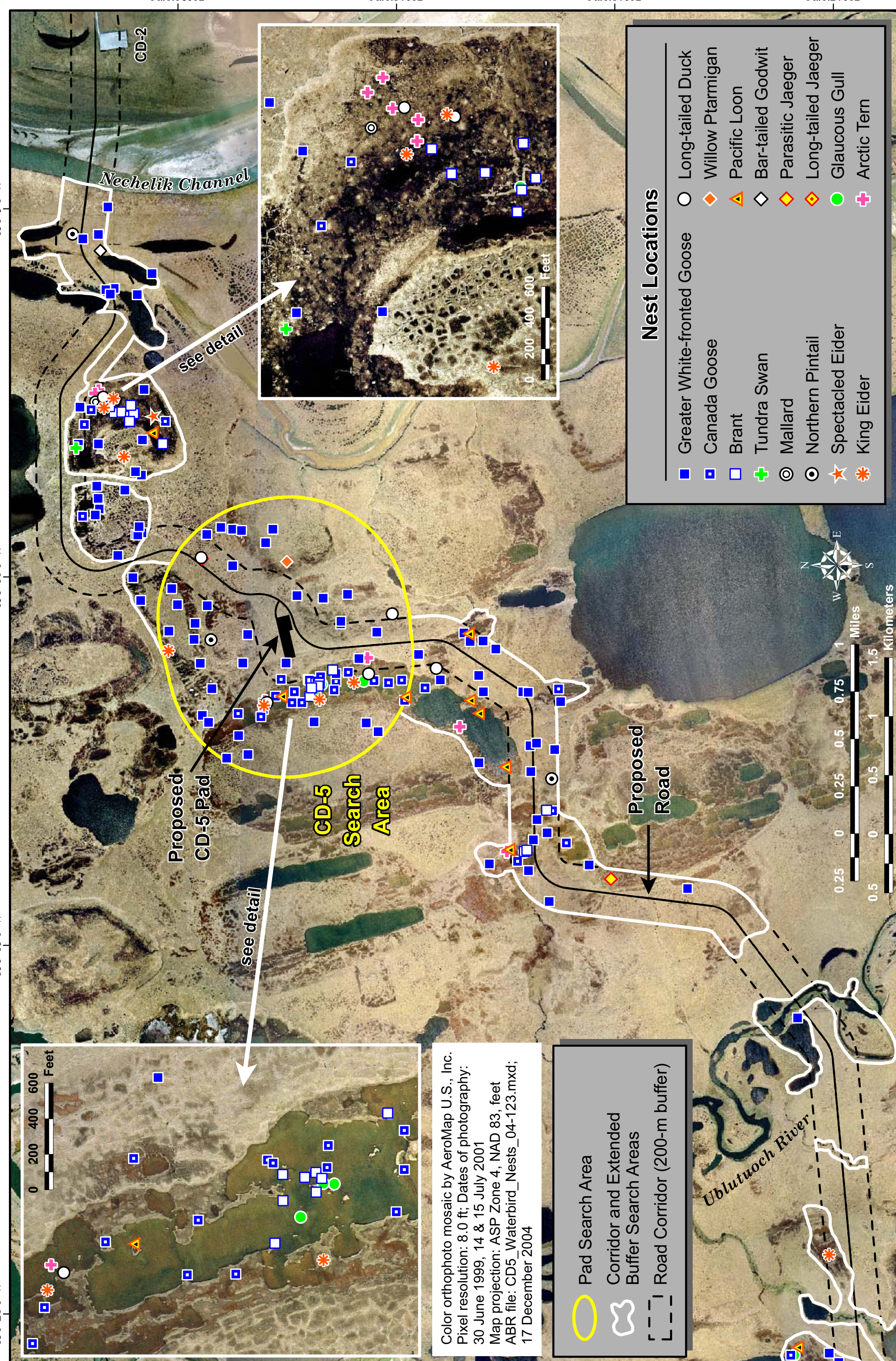

Figure 15. Large waterbird nests in the CD-5 search area and eastern corridor and extended buffer search areas, NPRA, Alaska, 2004.

Table 9. Number and density (nests/km²) of nests in the CD-5, CD-6, and CD-7 search areas, NPRA study area, Alaska, 2004.

	CD-5		CD-6		CD-7	
Species	Number	Density	Number	Density	Number	Density
Greater White-fronted Goose	33	8.0	3	0.7	4	0.7
Canada Goose	20[a]	5.0	0	0	1	0.2
Brant	8	1.9	0	0	2[a]	0.4
Northern Pintail	1	0.2	4	1.0	0	0
King Eider	4	1.0	0	0	1	0.2
Long-tailed Duck	4[a]	1.0	0	0	5[a]	0.9
Unknown duck	0	0	0	0	2	0.4
Willow Ptarmigan	1	0.2	0	0	0	0
Red-throated Loon	0	0	1	0.2	0	0
Pacific Loon	2	0.5	0	0	7[b]	1.3
Yellow-billed Loon	0	0	1	0.2	1	0.2
Bar-tailed Godwit	0	0	2	0.5	0	0
Parasitic Jaeger	1	0.2	1	0.2	2	0.4
Long-tailed Jaeger	1	0.2	0	0	0	0
Glaucous Gull	4	1.0	0	0	1	0.2
Sabine's Gull	0	0	0	0	3	0.5
Arctic Tern	2	0.5	2	0.5	4	0.7
Area searched (km²)	4.12		4.12		5.51	
Waterbird[c] nest density	19.5		3.4		6.0	
Total nest density	19.7		3.4		6.0	
Total number of nests	81		14		33	
Number of species	12		7		11	

[a] Includes 1 nest identified to species by feather and down sample
[b] Includes 1 case of renesting (loon pair used two nest sites in one season); density without the renesting = 1.1 nests/km²
[c] Waterbirds include loons, grebes, geese, swans, ducks, cranes, jaegers, gulls, terns, and large shorebirds

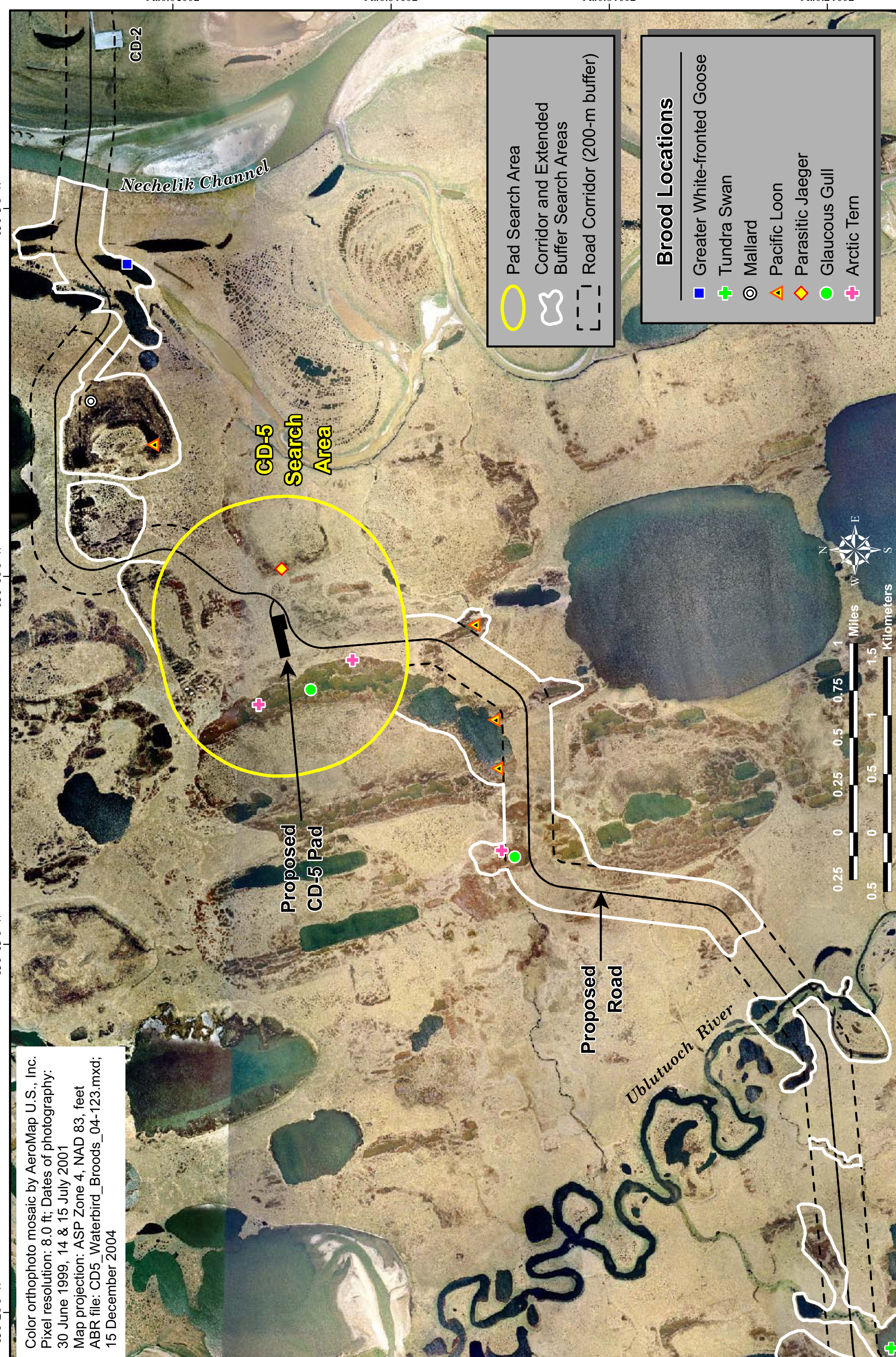

Figure 16. Large waterbird broods in the CD-5 search area and eastern corridor and extended buffer search areas, NPRA, Alaska, July and August 2004.

Table 10. Number of brood-rearing adults and young in the CD-5, CD-6, CD-7, corridor, and extended buffer search areas, NPRA study area, Alaska, July 2004.

	CD-5			CD-6			CD-7			Corridor			Extended Buffer		
Species	Adults	Young	Groups	Adults	Young	Groups	Adults	Young	Groups	Adults	Young	Groups	Adults	Young	Groups
Greater White-fronted Goose	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1
Tundra Swan	0	0	0	0	0	0	0	0	0	0	0	0	1	4	1
Mallard	0	0	0	0	0	0	0	0	0	0	0	0	1	7	1
King Eider	0	0	0	0	0	0	0	0	0	4	6	1	0	0	0
Pacific Loon	0	0	0	0	0	0	2	1	1	0	0	0	7	5	4
Parasitic Jaeger	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Glaucous Gull	2	1	1	0	0	0	1	1	1	2	1	1	0	0	0
Sabine's Gull	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1
Arctic Tern	4	4	2	1	1	1	3	1	1	0	0	0	6	4	3
Total	7	6	4	1	1	1	6	3	3	6	7	2	20	24	11

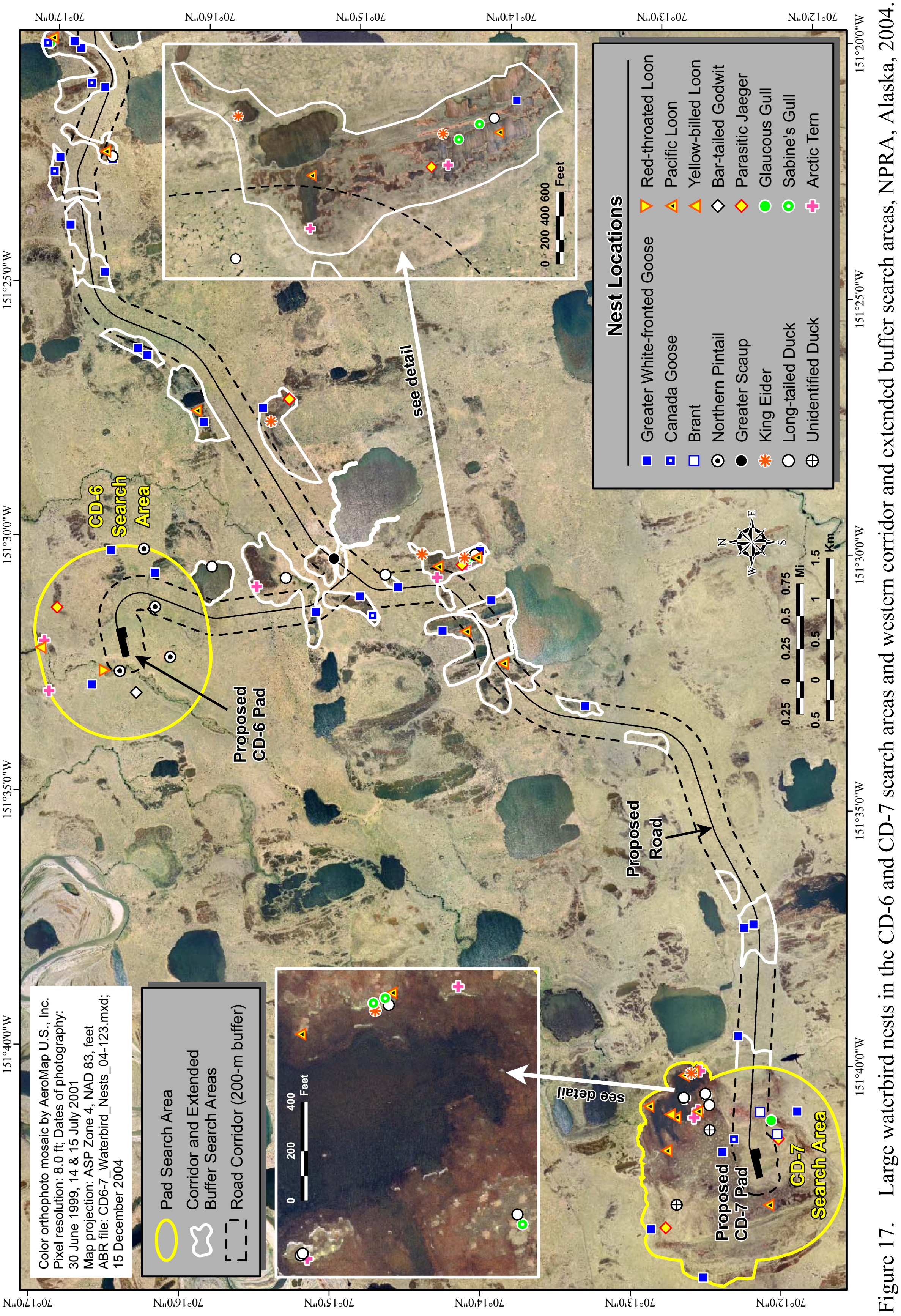

Figure 17. Large waterbird nests in the CD-6 and CD-7 search areas and western corridor and extended buffer search areas, NPRA, Alaska, 2004.

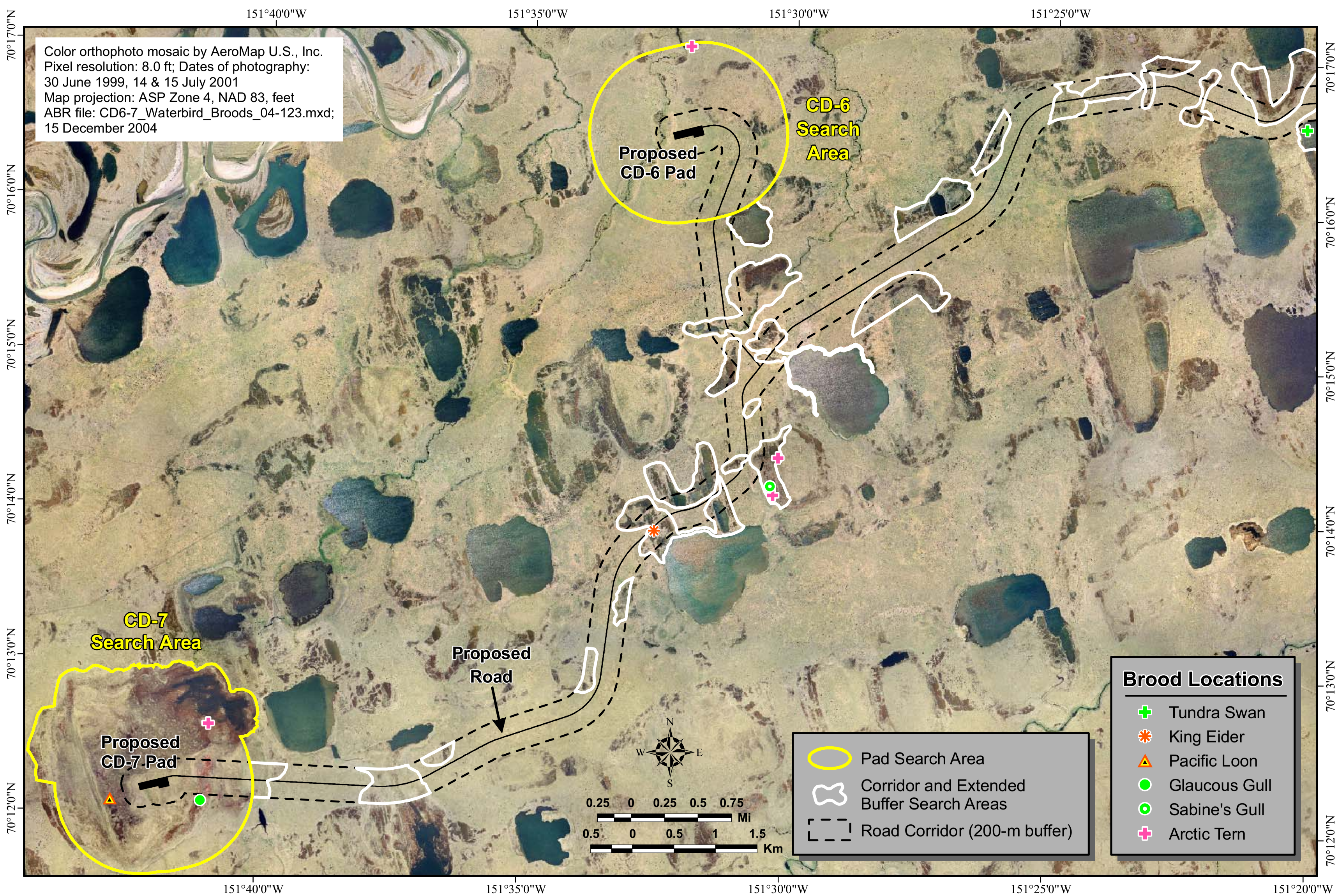

Figure 18. Large waterbird broods in the CD-6 and CD-7 search areas and western corridor and extended buffer search areas, NPRA, Alaska, July and August 2004.

dominant feature in the CD-7 search area is a large wetland basin (Figure 3). In 2004, the CD-7 search area comprised primarily aquatic and wet meadow habitats, each occupying 38% of the area (Table 4). Ten habitat types were present in the search area, and the 4 major habitat types were Nonpatterned Wet Meadow (34%), Young Basin Wetland Complex (20%), Moist Sedge–Shrub Meadow (17%), and Sedge Marsh (13%). No other habitat comprised >6% of the 2004 search area.

Thirty-three nests of 11 species were found in the CD-7 search area in 2004 (Figure 17, Table 9). Pacific Loon (7 nests, 1 of which was a suspected renesting attempt) was the most abundant nester at CD-7, followed by Long-tailed Duck (5 nests), Greater White-fronted Goose (4 nests), and Arctic Tern (4 nests). All other species had ≤3 nests. Single nests of Yellow-billed Loon and King Eider also were found in the search area. Nest density of all species combined in the CD-7 search area in 2004 was 6 nests/km² (Table 9).

Three species of goose—Greater White-fronted Goose, Canada Goose, and Brant—nested at CD-7 in 2004 (Table 9). Canada Geese and Brant were not recorded nesting in CD-7 in 2002 or 2003 (Burgess et al. 2003b; Johnson et al. 2004). The density of Greater White-fronted Goose nests in the CD-7 search area was low (0.7 nests/km²), similar to their density in the CD-6 search area. Eight duck nests—1 King Eider, 5 Long-tailed Duck, and 2 unidentified duck nests—were found, yielding 1.5 nests/km². The density of ducks at CD-7 in 2004 was higher than in the CD-6 search area, but still lower than in the CD-5 search area (Table 9).

Eight loon nests (7 Pacific Loon and 1 Yellow-billed Loon) in the CD-6 search area resulted in 1.5 nests/km² for loons, which was the highest loon nest density reported among the NPRA search areas (Table 9). The density of Pacific Loon nests (1.3 nests/km²) in the CD-7 search area was higher than in any other search area in the NPRA or at CD-3. The majority of loon nests at CD-7 were located on one lake, which had a complex shoreline and abundant emergent vegetation (Figure 17).

Three broods were observed in the CD-7 search area in July 2004. The broods belonged to 3 different species: Pacific Loon, Glaucous Gull, and Arctic Tern (Figure 18, Table 10).

Proposed Road Corridor

The corridor and extended buffer search areas (10.2 km²) followed the proposed road route from the Nechelik Channel southwest to the CD-7 pad (Figure 5). In 2004, the corridor search areas sampled 37% of the 400-m-wide road corridor (5.2 km² of a total 13. 9 km²) plus 5 km² of wetlands in the extended buffer search areas (beyond the 400-m-wide road corridor). The most abundant habitat types in the combined corridor and extended buffer search areas were Old Basin Wetland Complex (24% of total), Patterned Wet Meadow (17%), and Moist Sedge–Shrub Meadow (17%; Table 11). Aquatic habitats comprised an additional 25% of the corridor search area.

One hundred and sixty-four nests of 17 species were located in the combined corridor and extended buffer search areas for an overall density of 16 nests/km². (Figures 15 and 17, Table 12). Nearly half of these nests belonged to Greater White-fronted Geese (78 nests). Other common nesters were Canada Goose (14 nests), Brant (13 nests), Pacific Loon (13 nests), and Arctic Tern (11 nests). The remaining species had <10 nests each. One Spectacled Eider nest was found in an extended buffer search area northeast of the CD-5 site (Figure 15), which was the only Spectacled Eider nest found in NPRA search areas in 2004 (Table 13).

Twelve broods of 6 species were observed in the combined corridor and extended buffer search areas in 2004 (Table 10). Only one of the 12 broods was located in the corridor search areas (i.e., within 200-m of the road centerline). Pacific Loons and Arctic Terns each had 4 broods and the remaining species had single broods.

Nesting Success

Nesting success was evaluated for all of the NPRA search areas combined (Table 13). Nesting success for geese was moderate to high with 76% of Brant, 74% of Greater White-fronted Geese, and 53% of Canada Geese nests successful. Nesting success for King Eiders and Long-tailed Ducks was 60% and 18%, respectively. Nesting success for Long-tailed Ducks may actually have been higher than this estimate because 6 nests (30% of the total) were still in incubation at the time of nest-fate visit. Long-tailed Ducks typically nest later than other waterfowl in the area. For all duck

Table 11. Habitat availability in the road corridor and in the combined corridor and extended buffer search areas, NPRA study area, Alaska, 2004.

	Road Corridor[a]		Corridor and Extended Buffer Search Areas	
Habitat	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Deep Open Water without Islands	0.15	1.1	0.63	6.2
Deep Open Water with Islands or Polygonized Margins	0.04	0.3	0.31	3.0
Shallow Open Water without Islands	0.10	0.7	0.29	2.9
Shallow Open Water with Islands or Polygonized Margins	0.15	1.1	0.46	4.5
River or Stream	0.09	0.7	0.06	0.6
Sedge Marsh	0.12	0.8	0.29	2.9
Young Basin Wetland Complex	0.09	0.6	0.47	4.6
Old Basin Wetland Complex	1.14	8.2	2.40	23.7
Riverine Complex	0.06	0.4	0.08	0.8
Nonpatterned Wet Meadow	0.59	4.3	0.62	6.1
Patterned Wet Meadow	1.46	10.5	1.72	16.9
Moist Sedge–Shrub Meadow	3.78	27.2	1.71	16.8
Moist Tussock Tundra	5.76	41.5	1.00	9.9
Tall, Low, or Dwarf Shrub	0.20	1.4	0.12	1.2
Barrens	0.11	0.8	0	0
Human Modified	0.04	0.3	0	0
Total	13.89	100	10.16	100

[a] Total area within 200 m of road centerline excluding pad search areas; see Figure 5

species combined, nesting success was 34% (11 successful of 32 nests of known fate). Nine ducks (22% of the total) were still attending their clutches during our final nest visits.

Habitat Use

As with nesting success, habitat use also was evaluated for all NPRA search areas combined, including pad, corridor, and extended buffer search areas (23.9 km² total area; Table 14). Habitat use was documented for 277 nests of 20 species in the 2004 NPRA search areas. Birds nested in 10 of the 16 available habitat types. Seventy-three percent of nests were located in 5 habitat types: Old Basin Wetland Complex (21% of nests, 14% of total area), Shallow Open Water with Islands or Polygonized Margins (18% of nests, 4% of total area), Patterned Wet Meadow (13% of nests, 15% of total area), Young Basin Wetland Complex (11% of nests, 7% of total area), and Moist Sedge–Shrub Meadow (10% of nests, 18% of total area). Shallow Open Water with Islands or Polygonized Margins was used for nesting in far greater proportion than its availability, while Moist Tussock Tundra was used very little in proportion to availability (7% of nests, 20% of total area). Species richness was greatest in Young Wetland Complex (11 species), Sedge Marsh (9 species), and Old Basin Wetland Complex (9 species). Eight species nested in Shallow Open Water with Islands or Polygonized Margin and Moist Sedge–Shrub Meadow, and no other habitat type had >7 nesting species. We emphasize that the search areas were not a representative sample of the available habitats in the NPRA study area, thus the abundance of wet and aquatic habitats is higher and the abundance of moist and dry habitats is lower than it was for the larger study area (Table 3). Any comparisons of use and availability from these data should be made cautiously and differences would likely be more extreme, if calculated for the NPRA

Table 12. Number and density (nests/km²) of nests in the corridor and extended buffer search areas, NPRA study area, Alaska, 2004.

	Corridor		Extended Buffer		Total	
Species	Number	Density	Number	Density	Number	Density
Greater White-fronted Goose	50	9.6	28	5.7	78	7.7
Canada Goose	5	1.0	9	1.8	14	1.4
Brant	5	1.0	8[a]	1.6	13	1.3
Tundra Swan	1	0.2	0	0.0	1	0.1
Mallard	0	0.0	1	0.2	1	0.1
Northern Pintail	3[a]	0.6	0	0.0	3	0.3
Greater Scaup	1	0.2	0	0.0	1	0.1
Spectacled Eider	0	0.0	1	0.2	1	0.1
King Eider	1	0.2	6	1.2	7	0.7
Long-tailed Duck	2[a]	0.4	7	1.4	9	0.9
Pacific Loon	2	0.4	11	2.2	13	1.3
Bar-tailed Godwit	3	0.6	0	0.0	3	0.3
Parasitic Jaeger	1	0.2	2	0.4	3	0.3
Long-tailed Jaeger	1	0.2	0	0.0	1	0.1
Glaucous Gull	1	0.2	2	0.4	3	0.3
Sabine's Gull	0	0.0	2	0.4	2	0.2
Arctic Tern	2	0.4	9	1.8	11	1.1
Area searched (km²)	5.21		4.95		10.16	
Waterbird[b] nest density	15.0		17.4		16.1	
Total nest density	15.0		17.4		16.1	
Total number of nests	78		86		164	
Number of species	14		12		17	

[a] Includes 1 nest identified to species by feather and down sample
[b] Waterbirds include loons, grebes, swans, ducks, cranes, jaegers, gulls, terns, and large shorebirds

study area, due to the preponderance of moist habitats (Table 3).

In 2004, the guild of birds nesting primarily in aquatic habitats (species with >4 nests and >75% use of aquatic habitats) included Brant, Glaucous Gulls, Pacific Loons, and Arctic Terns. The guild of birds nesting primarily in non-aquatic habitats (wet or moist meadows and tundra) included Northern Pintail and Bar-tailed Godwit. Habitat use by geese, swans, eiders, loons, and gulls are discussed in detail in their respective species accounts, below.

Twenty-one brood locations of 9 species were recorded in July 2004 (Figures 16 and 18, Table 15). Eighty percent of all brood locations occurred in open water habitats. The greatest number of broods and the highest species diversity occurred in Shallow Open Water with Islands or Polygonized Margins (52% of all broods, 5 species). Only 1 species, Parasitic Jaeger, was observed with broods in non-aquatic habitats. Open water habitat types were used in higher proportion than their availability (Table 14), particularly Shallow Open Water with Islands or Polygonized Margins (52% of locations, 4% of total area).

NPRA BREEDING-BIRD PLOTS

NEST DENSITIES

During 5 visits (plot marking and nest searching visits) to 24 breeding-bird plots in 2004, 188 nests were found belonging to 19 species of

Table 13. Number and density of nests and nesting success of birds in the combined search areas, NPRA study area, Alaska, 2004.

Species	Number of Nests				Success[a] (%)	Density[b] (nests/km²)
	Total	Successful	Failed	Unknown		
Greater White-fronted Goose	113	83	29	1	74	4.7
Canada Goose	34[c]	17	15	2	53	1.4
Brant	21[c]	16	5	0	76	0.9
Tundra Swan	1	0	1	0	0	<0.1
Mallard	1	1	0	0	100	<0.1
Northern Pintail	7[c]	1	6	0	14	0.3
Greater Scaup	1	0	0	1	–	<0.1
Spectacled Eider	1	1	0	0	100	<0.1
King Eider	12[c]	6	4	2	60	0.5
Long-tailed Duck	17[d]	2	9	6	18	0.7
Unknown duck	2	0	2	0	0	0.1
Willow Ptarmigan	1	1	0	0	–	<0.1
Red-throated Loon	1	0	0	1	–	<0.1
Pacific Loon	22[e]	9	3	10	–	0.9
Yellow-billed Loon	2	0	1	1	–	0.1
Bar-tailed Godwit	4	1	1	2	–	0.2
Parasitic Jaeger	7	3	0	4	–	0.3
Long-tailed Jaeger	1	0	0	1	–	<0.1
Glaucous Gull	8	7	0	1	–	0.3
Sabine's Gull	5	0	0	5	–	0.2
Arctic Tern	18	8	2	8	–	0.8
Total	279	156	78	45	–	11.7

[a] Estimates are provided only for waterfowl and ptarmigan, as explained in text; nest success = number successful / (number successful + number failed) × 100
[b] Density calculations based on a combined search area of 23.9 km²
[c] Includes 1 nest identified to species by feather and down sample
[d] Includes 3 nests identified to species by feather and down samples
[e] Density includes 1 case of renesting; density without renesting = 0.80 nests/km²

birds, yielding 78 nests/km² (Table 16). The nest density in 2004 was similar to the densities reported in 2002 (82 nests/km²) and 2003 (83 nests/km²) when the same plots were sampled (Burgess et al. 2003b, Johnson et al. 2004). During nest monitoring visits in 2004, an additional 4 nests were found incidentally; inclusion of these nests yielded a total density of 80 nests/km² (192 nests). Nesting species in 2004 included 8 species of shorebirds, 3 species of passerines, 6 species of waterfowl, plus Willow Ptarmigan and Arctic Terns. The total number of nests per plot found ranged from 3 to 16 nests (30–160 nests/km²; Table 16). Species composition over all plots was 49% shorebirds (92 nests, 38 nests/km²), 42% passerines (78 nests, 32 nests/km²), 6% waterfowl (12 nests, 5 nests/km²), and 3% other birds (6 nests, 2 nest/km²; Table 17), which is similar to the species composition observed during the previous 3 years (Burgess et al. 2003b, Johnson et al. 2004). In 2004, shorebirds, passerines, and waterfowl nested on at least 1 plot in all 6 plot clusters (4 plots/cluster; Table 17). The number of species per plot cluster ranged from 7 to 12 in 2004 (Appendix C1). The most common breeding species in 2004 were Lapland Longspur (75 nests, 40% of all

Table 14. Habitat availability (%) and use (%) during nesting in the combined search areas, NPRA study area, Alaska, 2004.

Habitat	Habitat Availability[a]	Greater White-fronted Goose	Canada Goose	Brant	Tundra Swan	Mallard	Northern Pintail	Greater Scaup	Spectacled Eider	King Eider	Long-tailed Duck	Willow Ptarmigan	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Bar-tailed Godwit	Parasitic Jaeger	Long-tailed Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Number of Nests	Number of Species[b]
Deep Open Water without Islands	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	1.3	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	6	1	4	2
Shallow Open Water without Islands	1.4	1	9	5	0	0	0	0	0	0	0	0	0	9	0	0	0	0	13	0	0	3	8	5
Shallow Open Water with Islands or Polygonized Margins	4.3	0	53	52	0	0	0	0	0	8	6	0	0	36	0	0	0	0	75	20	17	18	49	8
River or Stream	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sedge Marsh	4.7	1	3	0	0	0	0	0	0	8	24	0	0	27	50	0	14	0	0	40	28	8	22	9
Grass Marsh	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Young Basin Wetland Complex	6.6	4	9	43	100	100	0	0	100	17	12	0	0	0	0	0	14	0	13	0	28	11	30	11
Old Basin Wetland Complex	13.9	27	24	0	0	0	0	0	0	58	18	100	0	14	0	0	57	0	0	20	11	21	59	9
Riverine Complex	1.1	1	0	0	0	0	14	0	0	0	0	0	100	0	0	0	0	0	0	0	0	1	3	3
Nonpatterned Wet Meadow	10.8	8	3	0	0	0	0	0	0	8	12	0	0	0	0	25	0	0	0	20	6	6	16	7
Patterned Wet Meadow	14.9	30	0	0	0	0	14	0	0	0	6	0	0	0	0	25	0	0	0	0	0	13	37	4
Moist Sedge–Shrub Meadow	17.8	19	0	0	0	0	29	100	0	0	12	0	0	0	0	25	14	0	0	0	6	10	29	7
Moist Tussock Tundra	19.5	11	0	0	0	0	43	0	0	0	12	0	0	0	50	25	0	100	0	0	0	7	20	6
Tall, Low, or Dwarf Shrub	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barrens	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of nests[c]		113	34	21	1	1	7	1	1	12	17	1	1	22	2	4	7	1	8	5	18		277	

[a] % habitat availability based on a total search area of 23.9 km²

[b] The total number of species nesting in the NPRA ground-search area was 20

[c] Excludes the 2 unknown duck nests

Table 15. Habitat use (%) during brood-rearing in the combined search areas, NPRA study area, Alaska, July 2004.

Habitat	Greater White-fronted Goose	Tundra Swan	Mallard	King Eider	Pacific Loon	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	All Species	Number of Brood Groups	Number of Species[a]
Deep Open Water without Islands	100	100	0	0	0	0	0	0	0	10	2	2
Deep Open Water with Islands or Polygonized Margins	0	0	0	0	40	0	0	0	0	10	2	1
Shallow Open Water without Islands	0	0	0	0	20	0	0	0	14	10	2	2
Shallow Open Water with Islands or Polygonized Margins	0	0	0	100	40	0	100	100	57	52	11	5
Sedge Marsh	0	0	0	0	0	0	0	0	29	10	2	1
Young Basin Wetland Complex	0	0	100	0	0	0	0	0	0	5	1	1
Old Basin Wetland Complex	0	0	0	0	0	100	0	0	0	5	1	1
Number of brood groups	1	1	1	1	5	1	3	1	7		21	

[a] The total number of species observed in the NPRA search area during brood-rearing was 9

nests), Pectoral Sandpiper (24 nests, 13%), and Semipalmated Sandpiper (19 nests, 10%; Table 16). The same 3 species were the most common breeding birds on the NPRA breeding bird plots in 2001–2003 (Burgess et al. 2003b, Johnson et al. 2004).

In 2004, the 5 most abundant shorebird species were Pectoral Sandpiper (24 nests), Semipalmated Sandpiper (19 nests), Long-billed Dowitcher (15 nests), Red-necked Phalarope (15 nests), and Red Phalarope (7 nests). Pectoral Sandpipers were found nesting on 11 plots and the largest number of nests found on a plot was 7. Semipalmated Sandpipers were found on more plots (13 plots) than Pectoral Sandpipers, but the largest number of nests found on a plot was only 3 nests (Table 16). Red-necked Phalarope, Long-billed Dowitcher, and Red Phalarope were found nesting on 10, 9, and 6 plots, respectively. These same 5 species also were the most abundant shorebird species in 2002 and 2003, but the order of abundance differed (Burgess et al. 2003b, Johnson et al. 2004). The same was true in 2001, except that Black-bellied Plovers were more common than Red Phalaropes. Shorebird species composition was similar in all 4 years, except no Black-bellied Plover or Bar-tailed Godwit nests were found on plots in 2004.

Among the 3 species of passerines nesting in the NPRA breeding-bird plots in 2004 (Eastern Yellow Wagtail, Savannah Sparrow, and Lapland Longspur), 96% of the nests (75 of 78 nests) belonged to Lapland Longspurs (Table 16). Lapland Longspur nests were found on all 24 plots and the number of longspur nests per plot ranged from 1–8 nests (mean = 3 nests/plot). Savannah Sparrow nests were found on 2 plots and a Yellow Wagtail nest was found on 1 plot. The density of Lapland Longspur nests on plots was 45% higher in 2003 and 2004 than it was in 2001 and 2002 (Burgess et al. 2003b, Johnson et al. 2004).

The 6 waterfowl species that nested on breeding bird plots in 2004 were Greater White-fronted Goose, Canada Goose, Northern Pintail, Greater Scaup, King Eider, and Long-tailed Duck (Table 16). The nest density of all waterfowl species on plots in 2004 was 5 nests/km² (12 nests; Table 17). The most abundant waterfowl species nesting in the NPRA breeding bird plots was the Greater White-fronted Goose (7 nests). For every

Table 16. Number and density of nests on 24 breeding-bird plots, NPRA study area, Alaska, 2004.

	Plot Number																								Total	Density[a]
Species	1	2	3	4	25	26	27	28	33	34	35	36	45	46	47	48	53	54	55	56	101	102	103	104	Nests	(nests/km²)
Greater White-fronted Goose	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	2	1	0	7	2.9
Canada Goose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.4
Northern Pintail	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.4
Greater Scaup	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.4
King Eider	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.4
Long-tailed Duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.4
Willow Ptarmigan	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	1.7
American Golden-Plover	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1.3
Semipalmated Sandpiper	0	0	0	0	0	2	0	2	1	0	0	1	1	1	1	2	0	0	0	3	2	1	1	1	19	7.9
Pectoral Sandpiper	1	2	0	0	0	1	1	0	0	2	0	0	0	0	1	0	0	1	5	7	2	1	0	0	24	10.0
Dunlin	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	1	6	2.5
Stilt Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	3	1.3
Long-billed Dowitcher	0	1	3	0	0	0	0	0	1	1	0	0	0	0	0	0	2	1	1	0	3	2	0	0	15	6.3
Red-necked Phalarope	0	0	1	0	0	1	1	0	1	0	5	1	0	0	0	1	0	1	2	0	0	0	0	1	15	6.3
Red Phalarope	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	2	1	0	0	0	0	7	2.9
Arctic Tern	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0.8
Eastern Yellow Wagtail	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.4
Savannah Sparrow	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.8
Lapland Longspur	1	1	3	2	3	3	4	5	8	5	1	1	5	4	1	2	2	3	2	4	6	2	6	1	75	31.3
Total nests	3	5	7	3	4	10	8	11	11	9	7	4	8	6	5	8	6	9	14	16	13	8	8	5	188	
Density (nests/km²)	30	50	70	30	40	100	80	110	110	90	70	40	80	60	50	80	60	90	140	160	130	80	80	50		78.3
Number of species	3	4	3	2	2	6	5	6	4	4	3	4	4	3	5	6	4	7	6	5	4	5	3	5	19	

[a] Each plot was 10 hectares, see Figure 5

Table 17. Number and density (nests/km²) of nests by species group on clusters of breeding-bird plots (4 plots per cluster), NPRA study area, Alaska, 2004.

	Shorebirds		Passerines		Waterfowl		Other Birds[a]	
Plots	Number	Density[b]	Number	Density[b]	Number	Density[b]	Number	Density[b]
1–4	9	22.5	7	17.5	1	2.5	1	2.5
25–28	11	27.5	18	45.0	1	2.5	3	7.5
33–36	15	37.5	15	37.5	1	2.5	0	0
45–48	11	27.5	12	30.0	2	5.0	2	5.0
53–56	30	75.0	11	27.5	4	10.0	0	0
101–104	16	40.0	15	37.5	3	7.5	0	0
Total nests	92	38.3	78	32.5	12	5.0	6	2.5
Number of species	8		3		6		2	

[a] Includes ptarmigan and terns
[b] Density based on a plot cluster area of 0.4 km²

other waterfowl species, 1 nest each was found on the plots in 2004. Greater White-fronted Goose, Northern Pintail, and Long-tailed Duck also nested in 2001–2003 (Burgess et al. 2003b). King Eider and Greater Scaup were found nesting on breeding-bird plots in previous years, whereas Canada Goose was not found in previous years of study. The breeding-bird plots were not designed to census low-density waterfowl, so only the most abundant species are likely to occur in plots.

Other birds occurring on the NPRA breeding bird plots in 2004 included Willow Ptarmigan (4 nests) and Arctic Tern (2 nests; Table 16). Nests of 5 additional species were found off plot in 2004: Brant, Red-throated Loon, Pacific Loon, Glaucous Gull, and Sabine's Gull.

NESTING SUCCESS AND SURVIVAL RATES

All nests found on (192 nests, including 4 nests found during nest monitoring visits) and off (95 nests) the NPRA breeding-bird plots in 2004 were checked for nest fate. Of these 287 nests, 184 were successful, 89 failed, and 14 were unknown fate. Eggshell evidence found at successful and failed shorebird nests during this study corroborated patterns of evidence found at nests of other shorebird species (Mabee 1997). Ninety-two percent of the 26 known successful shorebird nests (those with chicks) contained eggshell fragments in the nest scrape (Appendix C2). Also, eggshell tops or bottoms were found only near successful nests.

Daily survival rates during the incubation period in 2004 were quite variable both among groups of species (i.e., shorebirds, waterfowl, passerines) and among species (Table 18). Overall, shorebirds had the highest DSR, followed by passerines and waterfowl, similar to results from 2002 and 2003 (Burgess et al. 2003b, Johnson et al. 2004). By raising the DSR to the power of the average incubation period for the species of interest, one can calculate an estimate of nesting success (% of nests hatched) that accounts for the varying time periods individual nests were monitored. Shorebird nesting success in the NPRA study area during 2004 (using mean DSR and assuming a mean incubation period of 23 d) was 63% (0.980^{23}; Table 18), similar to the 64% nesting success in 2002 (Burgess et al. 2003b) and 60% in 2003 (Burgess et al. 2004). Among shorebirds, Stilt Sandpipers had the highest survival rates in 2004, followed by Dunlin, Semipalmated Sandpipers, Pectoral Sandpipers, Red-necked Phalarope, Red Phalarope, Long-billed Dowitcher, Black-bellied Plover, and American Golden Plover. The differences in survival rates among species resulted in substantial differences in nesting success, with 100% nesting success for Stilt Sandpipers and 59% for American Golden Plovers (Table 18). Waterfowl nesting success was low overall (~7%;

Table 18. Mean daily survival rates for nests on breeding-bird plots, NPRA study area, Alaska, 2004.

SPECIES GROUP Species	Mean Daily Survival Rate ± SE (Number of Nests)						
	All Plots	Plots 1–4	Plots 21–24	Plots 31–34	Plots 41–44	Plots 51–54	Plots 101–104
SHOREBIRDS	0.980 ± 0.003 (125)	0.978 ± 0.011 (12)	1.000 ± 0.000 (15)	0.969 ± 0.011 (22)	0.981 ± 0.009 (18)	0.975 ± 0.006 (41)	0.981 ± 0.008 (17)
American Golden Plover	0.946 ± 0.031 (5)	(2)	(1)	(0)	(0)	(1)	(1)
Black-bellied Plover	0.955 ± 0.026 (5)	(2)	(1)	(0)	(0)	(1)	(1)
Dunlin	0.992 ± 0.008 (8)	(0)	(1)	(0)	(2)	1.000 ± 0.000 (4)	(1)
Long-billed Dowitcher	0.969 ± 0.012 (16)	1.000 ± 0.000 (4)	(0)	(3)	(0)	0.946 ± 0.030 (5)	0.985 ± 0.015 (4)
Pectoral Sandpiper	0.983 ± 0.006 (31)	0.980 ± 0.020 (4)	1.000 ± 0.000 (4)	0.986 ± 0.013 (5)	(1)	0.971 ± 0.013 (13)	0.985 ± 0.015 (4)
Red Phalarope	0.971 ± 0.015 (11)	(0)	(1)	0.978 ± 0.022 (4)	(2)	0.960 ± 0.028 (4)	(0)
Red-necked Phalarope	0.979 ± 0.009 (19)	(1)	(3)	0.968 ± 0.018 (8)	(2)	(3)	(2)
Semipalmated Sandpiper	0.990 ± 0.005 (26)	(1)	1.000 ± 0.000 (4)	(2)	1.000 ± 0.000 (8)	0.978 ± 0.015 (6)	0.988 ± 0.012 (5)
Stilt Sandpiper	1.000 ± 0.000 (4)	(0)	(1)	(0)	(1)	(2)	(0)
WATERFOWL[a]	0.897 ± 0.023 (21)	(1)	(1)	(2)	0.886 ± 0.045 (6)	0.917 ± 0.033 (8)	(3)
Greater White-fronted Goose	0.917 ± 0.031 (10)	(0)	(0)	(1)	(2)	0.946 ± 0.037 (4)	(3)
PASSERINES[b] (Incubation)	0.969 ± 0.007 (86)	1.000 ± 0.000 (8)	0.971 ± 0.014 (23)	0.982 ± 0.018 (9)	0.928 ± 0.025 (14)	0.983 ± 0.012 (18)	0.972 ± 0.019 (14)
Lapland Longspur	0.969 ± 0.008 (81)	1.000 ± 0.000 (8)	0.964 ± 0.018 (19)	0.982 ± 0.018 (9)	0.926 ± 0.027 (13)	0.983 ± 0.012 (18)	0.972 ± 0.019 (14)
PASSERINES[c] (Incubation and Nestling Periods)	0.992 ± 0.002 (91)	0.988 ± 0.008 (13)	0.987 ± 0.007 (19)	1.000 ± 0.000 (14)	0.992 ± 0.008 (8)	0.993 ± 0.005 (20)	0.995 ± 0.005 (17)
Lapland Longspur	0.992 ± 0.002 (86)	0.988 ± 0.008 (13)	0.987 ± 0.007 (15)	1.000 ± 0.000 (14)	0.992 ± 0.008 (8)	0.993 ± 0.005 (20)	0.995 ± 0.005 (16)
Savannah Sparrow	0.982 ± 0.018 (4)	(0)	(3)	(0)	(0)	(0)	(1)
ALL SPECIES[d]	0.972 ± 0.003 (247)	0.980 ± 0.009 (21)	0.984 ± 0.006 (45)	0.969 ± 0.010 (33)	0.958 ± 0.009 (44)	0.971 ± 0.006 (69)	0.973 ± 0.008 (35)

[a] Includes Greater White-fronted Goose (n = 10), Brant (n = 2), Canada Goose (n = 1), Greater Scaup (n = 1), King Eider (n = 1), Long-tailed Duck (n = 3), and Northern Pintail (n = 3)
[b] Includes Eastern Yellow Wagtail (n = 1), Savannah Sparrow (n = 3), Lapland Longspur (n = 81), and Common Redpoll (n = 1)
[c] Includes Eastern Yellow Wagtail (n =1), Savannah Sparrow (n = 4), and Lapland Longspur (n = 86); mean daily survival rate is calculated for only those nests surviving past hatch
[d] Incubation period only; also includes species listed in the table plus Willow Ptarmigan (n = 6), Red-throated Loon (n = 1), Pacific Loon (n = 1), Glaucous Gull (n = 1), Sabine's Gull (n = 1), and Arctic Tern (n = 5)

Table 18), worse than the overall success (18%) during 2002 (Burgess et al. 2003b) and 2003 (26%; Johnson et al. 2004).

Nesting success of passerines (predominantly of Lapland Longspurs) was moderate overall (69%) in 2004 and ranged from 100% (plots 1–4) to 40% (plots 41–44; Table 18). Survival rates of passerine nestlings (including the incubation and fledging periods for only those nests that hatched) were high and varied moderately among clusters (again, predominantly Lapland Longspurs; Table 18). Nestling success of Lapland Longspurs was high (91%), ranging from 100% (plots 31–34) to a low of 85% (plots 21–24). Survival rates during the incubation period were nearly identical to those documented in 2002 (Burgess et al. 2003b) and 2003 (Johnson et al. 2004), whereas the survival rates during the incubation and nestling periods ranged from 91% (2004) to 76% (2003; Johnson et al. 2004).

NEST PREDATORS

Jaegers and gulls were the most abundant and widespread nest predators observed at breeding-bird plots. Potential nest predators seen incidentally while working on plots included Long-tailed, Parasitic, and Pomarine jaegers (62% of 676 sightings), Glaucous Gulls (18%), caribou (11%), raptors (3%; Short-eared Owl and Northern Harrier), arctic ground squirrels (3%), Common Ravens (2%), and arctic and red foxes (1%; Appendix C3). Caribou and ground squirrels were included as potential nest predators because both species are known to cause nest loss, through trampling by caribou and egg predation by ground squirrels. The same predators listed above except foxes were seen on the timed counts, and the proportion of observations of each predator group was similar to that seen on the incidental counts, with jaegers being the most common predator (56% of 196 sightings), followed by Glaucous Gulls (16%), caribou (16%), arctic ground squirrel (7%), raptor (4%), and Common Raven (2%; Appendix C3). Avian predators were most often seen flying over plots and only occasionally landed on plot. During timed counts, jaegers were seen on 22 of 24 plots and Glaucous Gulls were seen on 16 of 24 plots (Appendix C4).

The mean number of predators seen per hour was higher for timed counts (overall mean = 3.3 predators/hr) compared to incidental counts (overall mean = 1.3 predators/hr; Appendix C3). During timed counts observers were focused on detecting predators while during incidental counts observers were focused on other activities, and predators probably were missed. An exception was foxes, which were not observed during timed counts, probably because they occurred infrequently. Otherwise, many trends among species and among types of plot visits were similar between the 2 methods (Appendix C3).

SPECIES ACCOUNTS

SPECTACLED EIDER

Of the 4 species of eiders that may occur on the Colville Delta and in the NPRA study area, the Spectacled Eider has received the most attention because it was listed as a threatened species under the Endangered Species Act in 1993 (58 FR 27474-27480). The Spectacled Eider is a common breeding bird across the outer Colville Delta but occurs only in low numbers in inland parts of the delta (such as the CD South study area) and in scattered wetland basins in the NPRA study area (Burgess et al. 2003a, 2003b; Johnson et al. 2004).

Colville River Delta

Distribution and Abundance

The 2004 aerial survey for pre-nesting eiders on the Colville Delta was conducted on 14–15 June (Table 1), which is similar to the period flown in previous years. All sightings of Spectacled Eiders were of groups of 1–2 birds, exclusively in the CD North study area and the northeast delta (Figure 19). During the 2004 pre-nesting survey, we recorded the lowest number of Spectacled Eiders on the Colville Delta of any previous year (Figure 20, Table 19). No Spectacled Eiders were seen in the CD South study area, whereas 9 Spectacled Eiders (8 indicated birds [USFWS 1987a]) were sighted in the CD North study area, and 3 (2 indicated birds) were sighted in the northeast delta (Table 19). The Colville survey may have been flown late relative to the departure of male Spectacled Eiders from nesting areas in 2004 and thus may have missed the peak in numbers that actually occurred in the area. The trend line for the CD North study area suggests a decline may have occurred in this area after 1998 or 1999. However,

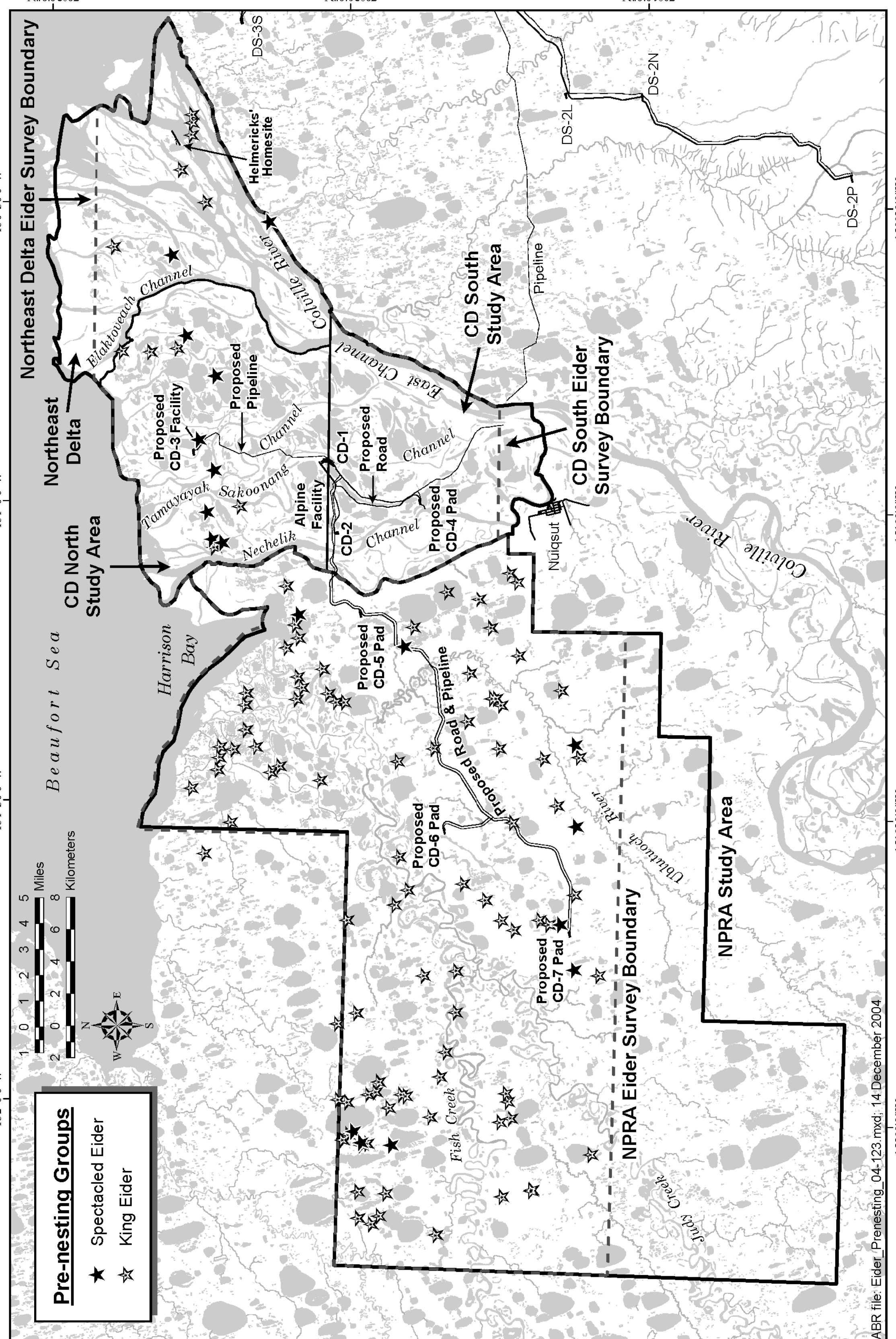

Figure 19. Spectacled and King eider groups (flying and on the ground) during pre-nesting aerial surveys, northeast delta and CD North, CD South, and NPRA study areas, Alaska, 2004.

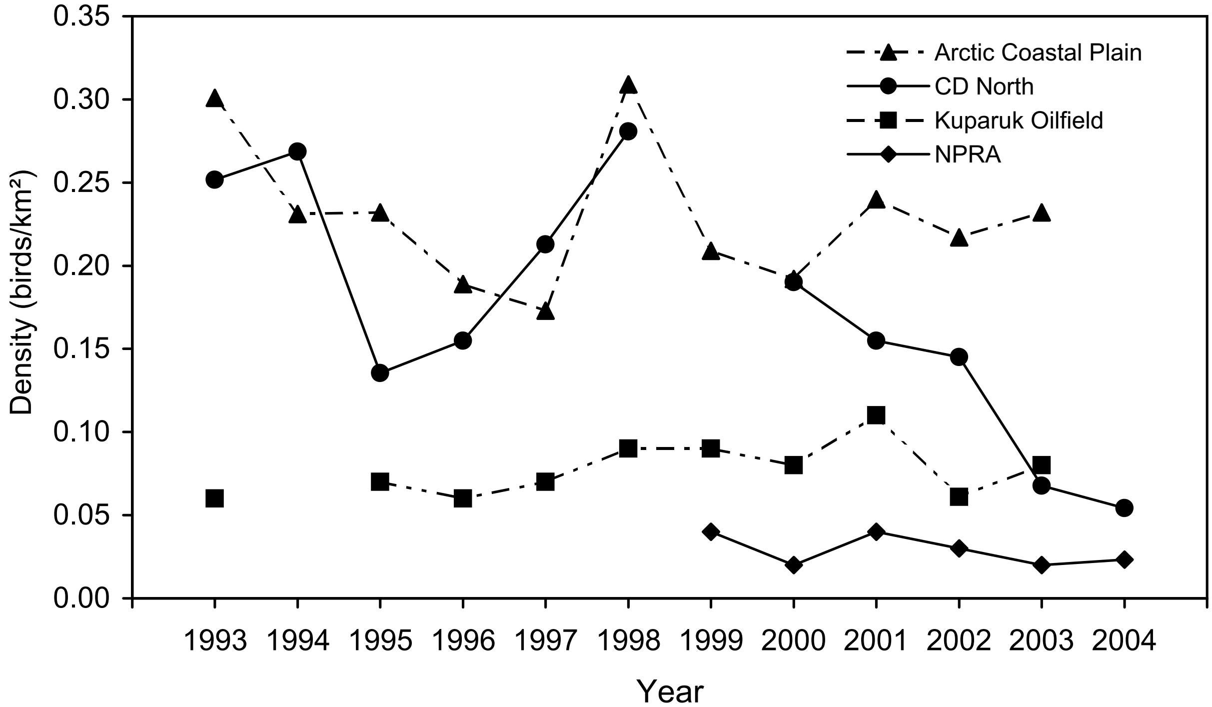

Figure 20. Trends in density of Spectacled Eiders (indicated birds; USFWS 1987a) from pre-nesting surveys in the CD North study area, NPRA study area, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2004. Data are from Anderson et al. (2004), Larned et al. (2004), and this study.

the number of Spectacled Eiders across the Arctic Coastal Plain has remained relatively stable with a slightly decreasing but nonsignificant trend (Larned et al. 2004). The Arctic Coastal Plain survey is probably more robust to variation in timing of arrival of Spectacled Eiders than the survey of the Colville Delta, because it is conducted over a longer period of time (6–11 days) and a larger survey area (30,755 km²).

Spectacled Eiders on the Colville Delta were closely associated with coastal areas in all years, and their distribution during pre-nesting in 2004 (Figure 19) was similar to that observed in previous surveys (Johnson et al. 2003b, 2004). During 2004, the mean distance of pre-nesting Spectacled Eiders from the coast was 5.8 km (n = 9 sightings), and the maximal distance was 12.8 km.

The distribution of Spectacled Eiders during nesting is similar to the distribution observed on pre-nesting aerial surveys; most nests occur on the outer Colville Delta in the CD North study area (Johnson et al. 2003b). Nest searches of the CD-3 search area in 2004 found 18 Spectacled Eider nests (1.0 nests/km²) and 1 unidentified eider nest (Figure 12, Table 5). The density of Spectacled Eider nests was the highest in the 5 years that nest searches have been conducted in this area.

Nine of the 18 Spectacled Eider nests found in 2004 hatched (50% apparent nesting success) and mean clutch size was 3.8 eggs (n = 6 nests). Seven Spectacled Eider nests had failed before their discovery, and the identification of six of those nests was based on color patterns of contour feathers (Anderson and Cooper 1994). Apparent nesting success of Spectacled Eider nests in 2004 was higher than the overall success of all nests we have found previously on the delta (31%, n = 55 nests of known fate), but mean clutch size in 2004 was similar to the long-term mean (4.0 eggs/nest, n = 34 nests).

Nine Spectacled Eider broods were seen in the CD-3 search area in 2004, the same number as

Table 19. Number and density of eiders during pre-nesting aerial surveys, northeast delta and CD North and NPRA study areas, Alaska, 2004. No eiders were recorded in the CD South study area.

STUDY AREA Species	Numbers of Eiders: Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[b]	Density (birds/km²)[a]: Observed Total	Indicated Total[b]
CD NORTH STUDY AREA							
Spectacled Eider							
On ground	4	0	4	0	8	0.03	0.05
Flying	4	1	5	1	–	0.03	–
All birds	8	1	9	1	–	0.06	–
King Eider							
On ground	2	1	3	1	4	0.02	0.03
Flying	3	1	3	0	–	0.02	–
All birds	5	2	6	1	–	0.04	–
NORTHEAST DELTA							
Spectacled Eider							
On ground	1	1	2	1	2	0.02	0.02
Flying	1	0	1	0	–	0.01	–
All birds	2	1	3	1	–	0.03	–
King Eider							
On ground	5	4	9	4	10	0.08	0.09
Flying	1	1	2	1	–	0.02	–
All birds	6	5	11	5	–	0.10	–
NPRA STUDY AREA							
Spectacled Eider							
On ground	5	4	9	4	10	0.02	0.02
Flying	5	0	5	0	–	0.01	–
All birds	10	4	14	4	–	0.03	–
King Eider							
On ground	65	47	114	43	130	0.26	0.30
Flying	31	23	54	20	–	0.13	–
All birds	96	70	168	63	–	0.39	–

[a] Density was calculated from strip transects totaling 147.4 km² in the CD North study area (50–100% coverage), 108.8 km² in the northeast delta (50–100% coverage), and 430.3 km² in NPRA study area (50% coverage, see Figure 7); numbers were not corrected for sightability

[b] Total indicated birds was calculated according to standard USFWS protocol (USFWS 1987a)

successful nests (Figure 14, Table 6). Brood size for Spectacled Eiders in 2004 averaged 3.9 young, which was slightly more than the mean from previous years (3.3 young/brood, n = 33 broods).

Habitat Use

During pre-nesting in 2004, 60% of the Spectacled Eiders on the Colville Delta used polygonal habitats: Deep Polygon Complex and Patterned Wet Meadow (Table 20). Three polygonal habitats and 3 salt-affected habitats were preferred (use was significantly greater than availability) by Spectacled Eiders in a selection analysis using 11 years of pre-nesting surveys: Brackish Water, Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and Deep Polygon Complex (Appendix D1). These preferred habitats are more abundant on the outer Colville Delta (19% of the CD North study area) than on the southern Colville Delta (4% of the CD South study area), which may

Table 20. Habitat use by Spectacled and King eider groups during pre-nesting, Colville River Delta[a] and NPRA study area, Alaska, 2004.

SPECIES Habitat	Colville River Delta Groups	 Adults	 Use[b] (%)	NPRA Groups	 Adults	 Use[b] (%)
SPECTACLED EIDER						
Brackish Water	–	–	–	1	2	25.0
Deep Open Water without Islands	1	1	20.0	–	–	–
Shallow Open Water without Islands	1	1	20.0	–	–	–
Sedge Marsh	–	–	–	1	1	25.0
Deep Polygon Complex	2	3	40.0	–	–	–
Old Basin Wetland Complex	–	–	–	1	2	25.0
Nonpatterned Wet Meadow	–	–	–	1	2	25.0
Patterned Wet Meadow	1	1	20.0	–	–	–
Total	5	6	100	4	7	100
KING EIDER						
Open Nearshore Water	–	–	–	2	4	4.3
Brackish Water	1	2	14.3	2	4	4.3
Salt Marsh	–	–	–	3	7	6.4
Tidal Flat Barrens	–	–	–	1	2	2.1
Salt–killed Tundra	1	1	14.3	1	2	2.1
Deep Open Water without Islands	–	–	–	2	6	4.3
Deep Open Water with Islands or Polygonized Margins	–	–	–	2	4	4.3
Shallow Open Water without Islands	–	–	–	2	5	4.3
Shallow Open Water with Islands or Polygonized Margins	–	–	–	2	4	4.3
River or Stream	–	–	–	5	7	10.6
Sedge Marsh	–	–	–	3	5	6.4
Deep Polygon Complex	1	2	14.3	–	–	–
Old Basin Wetland Complex	–	–	–	13	30	27.7
Nonpatterned Wet Meadow	1	1	14.3	2	3	4.3
Patterned Wet Meadow	1	2	14.3	6	11	12.8
Moist Sedge–Shrub Meadow	1	2	14.3	1	1	2.1
Barrens	1	2	14.3	–	–	–
Total	7	12	100	47	95	100

[a] The Colville River Delta comprises the CD North and CD South study areas and the northeast delta
[b] % use = (groups / total groups) × 100

explain the higher densities of Spectacled Eiders in the CD North study area.

Nesting Spectacled Eiders used many of the same habitats that were preferred during pre-nesting (Table 7). In 2004, 39% of the Spectacled Eider nests in the CD-3 North search area were in Patterned Wet Meadow and 33% were in Deep Polygon Complex. Among all 5 years that nest searching was conducted around CD-3, Spectacled Eiders nested most often in Patterned Wet Meadow, Salt-killed Tundra, or Deep Polygon Complex (each occupied by >20% of the nests), but only Deep Polygon Complex was significantly preferred (Appendix D2). Spectacled Eider nests were closely associated with water in 2004; the mean distance to water (including polygon ponds and troughs) was 4.9 m, and the mean distance to lakes was 33.8 m (n = 18).

Brood-rearing Spectacled Eiders primarily were sighted in the same habitats as were used for nesting, plus deep water habitats, which probably provided escape habitat. In 2004, 4 Spectacled Eider broods used Deep Open Water with Islands or Polygonized Margins, 4 used Deep Polygon Complex, and 1 used Deep Open Water without Islands (Table 8). Of the 41 Spectacled Eider broods seen on the delta since 1993, 39% used both Deep Open Water habitats and another 33% used Deep Polygon Complex and Salt-killed Tundra.

NPRA Study Area

The NPRA study area is used during the breeding period by fewer Spectacled Eiders but more King Eiders than use the Colville Delta. In 2004, Spectacled Eiders occurred in a few wetland basins in the northern portion of the NPRA study area (Figure 19), and this distribution was consistent with observations in past years (Burgess et al. 2003b, Johnson et al. 2004).

In 2004, the eider pre-nesting survey in the NPRA study area was conducted on 11 and 15 June (Table 1), within the time-frame typically flown in previous years. Fourteen Spectacled Eiders were seen during the aerial survey (Figure 19, Table 19), which was similar to previous years (Burgess et al. 2003b, Johnson et al. 2004). The indicated total density of Spectacled Eiders in the NPRA study area (0.02 birds/km²) was less than half that in the CD North study area and the same density as on the northeast delta in 2004 (Figure 20, Table 19).

One Spectacled Eider nest (0.1 nests/km²) was found in 2004 in an extended buffer search area near CD-5 (Figure 15, Table 12). That nest had 5 eggs and hatched. No broods of Spectacled Eiders were seen during ground searches in NPRA in 2004.

Habitat Use

Pre-nesting Spectacled Eiders in 2004 used 4 habitats equally in the NPRA study area (Table 20). Two habitats were preferred by pre-nesting Spectacled Eiders during 4 years of surveys: Brackish Water and Deep Open Water with Islands or Polygonized Margins (Appendix D3). The selection analysis was constrained by small sample size (21 groups of Spectacled Eiders), so different habitats likely will be designated as preferred as sample size increases with additional surveys. From 2001 to 2004, Old Basin Wetland Complex was the most frequently used habitat by both species of eider during pre-nesting in the NPRA study area (Appendix D3).

In 2004, 1 Spectacled Eider nest occurred in Young Basin Wetland Complex (Table 14). We have records of only 9 Spectacled Eider nests (includes historical data) in the NPRA study area and 5 (56%) of those nests were in Old Basin Wetland Complex. Sample size was too small to conduct a selection analysis. No broods of Spectacled Eiders were seen in 2004.

KING EIDER

Colville River Delta

Distribution and Abundance

Unlike Spectacled Eiders, King Eiders are widespread across the study areas and generally occur in low densities on the Colville Delta (Figure 19, Table 19). The annual trend in King Eiders on the delta has been relatively stable, compared with the fluctuations that have occurred in the Kuparuk Oilfield and on Alaska's Arctic Coastal Plain, where densities are much higher than on the Colville Delta (Figure 21).

King Eiders generally have occurred in lower numbers than Spectacled Eiders during pre-nesting aerial surveys of the Colville Delta (Johnson et al. 2003b). In 2004, King Eiders occurred at half the number of Spectacled Eiders in the CD North area, and no King Eiders were sighted in the CD South study area (Table 19). However, 11 King Eiders

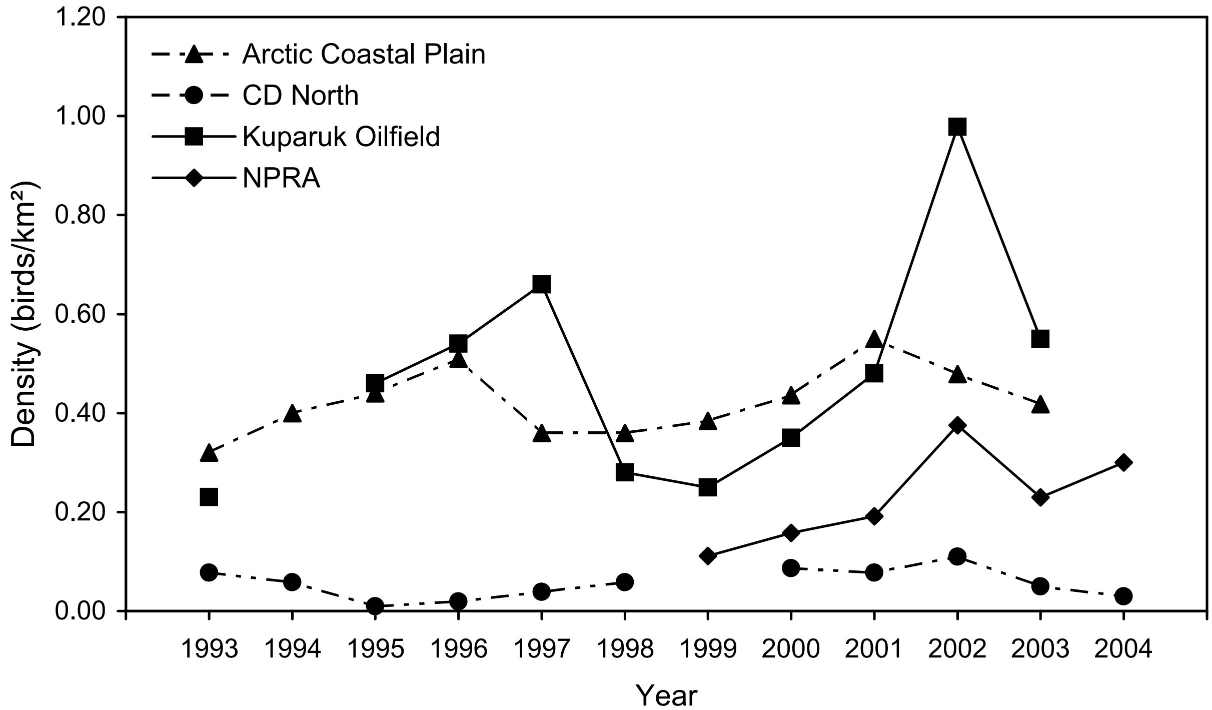

Figure 21. Trends in density of King Eiders (indicated birds, USFWS 1987a) from pre-nesting surveys in the CD North study area, NPRA study area, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2004. Data are from Anderson et al. (2004), Larned et al. (2004), and this study.

were recorded on the northeast Delta, more than 4 times the number of Spectacled Eiders seen in that area (Table 19). The northeast delta is highly dissected by distributary channels and in past years has been used by large flocks of King Eiders, probably in transit to breeding areas (Johnson et al. 2003b).

No nests or broods of King Eiders were found in the CD-3 search area in 2004. One eider nest was found after it failed and could not be identified to species.

Habitat Use

Unlike previous years, pre-nesting King Eiders on the Colville Delta in 2004 were found equally distributed among potential nesting habitats (Table 20), which suggests that our survey was conducted relatively later than in other years. Over 11 years of surveys, 43% of the King Eider groups and over 50% of the birds were found in River or Stream (Appendix D1), which is not used for nesting. The only preferred habitats for pre-nesting King Eiders on the Colville Delta were Brackish Water and River or Stream (Appendix D1).

NPRA Study Area

Distribution and Abundance

As mentioned previously, King Eiders are more abundant in the NPRA study area during breeding than they are in the Colville Delta, and King Eiders were about 10 times more numerous than Spectacled Eiders in this part of the NPRA in 2004. King Eiders were well-dispersed throughout aquatic habitat in the study area (Figure 19), and this distribution is consistent the distribution observed in past years (Burgess et al. 2003b).

During the pre-nesting aerial survey in 2004, 168 King Eiders (flying and non-flying birds) were recorded (Figure 19, Table 19). The number of King Eiders in the NPRA study area during 2004 declined only slightly from 2003 (191 birds, Figure 21). The density of King Eiders in the NPRA study area was 3–10 times the density of King Eiders in the 2 Colville Delta areas where King Eiders were seen in 2004.

King Eider nests also were much more abundant than Spectacled Eider nests in the NPRA search areas (Tables 9 and 12). Twelve King Eider nests (0.5 nests/km²) were found during 2004. Nesting success was 60% and mean clutch size was 3.5 eggs/nest (n = 8 nests). Nests were found throughout the search areas in wetland basins (Figures 15 and 17), which appear to be productive nesting areas for a variety of waterbirds. No broods of King Eiders were seen in the NPRA search areas in 2004.

Habitat Use

As was the case for Spectacled Eiders, Old Basin Wetland Complex was the most important habitat for pre-nesting King Eiders in the NPRA study area. King Eiders used 15 habitats during pre-nesting in 2004 (Table 20). The most used habitats in 2004 were Old Basin Wetland Complex (28% of all groups), Patterned Wet Meadow (13%), and River or Stream (11%). However, the habitats preferred by King Eiders during 4 years of surveys were Brackish Water and both types of Deep Open Water, Shallow Open Water with Islands or Polygonized Margins, and Old Basin Wetland Complex (Appendix D3).

King Eiders in 2004 also nested most frequently in Old Basin Wetland Complex (58% of nests; Table 14). The second most used habitat was Young Basin Wetland Complex (17% of nests). Among 63 King Eider nests (includes historical data) in the NPRA study area, 41% of those nests were in Old Basin Wetland Complex and 19% were in Shallow Open Water with Islands or Polygonized Margins.

YELLOW-BILLED LOON

Colville River Delta

Distribution and Abundance

During nesting in 2004, 23 Yellow-billed Loons were observed in the CD North study area and 18 loons were observed in the CD South study area (Table 21). The density of Yellow-billed Loons was 0.11 birds/km² in the CD North study area and 0.12 birds/km² in the CD South study area

Table 21. Number and density of loons and their nests, broods, and young during aerial surveys, CD North, CD South, and NPRA study areas, Alaska, 2004.

	Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
	Number			Density (number/km²)		Number			Number		
AREA[b] Survey Type	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
CD NORTH STUDY AREA											
Nesting	23	16	–	0.11	0.08	30	9	–	0	0	–
Brood-rearing[c]	29	9	12	0.14	0.04	58	13	14	2	0	0
CD SOUTH STUDY AREA											
Nesting	18	8	–	0.12	0.05	47	10	–	0	0	–
Brood-rearing[c]	23	3	3	0.15	0.02	66	9	10	5	1	1
NPRA SURVEY AREA											
Nesting	62	23	–	0.07	0.03	440	110	–	0	0	–
Brood-rearing[c]	67	10	12	0.08	0.01	152	25	32	3	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and surveys did not include smaller lakes (<10 ha) where those species commonly nest
[b] CD North study area = 206.7 km², CD South study area = 155.9 km², NPRA survey area (portion of the study area) = 878.2 km²; see Figure 8
[c] Only lakes known to have Yellow-billed Loon nests were surveyed during brood-rearing

in 2004 (Table 21), which was slightly lower than the mean of 10 years (0.13 birds/km² in each study area; Burgess et al. 2003a, Johnson et al. 2003b, 2004). Other studies have reported similar densities for Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska: Square Lake in the NPRA (0.14 birds/km²; Derksen et al. 1981) and the Alaktak region south of Smith Bay (0.16 birds/km²; McIntyre 1990).

Sixteen Yellow-billed Loon nests were found in the CD North study area and 8 nests were found in the CD South study area during the aerial survey in 2004 (Figure 22, Table 21). Nest density in 2004 in the CD North study area (0.08 nests/km²) was the same as 2003, and both years had higher densities than any previous year for that study area since delta-wide aerial surveys began in 1993. Nest density in the CD South study area in 2004 (0.05 nests/km²), was slightly higher than the mean of 10 years (0.04 nests/km²). Also, 1 brood was observed in the southeastern part of the CD North study area during the brood-rearing aerial survey in a traditional nest lake where a nest was not found in 2004, suggesting that an additional nest was active there but missed during the nesting survey (Figure 22). The total count of 25 nests (including the nest indicated by a brood location) for the Colville Delta in 2004 is the same as the total count for 2003, higher than the mean of 10 years (20 nests), and higher than the count from intensive ground surveys by North (1986) in 1983 (19 nests) and 1984 (20 nests).

As in previous years, Yellow-billed Loon nests in 2004 were concentrated in the central part of the delta (Figure 22; Rothe et al. 1983, North 1986, Burgess et al. 2003a, Johnson et al. 2003b, Johnson et al. 2004). All nests were on lakes where Yellow-billed Loons have nested in previous years (Burgess et al. 2003a, Johnson et al. 2003b, 2004). Unlike previous years, however, no nests were found on 4 traditional nest lakes in the southern part of the CD South study area. Only one pair of Yellow-billed Loons was seen on these lakes during the nesting aerial survey. In 2004, extensive flooding affected this area of the delta in early-mid June and high water levels at the time of nest initiation may have prevented Yellow-billed Loons from nesting in this area.

Twenty-nine adult Yellow-billed Loons and 9 broods were observed during the brood-rearing aerial survey in the CD North study area in 2004, and 23 adults and 3 broods were observed in the CD South study area (Figure 22, Table 21). Three of the broods in the CD North study area had 2 young each, and the remaining broods had one young each. All broods in the CD South study area had 1 young each. The total count of 12 Yellow-billed Loon broods for the Colville Delta in 2004 was among the 3 highest counts recorded during 10 years of surveys. Twelve broods also were observed on the delta in 1998, and 14 broods were seen in 2003.

Habitat Use

During aerial surveys of the Colville Delta in 2004, 24 Yellow-billed Loon nests were observed in 7 habitats (Table 22). The 2 habitats most frequently used for nesting were Patterned Wet Meadow (42% of all nests) and Deep Open Water with Islands or Polygonized Margins (33%). Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation; the latter 2 types could be classified as part of a waterbody at the scale of our habitat map.

Because Yellow-billed Loons typically 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. Five types of waterbodies were associated with Yellow-billed Loon nests in 2004: Deep Open Water with Islands or Polygonized Margins (50% of all nests), Deep Open Water without Islands (29%), Tapped Lake with High-water Connection (12%), Shallow Open Water with Islands or Polygonized Margins (4%), and Sedge Marsh (4%; Table 22). We did not measure the distance to water for nests recorded during aerial surveys, but all were close (<5 m) to water. Previous investigators have reported that Yellow-billed Loons on the Arctic Coastal Plain nest within 2 m of water (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989).

During 10 years of nesting aerial surveys on the Colville Delta, 171 Yellow-billed Loon nests were found in 9 of 24 available habitats (Appendix E1). One hundred sixteen nests were located in the 4 preferred habitats: Patterned Wet Meadow, Deep Open Water with Islands or Polygonized Margins,

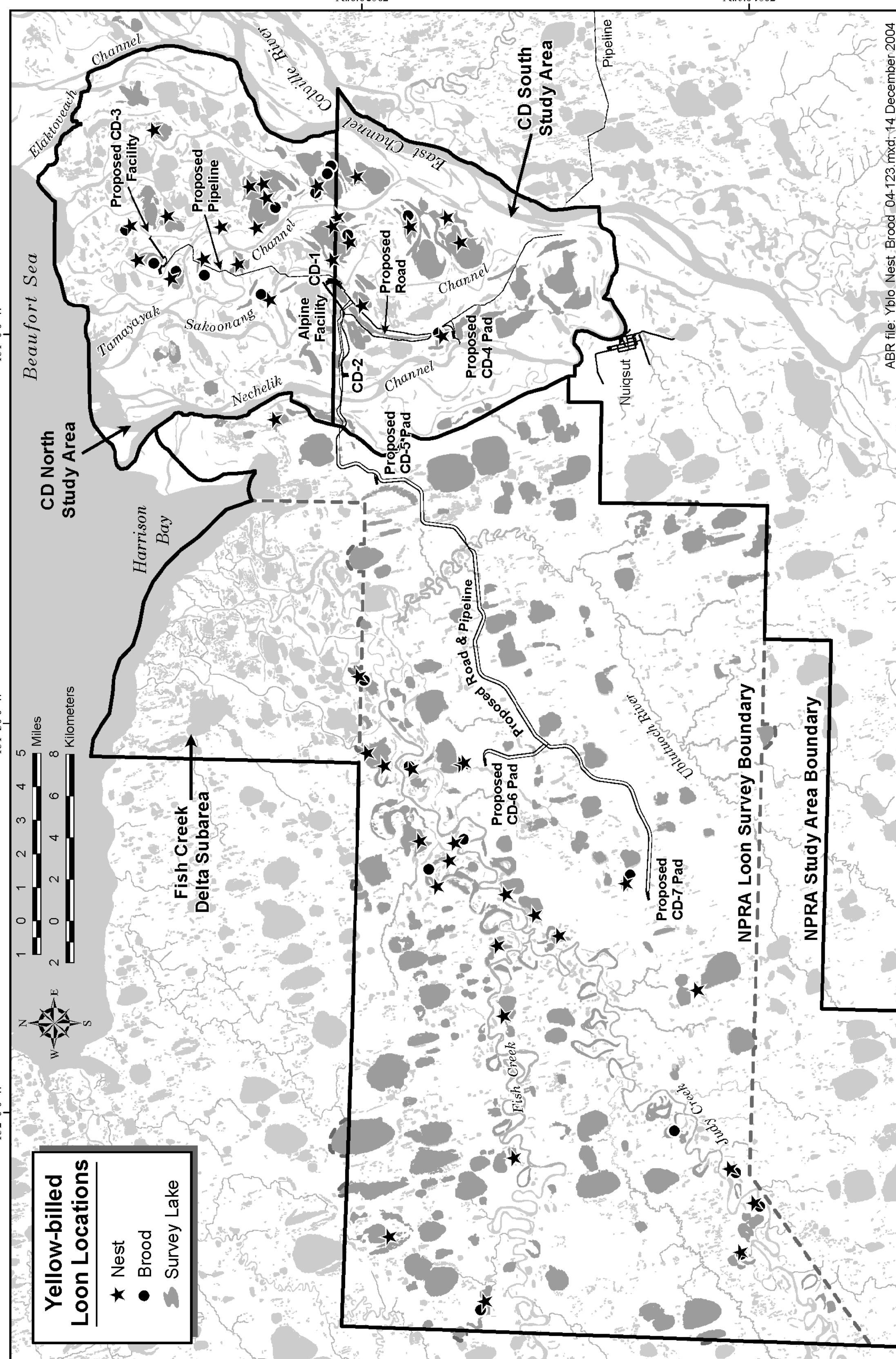

Figure 22. Yellow-billed Loon nests and broods, CD North, CD South, and NPRA study areas, Alaska, 2004.

Table 22. Habitat use by nesting and brood-rearing Yellow-billed Loons, CD North, CD South, and NPRA study areas, Alaska, 2004.

	CD North and CD South Study Areas				NPRA Study Area			
	Nests		Broods		Nests		Broods	
Habitat	Number	Use (%)	Number	Use (%)	Number	Use (%)	Number	Use (%)
HABITAT USED								
Tapped Lake with High-water Connection	1	4.2	1	8.3	0	0	0	0
Deep Open Water without Islands	2	8.3	5	41.7	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	8	33.3	6	50.0	9	47.4	6	85.7
Shallow Open Water with Islands or Polygonized Margins	1	4.2	0	0	2	10.5	1	14.3
Sedge Marsh	1	4.2	0	0	6	31.6	0	0
Deep Polygon Complex	1	4.2	0	0	0	0	0	0
Patterned Wet Meadow	10	41.7	0	0	1	5.3	0	0
Moist Sedge–Shrub Meadow	0	0	0	0	1	5.3	0	0
Total	24	100	12	100	19[a]	100	7	100
NEAREST WATERBODY[b]								
Tapped Lake with High-water Connection	3	12.5	–	–	0	0	–	–
Deep Open Water without Islands	7	29.2	–	–	2	10.5	–	–
Deep Open Water with Islands or Polygonized Margins	12	50.2	–	–	9	47.4	–	–
Shallow Open Water with Islands or Polygonized Margins	1	4.2	–	–	2	10.5	–	–
Sedge Marsh	1	4.2	–	–	6	31.6	–	–
Total	24	100	–	–	19	100	–	–

[a] Excludes 4 nests that occurred outside the area mapped for habitat
[b] Nearest waterbody not listed for broods because broods were found in aquatic habitats only

Sedge Marsh, and Shallow Open Water with Islands or Polygonized Margins. Patterned Wet Meadow was the most frequently used habitat for nesting (39% of all nests), and it also was the most abundant habitat on the delta (25% of the loon survey area; Appendix E1). Nesting Yellow-billed Loons avoided 8 habitats, all of which were unused but together they occupied a large portion (46%) of the CD North and CD South study areas (Appendix E1).

On the Colville Delta in 2004, 12 Yellow-billed Loon broods were found in 3 habitats: Tapped Lake with High-water Connection (8% of all broods) and both types of Deep Open Water (92%; Table 22). During 10 years of aerial surveys on the Colville Delta, 72 Yellow-billed Loon broods were found in the same 3 habitats, all of which were preferred (Appendix E1). Deep Open Water without Islands was used by the most broods (57% of total), followed by Deep Open Water with Islands or Polygonized Margins (25%), and Tapped Lake with High-water Connection (18%). 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.

NPRA Study Area

Distribution and Abundance

During the nesting aerial survey in 2004, 62 Yellow-billed Loons and 23 nests were recorded in the NPRA study area (Figure 22, Table 21). An additional nest, making 24 total, was indicated during the brood-rearing aerial survey by a brood in a lake where a nest was not found (Figure 22). The density of loons was 0.07 birds/km² in the NPRA study area in 2004. A similar distribution and density was found in the same study area in 2001–2003 (Burgess et al. 2002b, 2003b, Johnson et al. 2004). In all 4 years of surveys, both loons and nests were concentrated in lakes adjacent to Fish and Judy creeks, leaving much of the northwestern and southeastern portions of the study area unoccupied by Yellow-billed Loons (Figure 22). Most nests in 2004 were on lakes where Yellow-billed Loons had nested in previous years. Two new nest locations were found in 2004 in the western part of the NPRA study area. One additional Yellow-billed Loon nest was found north of the proposed CD-6 pad during nest fate checks in 2004 and assumed to be a renest attempt. This nest was 150 m from another Yellow-billed Loon nest that was found earlier during ground searches and the nesting aerial survey, but was failed at the time of fate checks (Figures 17 and 22).

In 2004, the density of Yellow-billed Loon nests was 0.03 nests/km² in the NPRA study area (Table 21), the same density found each year 2001–2003 (Burgess et al. 2003b, Johnson et al. 2004). Although the NPRA study area supports a lower overall density of nesting Yellow-billed Loons than the Colville Delta (as computed here), the concentration of nests in lakes adjacent to Fish and Judy creeks (19 of 23 nests in 2004) comprises a number of nests similar to what is typical of the entire Colville Delta (mean = 20 nests, range 13–25 nests, n = 10 years), making the Fish and Judy creek a regionally important breeding area for the species on the same scale as the Colville Delta (see Johnson et al. 2003b, 2004).

During the brood-rearing aerial survey in 2004, 67 adult Yellow-billed Loons and 10 broods were observed in the NPRA study area (Figure 22, Table 21). The density of Yellow-billed Loon broods in the NPRA study area in 2004 was 0.01 broods/km², which was the same as 2001 and 2002 (Burgess et al. 2003b), but only half the density of broods in 2003 (Johnson et al. 2004).

Habitat Use

During aerial surveys in 2004, a total of 19 Yellow-billed Loon nests were found in the part of the NPRA study area covered by the habitat map (Table 22). Nests occurred in 5 habitats, and the 3 habitats most frequently used for nesting were Deep Open Water with Islands or Polygonized Margins (47% of all nests), Sedge Marsh (32%), and Shallow Open Water with Islands or Polygonized Margins (10%). Four types of waterbodies were associated with Yellow-billed Loon nests in the NPRA study area in 2004: Deep Open Water with Islands or Polygonized Margins (47% of all nests), Sedge Marsh (32%), Deep Open Water without Islands (10%), and Shallow Open Water without Islands (10%; Table 22). As on the Colville Delta, most nests were located within several meters of a lake shore.

Eighty-five Yellow-billed Loon nests found in the NPRA study area in 2001–2004 were included in the analysis of habitat selection. These 85 Yellow-billed Loon nests occurred in 8 of 26 available habitats (Appendix E2). Two habitats were preferred for nesting: Deep Open Water with Islands or Polygonized Margins and Sedge Marsh. Three habitats were avoided by nesting Yellow-billed Loons: Old Basin Wetland Complex, Moist Tussock Tundra, and Moist Sedge–Shrub Tundra.

Yellow-billed Loon broods were observed in 2 habitat types in 2004: Deep Open Water with Islands or Polygonized Margins (6 broods) and Shallow Open Water with Islands or Polygonized Margins (1 brood; Table 22). Over 4 years of surveys, most broods occurred in Deep Open Water with Islands or Polygonized Margins (73% of all broods) and Deep Open Water without Islands (24%), both of which were identified as preferred in the NPRA study area by the selection analysis (Appendix E2), as they also were for the Colville Delta.

OTHER LOONS

Colville River Delta

Distribution and Abundance

Thirty adults and nine nests of Pacific Loons were found in the CD North study area, and 47 adults and 10 nests were found in the CD South study area during the Yellow-billed Loon nest aerial survey in 2004 (Figure 23, Table 21). No nests of Red-throated Loons were seen in either study area on that survey. Opportunistic counts of Pacific and Red-throated loons reflect their general distribution in the CD North and CD South study areas in lakes ≥10 ha but are not indicative of the relative abundance of these species (due to differences in species detectability). Because the survey focused on lakes larger than those typically occupied by Pacific and Red-throated loons for nesting, densities have not been calculated from aerial survey data for these 2 species. Nonetheless, it is clear that Pacific Loons were the most abundant loon in both study areas in 2004 (and previous years).

In the CD-3 search area, 20 Pacific and 16 Red-throated loon nests were found during ground searches in 2004 (Figure 13, Table 5). We assumed from the number and locations of Red-throated Loon broods found during the brood search that 1 additional Red-throated Loon nest was in the area but not detected (Figure 16). Nest densities of Pacific Loons in the CD-3 search area in 2004 were equal to the maximal density in that area in previous years (2000–2003), and nest densities of Red-throated Loons in 2004 were slightly higher in the CD-3 search area than in previous years (Johnson et al. 2003b, 2004).

During the brood-rearing aerial survey in 2004, 58 Pacific Loons and 13 broods were observed in the CD North study area and 66 adults and 9 broods were observed in the CD South study area (Figure 23, Table 21). Two adult Red-throated Loons were observed in the CD North study area during the aerial survey and 5 Red-throated Loons and 1 brood were observed in the CD South study area. As mentioned above, our aerial surveys greatly underestimate the actual number of Pacific and Red-throated loons with broods, and therefore, densities and comparisons among years are not presented.

During ground searches in 2004, 7 Pacific Loon broods and 5 Red-throated Loon broods were observed in the CD-3 search area (Figure 14, Table 6). The density of Pacific Loon broods in the CD-3 search area in 2004 (0.4 broods/km²) was the maximal density observed in previous years on similar surveys, while the density of Red-throated Loon broods in 2004 (0.3 broods/km²) was at the low end of the range observed in previous years.

Habitat Use

In the CD-3 search area in 2004, 20 Pacific Loon nests were found in 8 habitat types (Table 7). The most frequently used habitats were Deep Open Water with Islands or Polygonized Margins (30%), Tapped Lake with High-water Connection (20%), Deep Open Water (20%), and Salt-killed Tundra (10%). Red-throated Loons were found nesting in 5 habitat types in the CD-3 search area in 2004 and the most frequently used were Deep Polygon Complex (47% of all nests), Patterned Wet Meadow (27%), and Shallow Open Water with Islands or Polygonized Margins (13%; Table 7).

During 5 years of ground searches in the CD-3 search area, 76 Pacific Loon nests were found in 11 of 17 available habitats (Appendix E3). The selection analysis found 5 habitats were

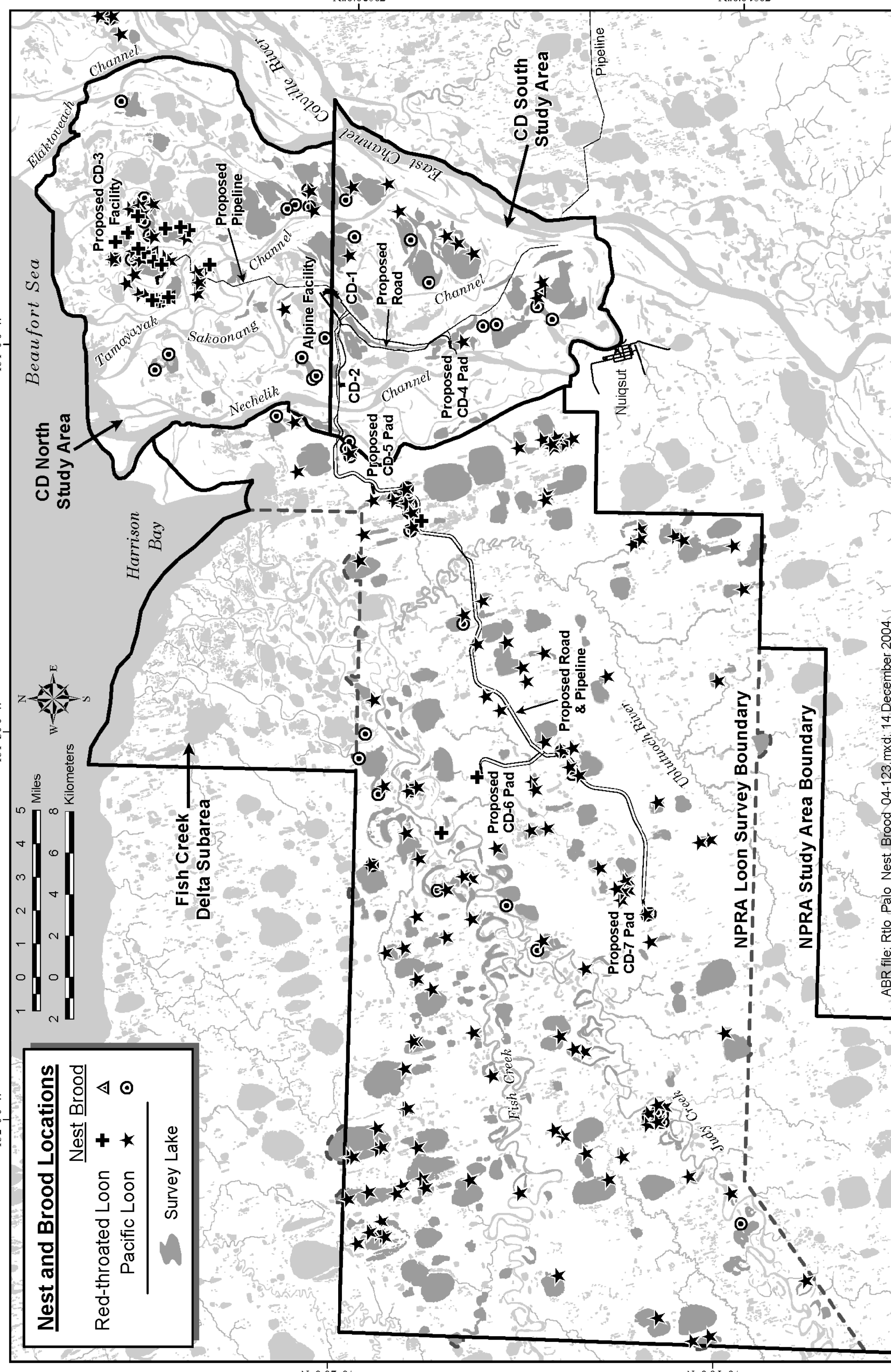

Figure 23. Pacific and Red-throated loon nests and broods, CD North, CD South, and NPRA study areas, Alaska, 2004.

preferred: both Deep Open Water types, Tapped Lake with High-water Connection, Brackish Water, and Shallow Open Water with Islands or Polygonized Margins. A similar analysis was not possible for Red-throated Loon nests because of small sample size.

In the CD-3 search area in 2004, 7 Pacific Loons broods were found only in 3 aquatic habitats: Tapped Lake with High-water Connection (43% of all broods), Deep Open Water with Islands or Polygonized Margins (43%) and Deep Open Water without Islands (14%, Table 6). Five Red-throated Loon broods were found in 2 habitats, which also were used for nesting: Deep Polygon Complex (60% of broods) and Shallow Open Water with Islands or Polygonized Margins (40%; Table 6).

NPRA Study Area

Distribution and Abundance

In 2004, Pacific and Red-throated loons were recorded incidentally during the Yellow-billed Loon aerial surveys (Figure 23, Table 21). As described above, the Yellow-billed Loon surveys were incomplete for other loons and densities are not presented. However, Pacific Loons were the most abundant and widespread loon species breeding in the NPRA study area (Figure 23). On the nesting aerial survey in 2004, 440 adult Pacific Loons and 110 nests were found (Table 21). Pacific Loons occupied small and large lakes, sometimes nesting on the same lakes as Yellow-billed Loons. No Red-throated Loon adults or nests were seen on the aerial survey in 2004. Nests of Red-throated Loons are not easily detected from the air.

During ground searches in the NPRA study area in 2004, 22 Pacific Loon nests and 1 Red-throated Loon nest were found (Figures 15 and 17; Tables 9, 12 and 13). Over all search areas combined, the density of Pacific Loon nests in the NPRA study area was 0.9 nests/km² and the density of Red-throated Loon nests was <0.1 nests/km². These estimates are not representative of the NPRA study area because search effort was not equal across all available habitats, particular in the NPRA road corridor where wet and aquatic habitats were searched preferentially (Table 11). Among the 3 pad search areas in the NPRA study area in 2004, the range of nest densities were 0–1.3 nests/km² for Pacific Loons and 0–0.2 nests/km² for Red-throated Loons (Table 9).

During the brood-rearing aerial survey for Yellow-billed Loons in 2004, 152 adult Pacific Loons (25 broods) and 3 Red-throated Loons (0 broods) were counted (Figure 23, Table 21). Again, these observations were collected incidentally and densities are not presented.

In the combined NPRA search areas, 5 Pacific Loon broods were observed (Figures 16 and 18; Table 10). No Red-throated Loon broods were sighted in NPRA search areas in 2004.

Habitat Use

In the combined NPRA search areas in 2004, 22 Pacific Loon nests were found in 5 habitats (Table 14). The most frequently used habitats were Shallow Open Water with Islands or Polygonized Margins (36% of all nests) and Sedge Marsh (27%), followed by Deep Open Water with Islands or Polygonized Margins (14%) and Old Basin Wetland Complex (14%). The single Red-throated Loon nest found in the NPRA search areas was located in Riverine Complex (Table 14).

Pacific Loon broods occurred in 3 habitats in the combined NPRA search areas in 2004: Shallow Open Water with Islands or Polygonized Margins (40% of 5 broods), Deep Open Water with Islands or Polygonized Margins (40%), Shallow Open Water without Islands (20%).

TUNDRA SWAN

Colville River Delta

Distribution and Abundance

A total of 228 swans including 59 pairs were counted on the Colville Delta during the 2004 nesting aerial survey. The number of adults observed was the lowest since 1995, and the number of pairs was the lowest since surveys were initiated in 1992 (Johnson et. al. 2003b, 2004). However, 37 swan nests were found on the Colville Delta in 2004, or 0.07 nests/km² (Table 23), which is slightly higher than the 11-year mean density of 0.06 nests/km². An additional 14 nests not observed during the aerial survey were found during ground-searches in the CD-3 search area (5 nests) and during helicopter-based surveys for loon nests (9 nests).

Of the 37 Tundra Swan nests counted during the aerial survey in 2004, 16 were located in the

Table 23. Number and density of Tundra Swan nests and broods during aerial surveys, Colville River Delta[a] and NPRA study area, Alaska, 2004.

Area	Nests		Nesting Success[b] (%)	Broods		Mean Brood Size
	Number	Density (nests/km²)		Number	Density (broods/km²)	
COLVILLE RIVER DELTA						
CD North study area	16	0.08	63	10	0.05	2.4
CD South study area	8	0.05	175	14	0.09	2.3
Northeast delta	13	0.07	138	18	0.09	1.9
Total	37	0.07	114	42	0.08	2.1
NPRA STUDY AREA[c]	63	0.05	59	37	0.03	2.1

[a] Colville River Delta = 552.2 km² and includes the CD North study area (206.7 km²), CD South study area (155.9 km²), and northeast delta (189.6 km²)
[b] Nest success = (nests / broods) × 100
[c] NPRA study area = 1,230.7 km²

CD North study area, 8 were located in the CD South study area, and 13 were on the northeast delta (Figure 24, Table 23). The number of Tundra Swan nests in the CD North study area in 2004 was slightly less than the 11-year mean of 17 nests (Johnson et al. 2003b, 2004). The density of swan nests in the CD North study area was 0.08 nests/km² (Table 23), which was within the range observed since 1992.

Eight nests (0.05 nests/km²) were found during the aerial survey in the CD South study area in 2004 (Figure 24, Table 23). An additional 6 nests were found in the CD South study area during helicopter-based loon surveys. Nest density in the CD South study area in 2004 was within the range of densities that were observed there during the previous 11 years.

Ten of the 42 swan broods (24%) found on the Colville Delta in 2004 were located in the CD North study area (Figure 24, Table 23). Nesting success in the CD North study area, estimated by dividing numbers of broods by the number of nests (data from aerial surveys only), was 63% in 2004 (Table 23). The density of swan broods in the CD North study area in 2004 was 0.05 broods/km², equal to the 11-year mean density of broods in this area. The mean brood size in the CD North study area in 2004 was 2.4 young (n = 10 broods), slightly less than the 11-year mean of 2.6 young.

In 2004, 14 swan broods were observed in the CD South study area, yielding an improbable 175% nesting success (Figure 24, Table 23). When 9 swan nests observed during the loon aerial survey are included, estimated nesting success is 100%. The density of swan broods in the CD South study area was 0.09 broods/km² in 2004. The mean brood size of 2.3 young was slightly less than the 11-year mean of 2.4 young recorded for the CD South study area.

The 42 Tundra Swan broods observed across the entire Colville Delta (CD North study area, CD South study area, and the northeast delta) was the highest since Tundra Swan surveys were initiated in the Colville Delta in 1992. The estimated nesting success of 114% in 2004 indicates an under-counting of nests during the aerial surveys in June. Both nest and brood densities of swans were above average for the Colville Delta in 2004, whereas mean brood size was below average. The mean brood size of 2.1 in 2004 was below the 11-year mean of 2.6 young/brood, but the total of 90 young on the delta was the highest since 1996.

Habitat Use

In 2004, 51 Tundra Swan nests were found in 11 habitat types (Table 24). Patterned Wet Meadow was used by the largest percentage (43%) of the swans nesting on the Colville Delta, followed by Deep Polygon Complex (16%) and Nonpatterned Wet Meadow (14%) (Table 24).

Habitat selection was evaluated for 374 Tundra Swan nests recorded on the Colville Delta

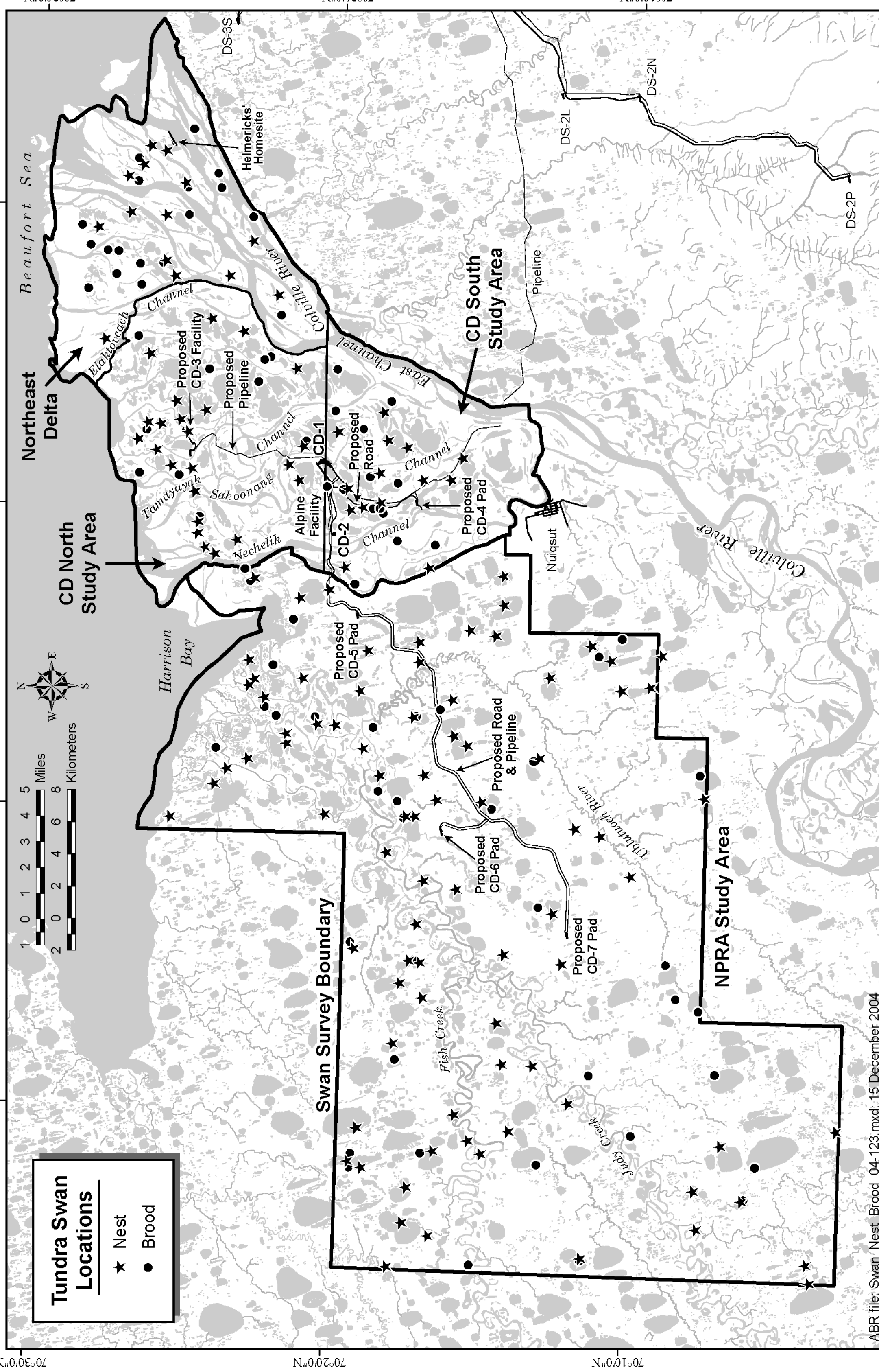

Figure 24. Tundra Swan nests and broods, northeast delta and CD North, CD South, and NPRA study areas, Alaska, 2004.

Table 24. Habitat use by nesting and brood-rearing Tundra Swans, Colville River Delta[a] and NPRA study area, Alaska, 2004.

	Colville River Delta				NPRA Study Area			
	Nests[b]		Broods[c]		Nests[b]		Broods[c]	
Habitat	Number	Use (%)	Number	Use (%)	Number	Use (%)	Number	Use (%)
Open Nearshore Water	0	0	0	0	0	0	1	4.2
Brackish Water	0	0	3	7.1	3	4.2	2	8.3
Tapped Lake with Low-water Connection	0	0	3	7.1	1	1.4	0	0
Tapped Lake with High-water Connection	0	0	8	19.0	0	0	0	0
Salt Marsh	2	3.9	4	9.5	3	4.2	1	4.2
Salt-killed Tundra	2	3.9	5	11.9	2	2.8	0	0
Deep Open Water without Islands	1	2.0	1	2.4	0	0	5	20.8
Deep Open Water with Islands or Polygonized Margins	2	3.9	0	0	4	4.2	4	16.7
Shallow Open Water without Islands	0	0	0	0	1	1.4	0	0
Shallow Open Water with Islands or Polygonized Margins	0	0	0	0	6	8.5	0	0
River or Stream	0	0	1	2.4	0	0	1	4.2
Sedge Marsh	0	0	0	0	1	1.4	1	4.2
Deep Polygon Complex	8	15.7	0	0	0	0	0	0
Grass Marsh	0	0	2	4.8	1	1.4	0	0
Young Basin Wetland Complex	0	0	0	0	2	2.8	0	0
Old Basin Wetland Complex	0	0	0	0	8	11.3	0	0
Nonpatterned Wet Meadow	7	13.7	5	11.9	4	5.6	1	4.2
Patterned Wet Meadow	22	43.1	3	7.1	7	9.9	2	8.3
Moist Sedge-Shrub Meadow	2	3.9	0	0	9	12.7	4	16.7
Moist Tussock Tundra	2	3.9	0	0	18	25.4	1	4.2
Tall, Low, or Dwarf Shrub	1	2.0	2	4.8	1	1.4	1	4.2
Barrens	2	3.9	5	11.9	0	0	0	0
Total	51	100	42	100	71	100	24	100

[a] The Colville River Delta comprises the CD North and CD South study areas and the northeast delta
[b] Includes nests found during swan and loon aerial surveys and ground surveys
[c] Includes broods found during aerial surveys only

since 1992 (Appendix F1). Although some nest sites were used in multiple years (and thus not annually independent locations), we were not able to distinguish these sites objectively from others where nests were close, but not in exactly the same location, in consecutive years. None of the nest sites was used in all the years that surveys were conducted. Previous investigations have reported that 21–49% of swan nests are located on mounds used during the previous year (Hawkins 1983, Monda et al. 1994) and that nest sites reused from previous years were slightly more successful than new nest sites (Monda et al. 1994). Therefore, deletion of multi-year nest sites from selection analysis could bias the results towards habitats used by less experienced or less successful pairs. Instead, we have chosen to include all nest sites, while recognizing that all locations may not be annually independent.

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. Over 11 years of surveys on the Colville Delta, Tundra Swans nested in 23 of 24 available habitats, of which 7 habitats were preferred and 7 were avoided (Appendix F1). Eighty-six percent of the nests were found in the 7 preferred habitats: Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Deep Polygon Complex, Patterned Wet Meadow, Nonpatterned Wet Meadow, and Moist Sedge–Shrub Meadow. Nests occurred most frequently in Patterned Wet Meadow (39% of all nests), Salt-killed Tundra (12%), and Nonpatterned Wet Meadow (11%).

Tundra Swan broods were observed in 12 of 24 available habitats on the Colville Delta in 2004 (Table 24). The largest proportion of broods in 2004 was observed in Tapped Lake with High-water Connection (19% of 42 broods). Habitat selection was evaluated for 261 Tundra Swan broods recorded on the Colville Delta since 1992 (Appendix F1). Eight habitats were preferred: Brackish Water, both types of Tapped Lakes, both types of Deep Open Water, Salt Marsh, Salt-killed Tundra, and Grass Marsh. Broods were seen most frequently in Tapped Lake with Low-water Connections (14% of all broods) and Patterned Wet Meadow (14%).

The high use of salt-affected or coastal habitats (e.g., Brackish Water, Salt Marsh, Salt-killed Tundra, Tidal Flat Barrens, and Tapped Lake with Low-water Connection) by brood-rearing swans reflects an apparent seasonal change in distribution or habitat preference, in that 38% of all swan broods on the delta were in salt-affected habitats, compared with only 21% of all nests (Appendix F1). Similar patterns have been reported by previous investigations (Monda et al. 1994, Spindler and Hall 1991).

NPRA Study Area

Distribution and Abundance

In 2004, 63 Tundra Swan nests (0.05 nests/km²) were found during the aerial survey of the NPRA study area (Figure 24, Table 23). Swan nesting density in the NPRA study area in 2004 was greater than the 16-year mean density in the Kuparuk Oilfield (Anderson et al. in prep.) but slightly less than the 11-year mean density recorded on the Colville Delta. Twenty-five additional nests were found by a combination of ground searches (1 nest) and helicopter-based surveys for nesting Yellow-billed Loons and Brant (24 nests).

Thirty-seven Tundra Swan broods (0.03 broods/km²) were observed in the NPRA study area in 2004 (Figure 24, Table 23). Estimated nesting success was 59% (37 of 63 nests successful), up from 42% in 2003. Comparable brood-rearing surveys in the Kuparuk Oilfield and on the Colville Delta in 2004 indicated estimated nesting success of 107% and 114%, respectively (Anderson et al., in prep). The mean brood size in the NPRA study area in 2004 was 2.1 young (n = 37 broods) (Table 23).

Habitat Use

Tundra Swan nests occurred in 16 of 25 available habitats in the NPRA study area in 2004 (Table 24). Nests occurred most frequently in Moist Tussock Tundra (24%), Moist Sedge–Shrub Meadow (13%), Old Basin Wetland Complex (11%), and Patterned Wet Meadow (10%).

Habitat selection was calculated for 182 Tundra Swan nests recorded in the NPRA study area since 2001 (Appendix F2). Tundra Swans nested in 18 of 25 available habitats, but preferred only 3 habitats—Shallow Open Water with Islands or Polygonized Margins, Grass Marsh, and Young Basin Wetland Complex—in which 24 nests were located.

Similar to swan broods on the Colville Delta, broods in NPRA were attracted to large, deep waterbodies. Swan broods used 12 of 25 available habitats in the NPRA study area in 2004 (Table 24). The 3 habitats used most frequently by brood-rearing swans were Deep Open Water without Islands (21% of all broods), Deep Open Water with Islands or Polygonized Margins (17%), and Moist Sedge–Shrub Meadow (17%).

Habitat selection was evaluated for 70 Tundra Swan broods recorded in the NPRA study area since 2001 (Appendix F2). Tundra Swan broods used 19 of 26 available habitats. Forty broods were located in the 3 preferred habitats: Deep Open Water without Islands, Deep Open Water with Islands or Polygonized Margins, and Tapped Lake with Low-water Connection.

GREATER WHITE-FRONTED GOOSE

Colville River Delta

Distribution and Abundance

Greater White-fronted Geese are by far the most abundant large bird nesting in the CD-3 search area. The 330 nests (18.3 nests/km²) of Greater White-fronted Geese accounted for 63% of all nests found in the CD-3 search area in 2004 (Figure 13, Table 5). More nests of Greater White-fronted Geese were found in the CD-3 search area in 2004 than in any previous year (previous high was 264 in 2003). The annual nest densities of this goose in CD-3 (≥9.8 nests/km²) were greater than any density reported previously elsewhere on the Colville Delta (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983, Burgess et al. 2003a, Johnson et al. 2003a) or in the NPRA (Derksen et al. 1981, Burgess et al. 2003b, Johnson 2004). Nesting success of White-fronted Geese in the CD-3 search area was 67% in 2004, which was similar to nesting success in 2000–2003.

In contrast, only 5 broods of Greater White-fronted Geese were observed in the CD-3 search area in 2004 (Table 6). Greater White-fronted Geese are wary and highly mobile during the brood-rearing period and this probably accounts for the scarcity of sightings during brood-rearing. The maximum number of broods of Greater White-fronted Geese that has been observed in the CD-3 search area since 2000 is 11 (Johnson et al. 2003b, 2004).

Habitat Use

Greater White-fronted Geese nested in a variety of habitats in 2004 (Table 7), but 2 habitats with polygonal surfaces accounted for >65% of all nests: Patterned Wet Meadow (40% of all nests) and Deep Polygon Complex (27%). Nonpatterned Wet Meadow and Salt-killed Tundra were the only other habitats that accounted for ≥10% of nests. Most (80%) Greater White-fronted Goose nests in 2004 were on slightly elevated landforms—polygon rims, low ridges, or small hummocks—that were similar to the nesting sites reported for other areas of the delta (Simpson et al. 1982, Johnson et al. 2003a). Nests ranged from <1 to 270 m from the nearest waterbody (mean = 81.2 m, n = 330 nests).

Habitat selection was analyzed for 1,104 Greater White-fronted Goose nests from 5 years of surveys in the CD-3 search area (Appendix G1). The 2 most frequently used habitats were identified as preferred for nesting: Patterned Wet Meadow (39% of nests) and Deep Polygon Complex (28%). Ten habitat types were avoided, although 193 nests occurred in these avoided habitats. One avoided habitat, Salt-killed Tundra, occupied 14% of the search area and contained 11% of the nests (117 nests), suggesting that it was an important nesting habitat for Greater White-fronted Geese, despite its being used less than its availability.

Most groups of brood-rearing Greater White-fronted Geese observed in the CD-3 search area in 2004 were located in Patterned Wet Meadow, although 1 group each was observed in Deep or Shallow Open Water with Islands or Polygonized Margins (Table 8). In previous years, when more broods were seen, they occurred in a variety of terrestrial and aquatic habitats (Johnson et al. 2003b, 2004).

NPRA Study Area

Distribution and Abundance

Greater White-fronted Geese also were the most abundant large birds nesting in the NPRA search areas. Their 113 nests constituted 41% of the total nests found (Figures 15 and 17, Table 13). Overall nest density in the combined NPRA search areas was 4.7 nests/km², with densities in the CD-5 search area reaching 8.0 nests/km² (Table 9). The overall nesting success for Greater White-Fronted Geese in the NPRA search areas in 2004 was 74% (Table 13).

Only 2 broods of Greater White-fronted Geese were observed in the NPRA search areas in 2004 (Table 10). However, a large number of broods were sighted during brood-rearing and fall-staging aerial surveys in 2004. Greater White-fronted Geese comprised 92% (1,755 geese in 31 groups, mean = 56.6 geese/group) of all geese sighted (Figure 25, Table 25). Juvenile geese were 22% of the total (383 young). The density of brood-rearing Greater White-fronted Geese was 2.9 birds/km², which was comparable to the density in 2003, but higher than in previous years.

During the fall-staging survey in 2004, Greater White-fronted Geese comprised 41% of total geese sighted, with 283 Greater White-fronted Geese observed in 18 groups (mean = 15.7 geese/group 2–56, density = 0.5 birds/km²) (Figure25, Table 25), For the second year in a row, observation conditions flying at the time of the surveys were sub-optimal for detecting geese due to extensive fog and low ceilings.

Habitat Use

Greater White-fronted Geese nested in a wide range of habitat types in the NPRA search areas, and unlike other geese in the region, the majority of nests were not in aquatic habitats (Table 14). The four habitats used most commonly by Greater White-fronted Geese for nesting were Patterned Wet Meadow (30% of all nests), Old Basin Wetland Complex (27%), Moist Sedge–Shrub Meadow (19%), and Moist Tussock Tundra (11%). Two habitats were preferred for nesting: Patterned Wet Meadow and Old Basin Wetland Complex (Appendix G2). Most Greater White-fronted Geese nested on elevated sites: polygon rims, low ridges, or small hummocks. Only 7 % of the Greater White-fronted Geese nested on islands. Greater White-fronted Geese in the NPRA study area nested farther from waterbodies (range ≤1–702m, mean = 181 m, n = 113 nests) than in the CD North study area.

In 2004, the two broods of Greater White-fronted Geese observed during ground surveys in the NPRA search areas were using Deep Open Water with Islands or Polygonized Margins (Table 15). During the brood-rearing aerial survey, Greater White-fronted Geese were located in or near lakes, rivers, streams, and marshes (Figure 25, Table 26). More than 57% of all Greater White-fronted Goose sightings were in aquatic habitats, usually near creek or river drainages. The terrestrial habitats in which Greater White-fronted Geese were observed were those associated with lakes or streams in the study area. It should be noted that the high use of lakes by geese that was observed during the aerial surveys was possibly an escape response to the aircraft, and may not represent use of foraging habitat.

Table 25. Number and density of brood-rearing and fall-staging geese during aerial surveys, NPRA study area, Alaska, 2004.

	Brood-rearing			Staging	
Species	Adults	Young	Density[a] (total birds/km²)	Number	Density[a] (birds/km²)
Greater White-fronted Goose	1,372	383	2.94	283	0.47
Snow Goose	30	30	0.10	96	0.16
Canada Goose	60	30	0.15	244	0.41
Brant	18	30	0.08	20	0.03
Unknown goose	0	0	0	35	0.06
Total	1,480	473	3.28	678	1.14

[a] Density based on a 50% survey of 1,192 km² (596 km²)

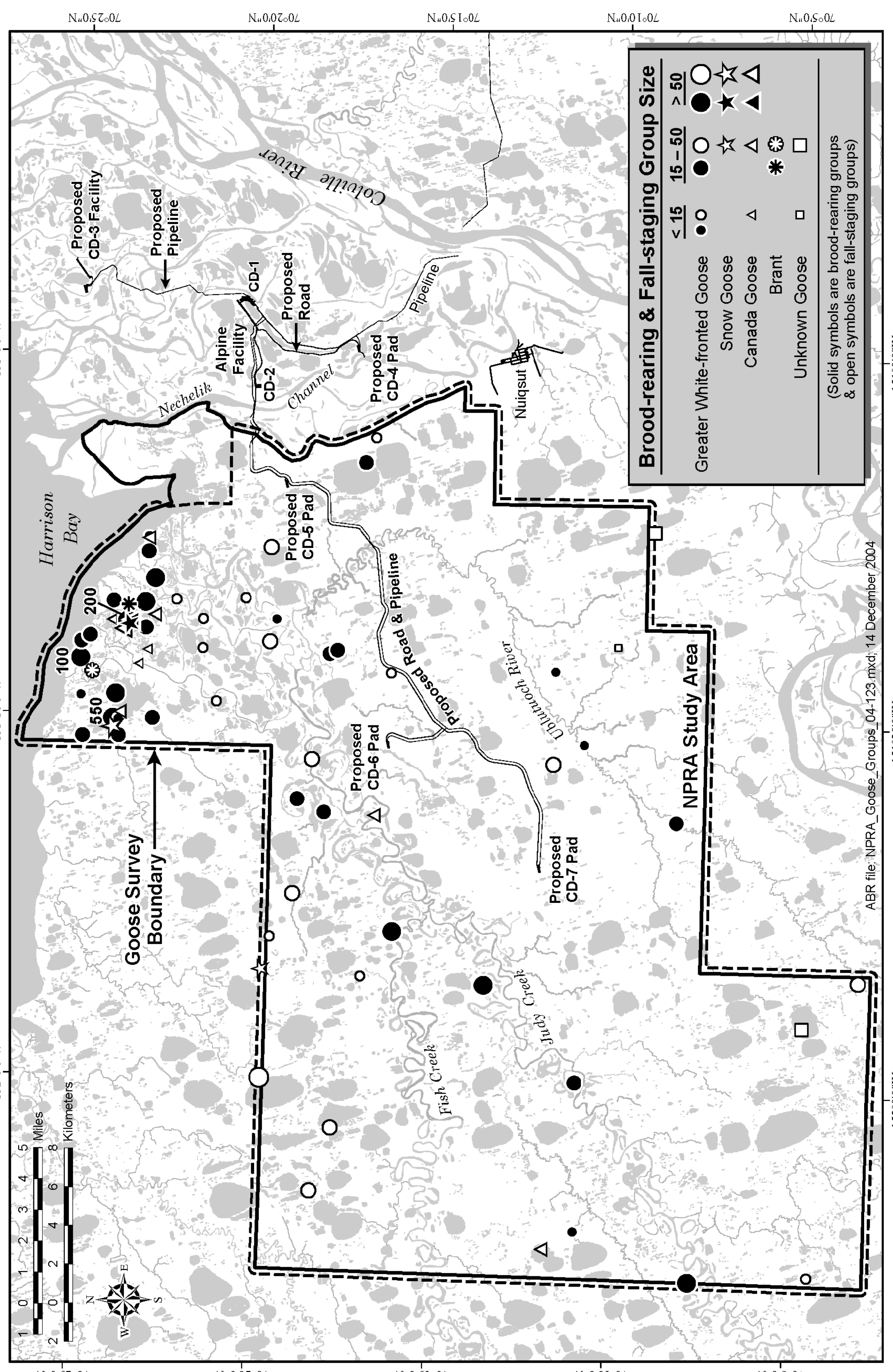

Figure 25. Greater White-fronted, Canada, and Snow Goose brood-rearing and fall-staging groups, NPRA study area, Alaska, 2004. Groups >100 birds are indicated.

Table 26. Habitat use by groups of brood-rearing/molting and fall-staging Greater White-fronted, Canada, and Snow geese, NPRA study area, Alaska, 2004.

SEASON	Greater White-fronted Goose		Snow Goose		Canada Goose		Brant		Unknown Goose	
Habitat	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)
BROOD-REARING										
Brackish Water	4	14.3	1	100	1	100	1	100	0	0
Tapped Lakes with Low-water Connection	3	10.7	0	0	0	0	0	0	0	0
Salt Marsh	3	10.7	0	0	0	0	0	0	0	0
Tidal Flat Barrens	5	17.9	0	0	0	0	0	0	0	0
Deep Open Water without Islands	1	3.6	0	0	0	0	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	7	25.0	0	0	0	0	0	0	0	0
Grass Marsh	1	3.6	0	0	0	0	0	0	0	0
Nonpatterned Wet Meadow	2	7.1	0	0	0	0	0	0	0	0
Patterned Wet Meadow	1	3.6	0	0	0	0	0	0	0	0
Tall, Low, or Dwarf Shrub	1	3.6	0	0	0	0	0	0	0	0
Total	28[a]	100	1	100	1	100	1	100	0	0
STAGING										
Brackish Water	0	0	0	0	2	25.0	0	0	0	0
Tapped Lakes with Low-water Connection	1	7.1	0	0	1	12.5	0	0	0	0
Salt Marsh	0	0	0	0	2	25.0	0	0	0	0
Tidal Flat Barrens	0	0	0	0	1	12.5	1	100	0	0
Salt-killed Tundra	1	7.1	0	0	0	0	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	1	7.1	0	0	0	0	0	0	0	0
River or Stream	1	7.1	0	0	1	12.5	0	0	0	0
Grass Marsh	2	14.3	0	0	0	0	0	0	0	0
Old Basin Wetland Complex	3	21.4	1	100	0	0	0	0	1	100
Patterned Wet Meadow	1	7.1	0	0	0	0	0	0	0	0
Moist Sedge–Shrub Meadow	2	14.3	0	0	1	12.5	0	0	0	0
Moist Tussock	1	7.1	0	0	0	0	0	0	0	0
Tall, Low, or Dwarf Shrub	1	7.1	0	0	0	0	0	0	0	0
Total[b]	14	100	1	100	8	100	1	100	1	100

[a] Excludes 3 groups seen outside the area mapped for habitat

[b] Excludes groups seen outside the area mapped for habitat: 5 Greater White-fronted Goose, 2 Snow Goose, 1 Canada Goose, and 2 unidentified goose groups

During the staging aerial survey in 2004, Greater White-fronted Geese also were located near aquatic habitats, but were more widely distributed than during brood-rearing (Figure 25). Three habitats (2 terrestrial) accounted for >40% of all group sightings: Grass Marsh, Old Basin Wetland Complex, and Moist Sedge–Shrub Tundra (Table 26).

BRANT

Colville River Delta

Distribution and Abundance

Nesting Brant are abundant on the Colville Delta, but the largest colonies lie outside of the CD-3 search area on islands in the East Channel of the Colville River (see Johnson et al. 1999). In 2004, 23 Brant nests (1.3 nests/km²) were found in the CD-3 search area (Figure 12, Table 5), which was almost double that found in 2003 (12 nests, Johnson et al. 2004), but similar to other years (range 23–40 in 2000–2002; Johnson et al. 2003b). Nesting success was 55% in 2004, the second highest recorded since 2000.

No brood-rearing Brant were observed in the CD-3 search area in 2004. The lack of Brant broods in most years probably is due both to moderate nesting success and to post-hatching movements of Brant to coastal salt marshes for brood-rearing (see Johnson et al. 2003b). Aerial surveys for nesting, brood-rearing, and fall-staging geese were not conducted on the Colville Delta in 2004.

Habitat Use

Brant nests in 2004 were found primarily within the colonies that were identified in previous years and mostly were located on islands or peninsulas in Deep Open Water with Islands or Polygonized Margins (74% of all known nests) and Deep Polygon Complex (13%; Table 7). All Brant nests were <1 m from water.

NPRA Study Area

Distribution and Abundance

Twenty-one Brant nests were found in the various NPRA search areas in 2004, yielding 0.9 nests/km² (Table 13). The majority of these Brant nests were within 2.5 km of the proposed CD-5 pad (Figures 15 and 26). However, in 2004, Brant nested (2 nests) near the proposed CD-7 pad for the first time since our searches began there in 2002 (Figure 17). Overall nesting success for Brant was relatively high (76%) in 2004 compared with past years.

No Brant broods were observed in the NPRA search areas in 2004. Brant broods were observed during the brood-rearing aerial survey, the first record of Brant broods in the 4 years of the survey (Burgess et al. 2003b, Johnson et al. 2004). Forty-eight Brant (18 adults and 30 goslings) were observed in one group in the NPRA study area in 2004 (Figure 25, Table 25). Another smaller group of Brant also was seen during the staging survey in August. Both Brant groups were observed close to the coast in the Fish Creek Delta, which was surveyed for the first time in 2004.

Habitat Use

In the NPRA search areas in 2004, all Brant nests were located on islands. These Brant colonies often included Canada Goose nests. Brant nests in the NPRA search areas were located in 3 habitats: Shallow Open Water with Islands or Polygonized Margins, Young Basin Wetland Complex, and Shallow Open Water without Islands (Table 14). The single nest in Shallow Open Water without Islands occurred on a small islet that was not recognized at the scale of mapping (islands were ≥1 m in diameter and ≥3 m from the shore of a waterbody ≥1/4 ha in size) used in the habitat classification.

The brood-rearing group of Brant seen during the aerial survey was located in Brackish Water (Table 26), which most likely represented escape habitat, as Brant broods typically feed in salt marshes (Sedinger and Stickney 2000). The group of staging Brant was seen in Tidal Flat Barrens (Table 26).

CANADA GOOSE

Colville River Delta

Distribution and Abundance

Canada Geese are relatively uncommon in the Colville Delta and only 4 nests were found in the CD-3 search area in 2004 (Table 5). Nest density was 0.2 nests/km² and nesting success was 67%. No brood-rearing Canada Geese were observed in the CD-3 search area in 2004.

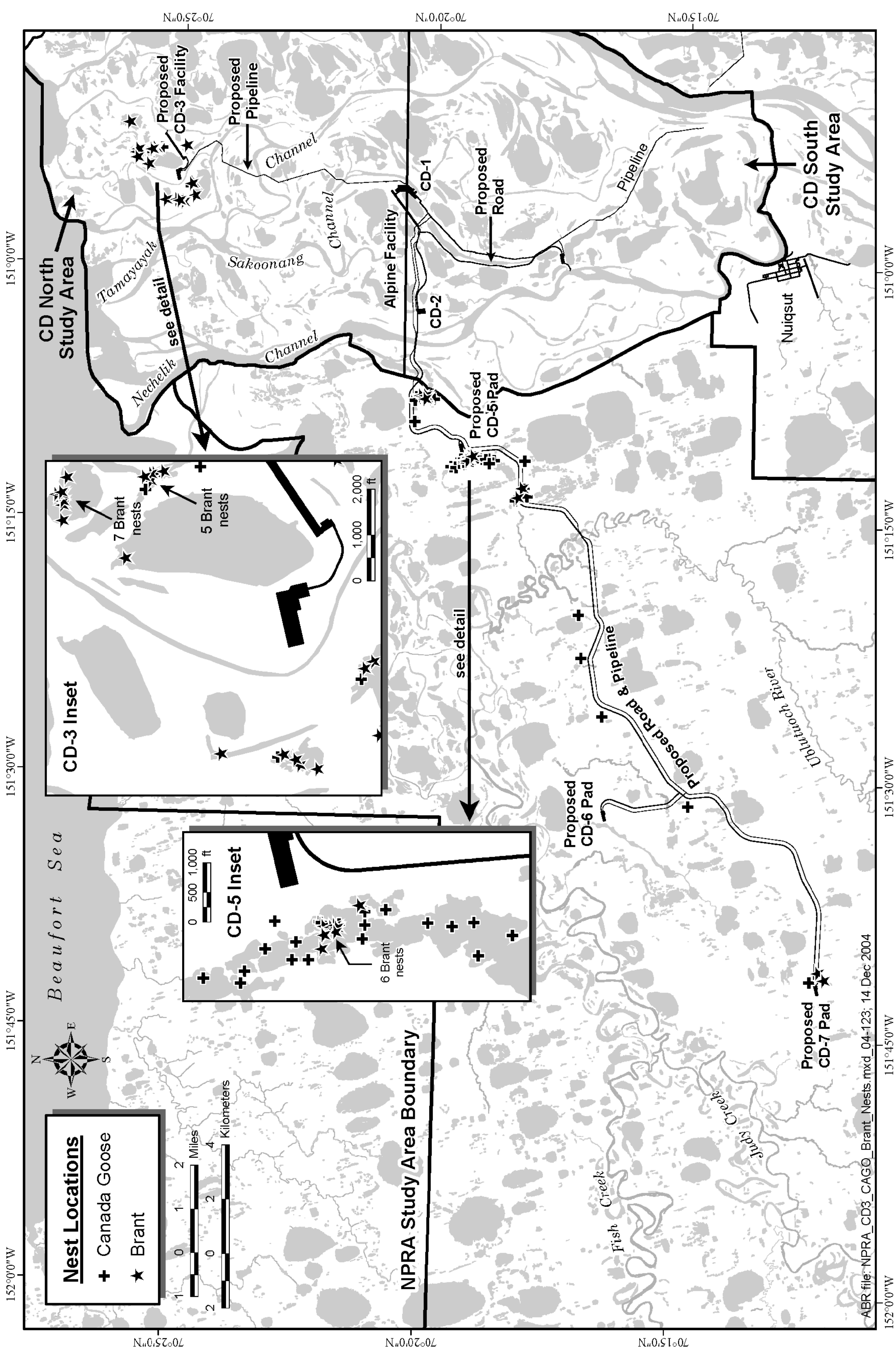

Figure 26. Brant and Canada Goose nest locations from ground-based surveys, CD North and NPRA study areas, Alaska, 2004.

Habitat Use

Canada Geese nested in 4 habitat types in the CD-3 search area: Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, Nonpatterned Wet Meadow, and Patterned Wet Meadow (Table 7). Nests were located on small islands, hummocks, and polygon rims, all within 10 m of water.

NPRA Study Area

Distribution and Abundance

Nesting Canada Geese were common in the NPRA search areas. Thirty-four Canada Goose nests (1.4 nests/km²) were found in 2004 (Figure 26, Table 13). Twenty Canada Goose nests occurred in the CD-5 search area, and the density of nests (5 nests/km²) in this search area was the highest of any area searched in 2004 (Tables 9 and 12). Nesting success was 53% in the combined NPRA search areas in 2004.

No Canada Goose broods were observed during ground searches in 2004. During brood-rearing aerial surveys, 90 Canada Geese (including 30 young) were observed at 1 location in the NPRA study area (Figure 25, Table 25). During fall-staging surveys, 244 Canada Geese were observed at 9 locations in the NPRA study area (Figure 25, Table 25). Canada Geese have only been recorded in 2 previous years during fall staging surveys and in very low numbers (<10 birds each year; Burgess et al. 2003b, Johnson et al. 2004).

Habitat Use

Canada Goose nests in the NPRA search areas in 2004 were located primarily in aquatic or wetland basin habitats (Table 14), with the majority of the nests in Shallow Open Water with Islands or Polygonized Margins (53% of nests) and Old Basin Wetland Complex (24%). Canada Geese nested on islands (81%) or on shoreline features (9%) and usually <1 m from water.

During the brood-rearing aerial survey, the 1 group of Canada Geese occurred in Brackish Water, which most likely was escape habitat (Figure 25, Table 26). During the staging survey, most groups were equally distributed between terrestrial and aquatic habitats, most of which were salt-affected.

SNOW GOOSE

Colville River Delta

Distribution and Abundance

Snow Geese nest in small numbers and scattered locations on the Colville Delta. In 2004, 3 Snow Goose nests were found in the CD-3 search area (Table 5). All 3 nests were successful, and the nest density was 0.2 nests/km². In most of the years that the CD-3 area has been searched, 1–3 Snow Goose nests have been recorded there (Johnson et al. 2003b, 2004).

No Snow Geese were observed in the search area during brood-rearing in 2004. Snow Goose broods were not recorded in the CD-3 search area in most years, except for 2003, but the larger CD North study area had Snow Goose broods (range 0–72 geese) in 5 out of 6 years aerial surveys were conducted there (Johnson et al. 2003b).

Habitat Use

In 2004, Snow Geese in the CD-3 search area nested in Patterned Wet Meadow (2 nests) and Tall, Low and Dwarf Shrub (1 nest) (Table 7). Nests were found on an island, hummock, and polygon rim, all within 10 m of water.

NPRA Study Area

No Snow Goose nests or brood-rearing groups were observed in 2004 within the NPRA search areas. During the brood-rearing aerial survey in 2004, a single group of 60 Snow Geese (including 30 goslings) was observed in the NPRA study area in Brackish Water (Figure 25, Table 26). During staging, 1 group of 96 Snow Geese was seen in the Fish Creek Delta in Old Basin Wetland Complex (Figure 25, Table 26).

GLAUCOUS GULL

Colville River Delta

Distribution and Abundance

Twenty-one Glaucous Gull nests were counted in the CD North study area and 17 nests were counted in the CD South study area during aerial surveys for Tundra Swans and Yellow-billed Loons in 2004 (Figure 27; Table 27). An additional 5 nests were found during ground searches in the CD-3 search area (Figure 13). In the CD North study area, most nests were found in the northern part of the study area, including a colony of 7 nests.

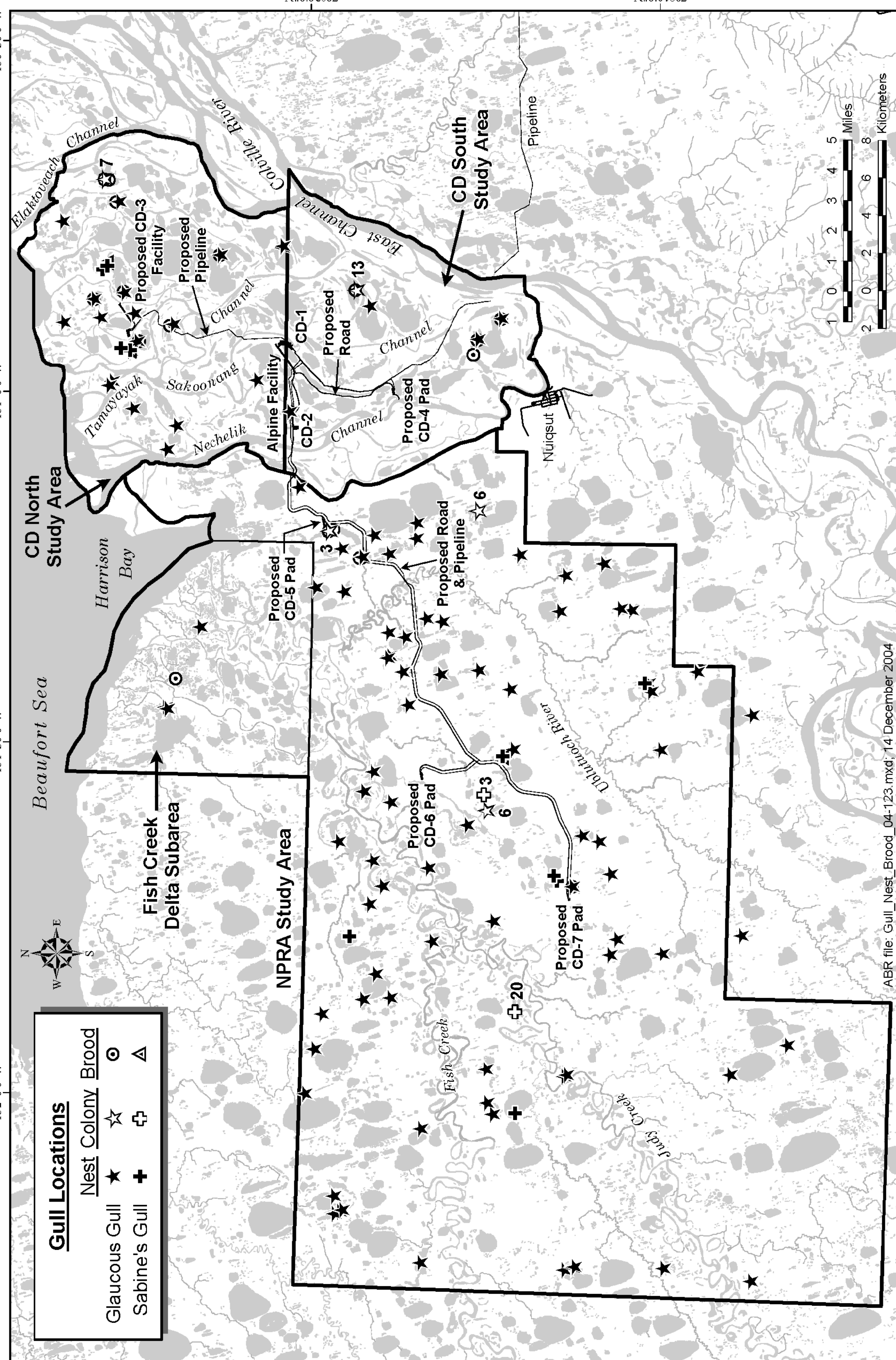

Figure 27. Glaucous and Sabine's gull nests and broods, CD North, CD South, and NPRA study areas, Alaska, 2004. Labels indicate the number of nests where >2 nests present.

Table 27. Number and density of Glaucous and Sabine's gull nests, CD North, CD South, and NPRA study areas, Alaska, 2004.

AREA[a] Species	Number of Nests			Nest Density[d] (nests/km²)
	Aerial Surveys[b]	Ground-searches[c]	Total	
CD NORTH STUDY AREA				
Glaucous Gull	21	7[e]	26	0.13
Sabine's Gull	0	4	4	–
CD SOUTH STUDY AREA[f]				
Glaucous Gull	17	–	17	0.11
Sabine's Gull	0	–	0	–
NPRA STUDY AREA				
Glaucous Gull	86	10[g]	90	0.08
Sabine's Gull	27	5[h]	31	–

[a] CD North study area = 206.7 km², CD South study area = 155.9 km², NPRA study area = 1,100.2 km²
[b] Data were collected during aerial surveys for nesting Tundra Swans and Yellow-billed Loons
[c] Data were collected in large waterbird ground-search areas (see Figures 4 and 5)
[d] Nest density not calculated for Sabine's Gulls because detectability of nesting pairs on aerial survey is low and surveys were not comprehensive
[e] Two nests found during ground searches also were found on aerial survey
[f] No ground search was conducted in the CD South study area in 2004
[g] Six nests found during ground searches also were found on aerial survey
[h] One nest found during ground searches also was found on aerial survey

Only 1–2 nests have been observed at this location in 3 previous years of surveys (Johnson et al. 2003b, 2004). In the CD South study area, 13 nests were part of a Glaucous Gull colony located ~5 km southeast of the Alpine project area (Figure 27). Counts at this colony have ranged from 10 to 18 nests during 6 years of surveys (Burgess et al. 2003a, Johnson et al. 2004).

The density of Glaucous Gull nests in the CD North study area in 2004 (0.13 nests/km²; Table 27) was higher than any of the 3 previous years of surveys (Johnson et al. 2003b, 2004). In the CD South Study area, nest density in 2004 (0.11 nests/km²) was within the range of densities reported (Burgess et al. 2003b, Johnson et al. 2004). Because Glaucous Gulls were counted on aerial surveys designed to survey other species, some nests probably were missed in each year. The density of Glaucous Gull nests estimated from the ground search in the CD-3 search area was 0.4 nests/km² in 2004 (Table 5), which was within the range for this area from previous years (Johnson et al. 2003b, 2004).

Glaucous Gull broods were recorded incidentally in 2004 during the aerial survey for brood-rearing loons. Ten Glaucous Gull broods were recorded, 4 in the CD North study area and 6 in the CD South study area (Figure 27). Four additional broods were observed during ground searches in the CD-3 search area (Figures 14 and 27, Table 6). The total count of 14 Glaucous Gull broods was higher than that seen in any previous year of surveys (Johnson et al. 2003b, 2004). Most Glaucous Gull broods were located near known nest locations. Two young were observed at the colony location in the CD North study area in 2004, and 5 young were observed at the colony location in the CD South study area.

Habitat Use

Thirteen of the 39 Glaucous Gull nests (33%) found on the Colville Delta in 2004 were from the colony in the CD South study area, which is a large island classified as Patterned Wet Meadow (Figure 27, Table 28) in Deep Open Water with Islands or Polygonized Margins. One additional nest in the CD North Study area was in Patterned Wet

Table 28. Habitat use by nesting Glaucous Gulls, Colville River Delta[a] and NPRA study area, Alaska, 2004.

	Colville River Delta		NPRA Study Area	
Habitat	Nests	Use (%)	Nests	Use (%)
Brackish Water	1	2.6	0	0
Tapped Lake with High-water Connection	11	28.2	0	0
Salt Marsh	0	0	2	2.5
Salt-killed Tundra	2	5.1	1	1.3
Deep Open Water with Islands or Polygonized Margins	4	10.3	6	7.5
Shallow Open Water without Islands	0	0	5	6.3
Shallow Open Water with Islands or Polygonized Margins	1	2.6	39	48.8
Sedge Marsh	0	0	7	8.8
Deep Polygon Complex	5	12.8	0	0
Grass Marsh	0	0	1	1.3
Young Basin Wetland Complex	0	0	2	2.5
Old Basin Wetland Complex	0	0	14	17.5
Nonpatterned Wet Meadow	1	2.6	0	0
Patterned Wet Meadow	14	35.9	3	3.8
Total	39	100	80	100

[a] The Colville River Delta comprises the CD North and CD South study areas and the northeast delta

Meadow. The colony of 7 nests (18% of all nests) in the northeastern part of the CD North study area were on 4 small islands in Tapped Lake with High-water Connection. Four additional nests were found on the delta in Tapped Lake with High-water Connection. Most of the remaining nests were located on islands in Deep Polygon Complex (13% of all nests) and Deep Open Water with Islands or Polygonized Margins (10%). Glaucous Gull broods observed during aerial and ground surveys were located near nests and in the same habitats as were the nests (Table 8).

NPRA Study Area

Distribution and Abundance

Eighty-nine Glaucous Gull nests were counted in the NPRA study area in 2004 during aerial surveys for swans and loons (Figure 27, Table 27). Four additional nests were found during ground searches. Of the 93 nests found in the NPRA study area in 2004, 15 nests were in 3 colonies—1 colony in the CD-5 search area had 3 nests, 1 colony south of the CD-6 search area had 6 nests, and another in the eastern part of the study area had 6 nests (Figures 15 and 27). These colonies also were active in 2002 and 2003, when 4–7 nests were found at each location (Burgess et al. 2003b, Johnson et al. 2004). Most other Glaucous Gull nests found in 2004 were individual nest locations (Figure 27).

Glaucous Gull nests were distributed throughout the NPRA study area in 2004 (Figure 27), and many were in the same locations as in previous years of survey (Burgess et al. 2003b, Johnson et al. 2004). Nest density in 2004 in the NPRA study area was 0.08 nests/km² (Table 27), similar to previous years (Burgess et al. 2003b, Johnson et al. 2004). The density of Glaucous Gull nests found in the combined search areas in the NPRA study area in 2004 was 0.3 nests/km² (Table 13), but, as mentioned earlier, the search areas were not representative of the entire study area.

Three Glaucous Gull broods were observed during the brood-rearing aerial survey for Yellow-billed Loons in 2004, 2 of which were at the colony site in the CD-5 search area (Figures 16 and 27). One additional brood was seen during ground searches in the CD-7 search area (Figure 18 and 27, Table 10), and another additional brood was seen in the Fish Creek Delta during the goose staging survey.

Habitat Use

Glaucous Gulls nested primarily on islands in lakes. Habitat information is available for 80 Glaucous Gull nests in the NPRA study area in 2004 (Table 28). Glaucous Gulls were found nesting in 10 of 26 available habitats. Most nests were located on islands in Shallow Open Water with Islands or Polygonized Margins (49% of all nests) and Old Basin Wetland Complex (17%). The remaining 27 nests were found on islands or complex shorelines of 8 other habitats (Table 28). Glaucous Gull broods were found in aquatic habitats near nest locations, often in the same habitat as the nest (Table 15).

SABINE'S GULL

Colville River Delta

Distribution and Abundance

No Sabine's Gull nests were observed during the aerial survey for nesting loons on the Colville Delta in 2004. Sabine's Gulls are difficult to detect from the air and nest in a wider variety of habitats than are included in the loon survey, which focused on large (≥10 ha) waterbodies. Four Sabine's Gull nests were found during ground searches in the CD-3 search area in 2004, and the density was 0.2 nests/km² for that area (Figure 13, Table 5). Three Sabine's Gull broods were found during nest fate checks in July in the CD-3 search area (Figure 14, Table 6).

Habitat Use

All Sabine's Gull nests in the CD-3 search area were single-nest locations on islands, peninsulas or along complex shorelines in 4 habitats: Salt-killed Tundra, Deep Open Water with Islands and Polygonized Margins, Deep Polygon Complex, and Patterned Wet Meadow (Table 7). Sabine's Gull broods were located in Deep Open Water with Islands or Polygonized Margins and Deep Polygon Complex (Table 8).

NPRA Study Area

Distribution and Abundance

During the nesting survey in 2004 for loons, 27 Sabine's Gull nests were found in the NPRA study area, either as single nests, pairs of nests, or colonies (Figure 27, Table 27). An additional 4 nests were found during ground searches, 2 nests in extended buffer search areas in the road corridor, and 2 nests in the CD-7 search area (Figures 17, Tables 9 and 12). The third nest found in the CD-7 search area was seen on both aerial and ground surveys. Twenty-three of the Sabine's Gull nests were located in 2 nesting colonies, one with 20 and the other with 3 nests and both previously occupied sites (Figure 27) (Burgess et al. 2003b, Johnson et al. 2004).

Both Sabine's Gull colonies and nests were located in the northern half of the study area, but that may be because the Yellow-billed Loon aerial survey and the ground searches were concentrated there. Sabine's Gull densities were not calculated for the NPRA study area because our sightings are opportunistic and not comprehensive for that area. However, nest densities were calculated for the combined search areas in the NPRA study area and Sabine's Gulls nested at a density of 0.2 nests/km² (Table 13). One group of Sabine's Gulls, including 3 adults and 2 young, was observed in an extended buffer search area (Figure 18, Table 10).

Habitat Use

The Sabine's Gull colony with 20 nests in 2004 was located in an extensive area of Grass Marsh. The other Sabine's Gull colony of 3 nests was located in Shallow Open Water with Islands or Polygonized Margins. Other nests were found in Shallow Open Water with Islands or Polygonized Margins, Sedge Marsh, Old Basin Wetland Complex, and Nonpatterned Wet Meadow (Table 14). One Sabine's Gull brood group was seen in Shallow Open Water with Islands or Polygonized Margins (Table 15).

CARIBOU

Caribou from 2 adjacent herds—the Teshekpuk Herd and the Central Arctic Herd—use the Colville Delta and NPRA study areas. The 2 herds are roughly similar in size, although the Teshekpuk Herd has grown at a faster rate in recent years. The latest ADFG photocensuses, conducted in July 2002, counted 45,166 caribou in the Teshekpuk Herd (Carroll 2003) and 31,857 caribou in the Central Arctic Herd (Lenart 2003). Although the degree of use of the study areas by each herd varies by season and year, telemetry data indicate consistent use of the northeastern NPRA area by Teshekpuk Herd caribou and of the Colville Delta by Central Arctic Herd caribou. The Teshekpuk Herd calves and summers in a core area surrounding Teshekpuk Lake in the NPRA, about 50 km northwest of our study area, and disperses across the coastal plain in winter, traveling south of the Brooks Range in some years (Silva 1985, Carroll 1995, Philo et al. 1993, Prichard et al. 2001). The nearest high-density calving area used by the Central Arctic Herd is located south and southwest of the Kuparuk Oilfield, ~35 km east of the Colville Delta; the herd summers on the coastal plain between the Colville Delta and the Canning River and winters in the foothills of the Brooks Range (Murphy and Lawhead 2000).

Colville River Delta

Distribution and Abundance

Caribou density on the Colville Delta was fairly high (1.33 caribou/km²) on the aerial survey on 25 June 2004 and very low (0.02 caribou/km²) on the 11 August survey (Table 29). The relatively high density on the first survey resulted from the aggregation of mosquito-harassed caribou on the outer delta (Figure 28); 329 caribou were counted (658 estimated) on transects and at least another 724 were observed off transect, for a minimal observed number of >1,050 caribou on the delta that day. A similar number of caribou were observed during avian nest searches on the outer delta several days earlier (21–22 June; M. Evans, ABR, pers. comm.). These caribou were most likely Teshekpuk Herd animals that had moved northeastward onto the delta from the NPRA study area after mosquito harassment began on 20 June. The western segment of the Central Arctic Herd reportedly remained well east of the delta during the 2004 insect season, even moving east of the Sagavanirktok River later in July (S. Arthur, ADFG, pers. comm.). Only 4 caribou were recorded on delta transects on the 11 August survey, which occurred during the period when oestrid flies were harassing caribou.

Table 29. Number and density of caribou observed during aerial strip-transect surveys, Colville River Delta[a] and NPRA study area, Alaska, May–October 2004.

AREA Date	Large Caribou[b]	Calves	Total Caribou	Estimated Total[c]	SE[d]	Density (caribou/km²)[e]	Mean Group Size
COLVILLE RIVER DELTA (494 km²)[f]							
25 June	316	13	329	658	418.7	1.33	82.3
11 August	4	0	4	8	3.1	0.02	1.0
Total	320	13	333	666	–	0.67	41.6
NPRA (1,310 km²)[f]							
18 May	29	0	29	58	17.0	0.04	5.8
25 June	2	0	2	4	2.8	<0.01	1.0
10 August	45	0	45	90	11.0	0.07	1.1
15 September	183	27	210	420	81.9	0.32	6.0
18 October	802	nr[g]	802	1,604	229.3	1.23	12.2
Total	1,061	27	1,088	2,176	–	0.33	7.4

[a] The Colville River Delta comprises the CD North and CD South study areas and the northeast delta
[b] Adults + yearlings
[c] Estimated total = total caribou × 2, to adjust for 50% sampling coverage
[d] Standard error of total caribou calculated as described by Gasaway et al. (1986), using transects as sample units
[e] Density = estimated total / survey area
[f] Survey coverage was 50% of these areas (654 km² in NPRA and 247 km² on the Colville River Delta were surveyed), see Figure 28
[g] nr = not recorded; calves not reliably differentiated due to large size

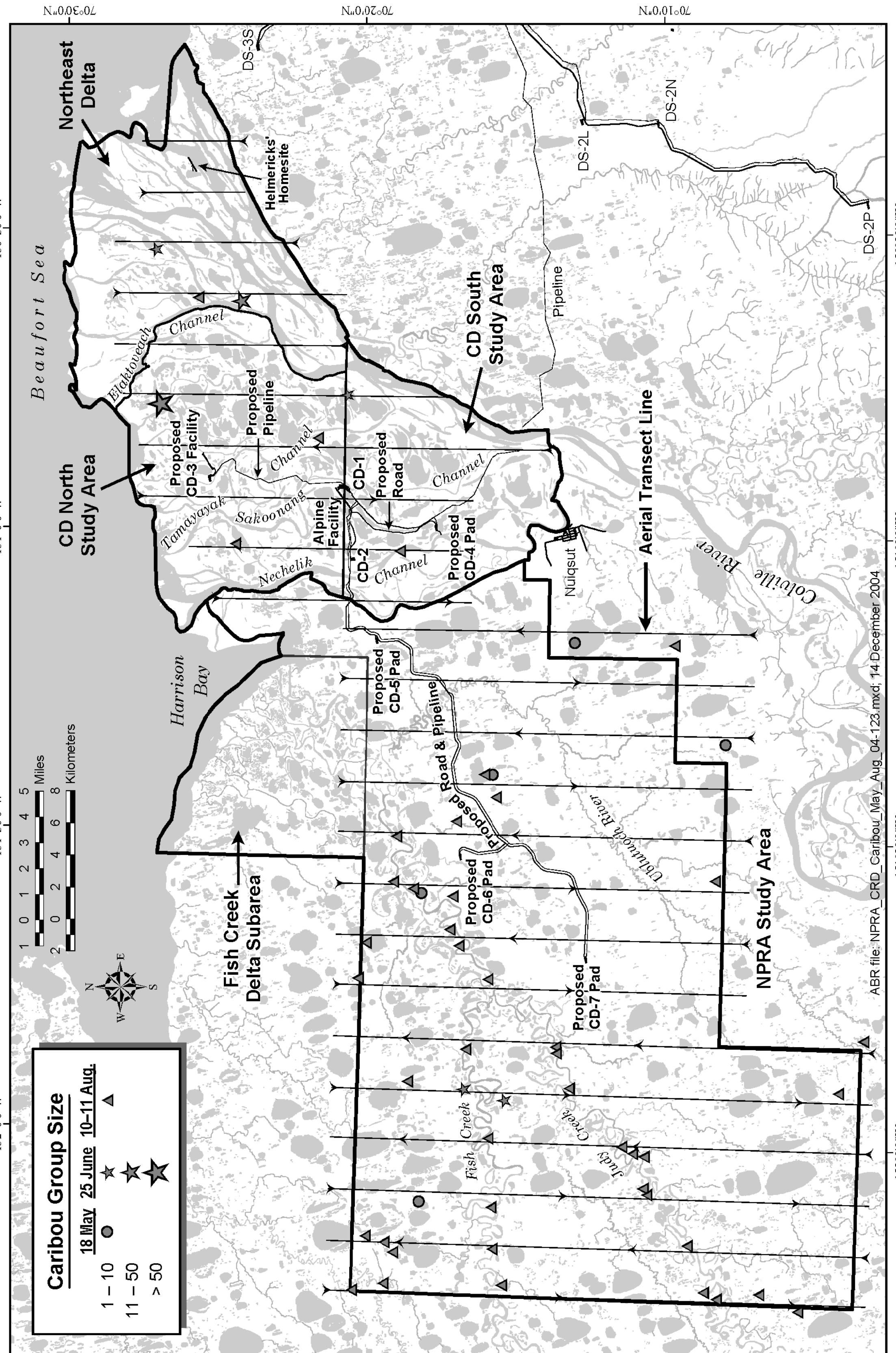

Figure 28. Distribution and group size of caribou, northeast delta and CD North, CD South, and NPRA study areas, Alaska, May–August 2004.

NPRA Study Area

Distribution and Abundance

Caribou use of the NPRA study area appears to peak during fall and winter (Burgess et al. 2002b, 2003b; Johnson et al. 2004), in contrast to the neighboring Colville Delta, where the greatest use occurs during the insect season (Burgess et al. 2003a, Johnson et al. 2004). No late winter survey was conducted in 2004. Few caribou were present in the study area during the pre-calving survey on 18 May 2004 (Figure 28), when only 29 caribou were seen (58 estimated) in the area (Table 29). This number was the lowest recorded in the month of May since surveys began in 2001 (Burgess et al. 2002b, 2003b; Johnson et al. 2004).

Although we were unable to conduct the calving survey we had planned in 2004, surveys in 2001–2003 indicated that the NPRA survey area was not an important calving area (Burgess et al. 2002b, 2003b; Johnson et al. 2004). Results of other surveys have demonstrated that our NPRA study area is at the southeastern periphery of the Teshekpuk Herd calving grounds and is used only rarely for calving by Central Arctic Herd animals (Philo et al. 1993; Noel 1999, 2000; Prichard et al. 2001; Jensen and Noel 2002; Arthur and Del Vecchio 2003; Prichard and Murphy 2004; Noel and George 2004; G. Carroll and E. Lenart, ADFG, pers. comm.).

The beginning of mosquito harassment in the NPRA survey area on 20 June 2004 caused caribou to move toward the coast. Only 2 caribou were seen on the 25 June survey and none were seen during fox den checks on 29–30 June. No aerial surveys were conducted during July 2004 and few caribou were seen during fox den observations on 9–12 July. Caribou typically leave the survey area during harassment by mosquitoes, which normally are active from late June through July in the region. The area surveyed in NPRA is inland from the coastal habitats typically used for relief from mosquitoes, so caribou numbers would be expected to be low during warm, calm weather in the insect season. It is likely, however, that caribou move inland into the area when insect harassment subsides during cool, windy periods, although our periodic aerial surveys since 2001 generally appear to have been too infrequent to detect such movements (some were noted in 2002; Burgess et al. 2003b).

The number of caribou in the study area increased slightly by early August 2004, after the seasonal decline in mosquito abundance but when oestrid flies evidently were still present. On 10 August, 45 caribou were seen (90 estimated) in the survey area (Table 29), many of which were feeding in riparian shrub habitats or standing on sand bars along Fish and Judy creeks (Figure 28). A strong association of caribou with riparian habitats also was noted in August 2002 and 2003 (Burgess et al. 2003b, Johnson et al. 2004), but not in August 2001 (Burgess et al. 2002b).

Caribou numbers in the study area increased further during fall 2004 (Figure 29, Table 29), consistent with the general pattern seen since 2001. The mid-September survey recorded 210 caribou (420 estimated) and the mid-October survey recorded 802 caribou (1,604 estimated; Table 29). The October survey occurred during the breeding season (rut), which is reflected in the increased mean group size at that time (Table 29). Although the timing has varied somewhat, the number of caribou in the study area has increased in the fall in all 4 years of surveys (Figure 30). The density of 3.46 caribou/km² in late September 2003 (Johnson et al. 2004) was the highest recorded among all of our surveys (Figure 30). In mid-October 2004, a southeasterly movement through the survey area and across the Colville River south of Nuiqsut occurred, as numerous Teshekpuk Herd caribou moved into the northern portions of the Central Arctic Herd winter range by November (L. Parrett, Univ. Alaska Fairbanks, pers. comm.; G. Carroll, ADFG, pers. comm.). A similar migratory movement was observed in mid-October 2003, including a highly unusual movement of >10,000 Teshekpuk Herd caribou far east of the NPRA to winter in the Arctic National Wildlife Refuge, an area not known to have been used before by this herd (Carroll et al. 2004).

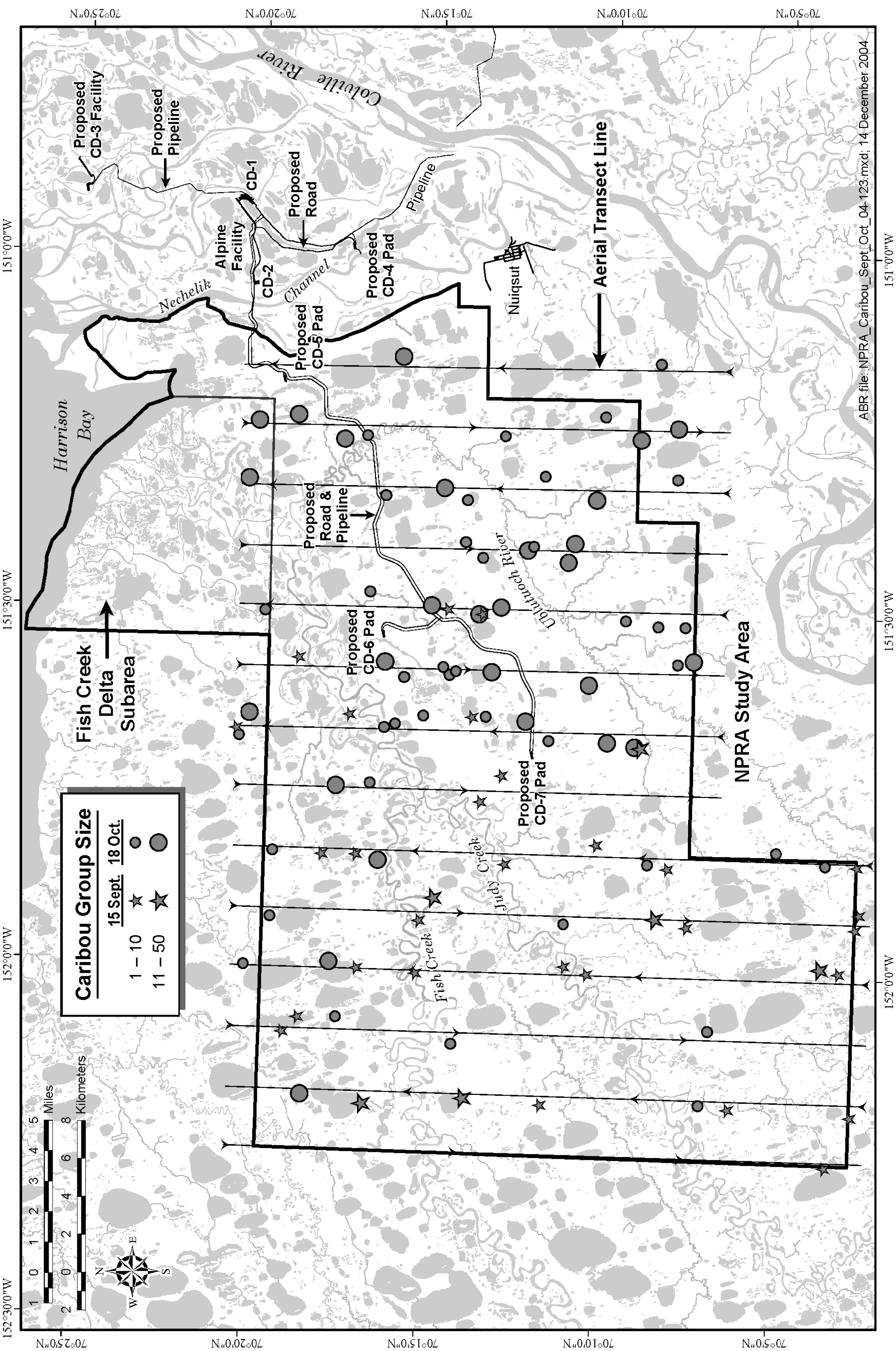

Figure 29. Distribution and group size of caribou, NPRA study area, Alaska, September–October 2004.

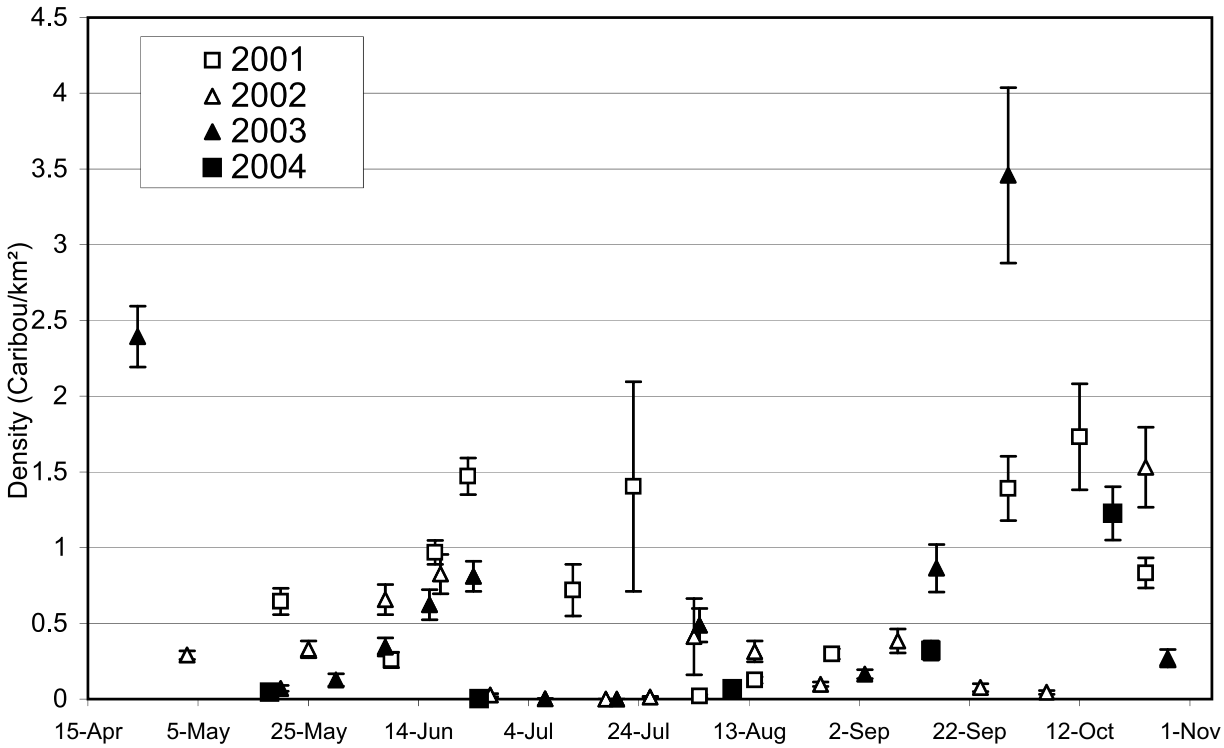

Figure 30. Caribou density (mean number/km² ± SE), NPRA study area, Alaska, April–October 2001–2004.

ARCTIC FOX

Colville River Delta

Distribution and Abundance

Since 1992, 25 fox dens have been found on the Colville Delta (Figure 31, Appendix H1). One new arctic fox site (Den 107) was found on the CD North study area on 29 June 2004. Although this was the first den found on the delta since 2001, it did not appear to be a newly excavated site; rather, it probably was a site reported in 1998 as being located farther west (S. Earnst, pers. comm.) but never found on previous searches. In 2004, 16 (64%) of the 25 sites on the delta were classified as arctic fox dens, including 10 (77%) of the 13 dens in the CD North study area, 5 (50%) of the 10 dens in the CD South study area, and 1 (50%) of the 2 dens in the northeast delta area. The total density of arctic fox dens (occupied and inactive) on the entire delta (552 km²) was 1 den/35 km², virtually identical to the density of 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).

Based on brief visits on 28–29 June at all 16 arctic fox dens on the delta and ~30 h in 11 observation bouts at 7 of those dens during 10–11 July, we concluded that pups were present at a minimum of 3 natal dens and suspected that pups may have been present at 3 other dens that appeared to be active (Appendix H1). The total count for the 3 natal sites was 12 pups, for a mean litter size of 4 pups. Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to reliably obtain complete counts. The mean litter size in 2004 was similar to those calculated in most recent years when small mammals were not particularly abundant, and was near the middle of the range observed annually on the Colville Delta and adjacent coastal plain tundra to the east of the delta during 1993–2001 (3.2–6.1 pups/litter; Johnson et al. 2003a).

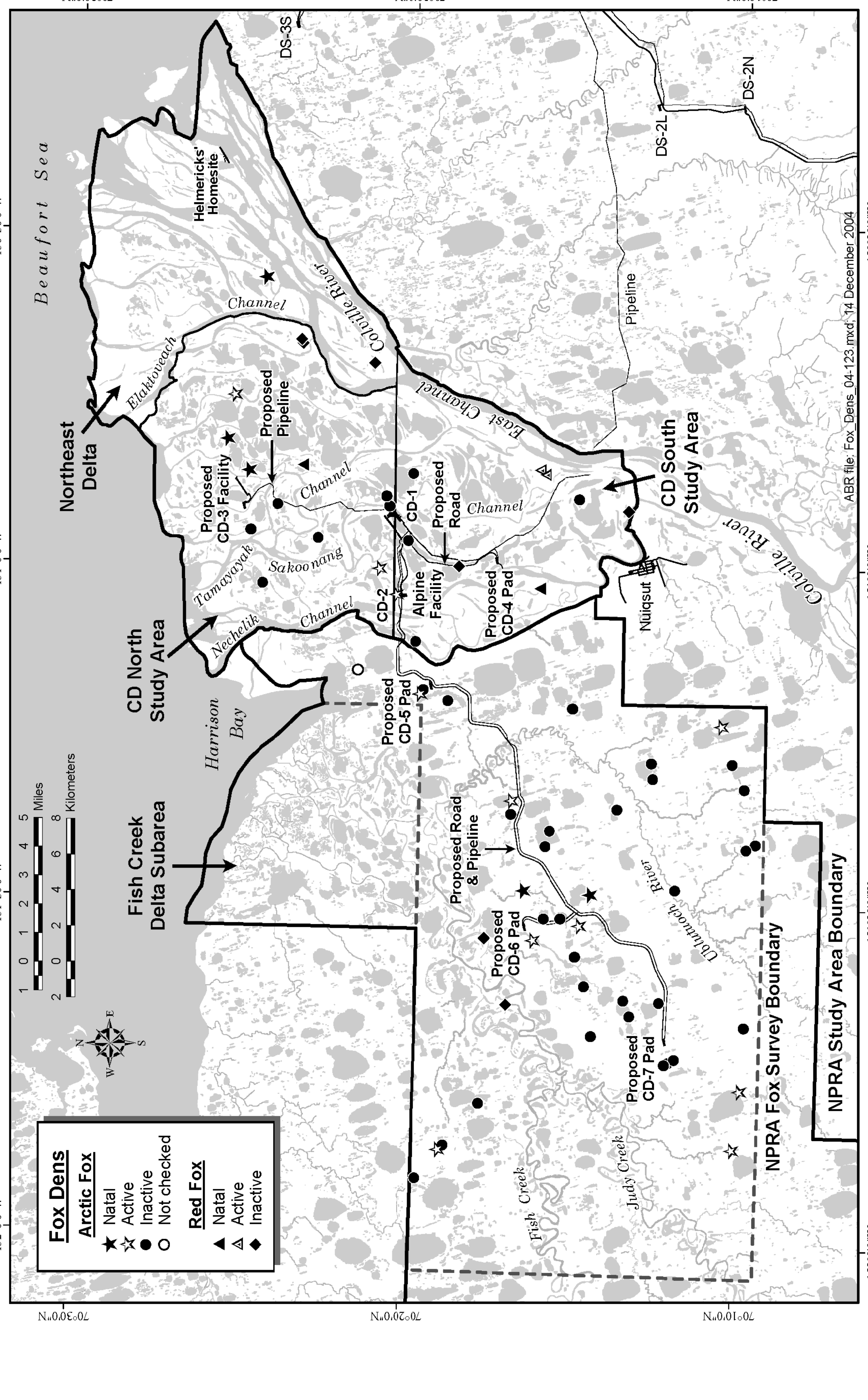

Figure 31. Distribution and status of arctic and red fox dens, northeast delta and CD North, CD South, and NPRA study areas, Alaska, late June–mid-July 2004. Survey coverage (since 1992 on Colville River Delta and 2001 in NPRA) was not uniform over the area portrayed.

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 suspected, but could not confirm, that Den 45 (CD North) and Den 61 (CD South) may have been used by one litter; these 2 dens near the Alpine facilities have been used in the past as a natal–secondary pair (Johnson et al. 2003a).

The estimated occupancy rate by litters (natal and active categories combined) at the 16 arctic fox dens checked on the Colville Delta in 2004 was 38%, just below the midpoint of the range of rates observed on the delta since 1993 (24–67% occupied; Johnson et al. 2003a). Over the last decade, the occupancy rate of arctic fox dens in the CD North study area (40–89%; Johnson et al. 2003b) generally has been greater than on the delta and adjacent coastal plain tundra to the east. The maximal occupancy rates were recorded in 1996 when microtine rodent populations peaked and fox productivity was high throughout the delta and adjacent coastal plain (Johnson et al. 2003a).

Habitat Use

Because both arctic and red foxes have similar denning requirements and may occasionally use the same den sites in different years, we included all dens discovered since 1992, regardless of species, to analyze habitat selection on the delta. The changes in the habitat classification described earlier and the discovery of two new den sites on the delta in 2004 affected the outcome of the habitat selection analysis. In previous analyses, which lumped all shrub classes into one habitat type, 70% of the dens on the delta were located in Riverine or Upland Shrub, the only habitat that was preferred (Johnson et al. 2004). Under the revised classification, two habitat types were preferred for denning on the delta: Moist Low Shrub and Dwarf Dry Shrub, which together contained 68% of the dens (Appendix H2). The selection analysis for 2004 also indicated that 3 habitats were used in proportion to their availability and 2 habitats were avoided (Appendix H2).

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. On the Colville Delta and adjacent coastal plain to the east, foxes den in sand dunes (mostly those stabilized by vegetation), banks of streams and lakes (including banks of drained-lake basins), ridges, and pingos (Appendix H1; Garrott 1980, Eberhardt et al. 1983, Johnson et al. 2003a). In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville Delta, red foxes dens almost exclusively in sand dunes.

NPRA Study Area

Distribution and Abundance

In 2004, we found 5 more arctic fox dens in the NPRA study area, giving a 4-year total of 42 dens (active and inactive) of both species (Figure 31, Appendix H1). Arctic foxes were much more abundant than red foxes, and all but 2 of the 42 sites were arctic fox dens (95% of the total). All 5 dens added in 2004 were small, poorly developed sites that appeared to be auxiliary dens rather than the well-established sites that are used most often as natal dens.

The presence of 40 arctic fox dens in our 696-km² fox survey area (Figure 31) produced a minimal density estimate of 1 den/17 km² in northeastern NPRA. This density is twice as high as on the Colville Delta but identical to the density of dens in the Alpine Transportation Corridor area studied by Johnson et al. (2003a) east of the Colville Delta.

After brief visits at 39 of the 40 arctic fox dens on 29–30 June and longer observations at 9 of those dens on 9 and 12 July, we classified 10 dens (26%) as occupied sites, including 2 confirmed natal dens and 8 dens classified as active, where pups were suspected to be present (Appendix H1). The remaining 29 dens (74%) showed signs of occasional use by adults only or were completely inactive. The 26% occupancy rate of arctic fox dens (natal and active categories combined) in 2004 was substantially lower than the 40% occupancy recorded in 2003 (Johnson et al. 2004), but similar to occupancy rates in 2001 and 2002 (Burgess et al. 2002b, Burgess et al. 2003b).

On 9 and 12 July 2004, we expended ~43 h in 13 observation bouts at 9 dens that were known or suspected to be active during the status check on 29–30 June, but counted only 4 pups at 2 sites (Appendix H1). We were not aware of any instances of secondary den use or splitting of litters during our observations in 2004, which could have confounded estimates of pup production. Evidence of mortality by predation was found at one natal site. The remains of an adult fox (and possibly a pup) that evidently had been killed and fed upon by a Golden Eagle were found on 30 June at Den 215, and an eagle stooped at 2 pups playing at that den during observations on 9 July.

Estimation of mean litter size in 2004 was precluded by low observation success; observers were not confident that they had seen entire litters at either of the 2 natal sites identified, and no pups were seen at the other 8 sites suspected to be active. Den observations in 2004 were not as successful as in 2003, suggesting that the productivity of the population was lower, similar to the low productivity recorded in 2001 and 2002 (Burgess et al. 2002b, 2003b). Our surveys indicate that, although den density is lower on the Colville Delta, production of fox pups tends to be higher there than in NPRA.

The low occupancy rates and pup counts at arctic fox dens in 2004 and 2001–2002 lead us to infer that the density of small mammal prey in the NPRA study area was low in those years, although we have no rodent population sampling data to support this inference directly. It appeared that small mammals may have been more abundant in 2003, judging from the higher occupancy rate and pup counts.

Habitat Use

Foxes tend to den in bank habitats in the study area, including banks of lakes, streams, and drained-lake basins (Appendix H1). Fox dens occurred in 9 of the 18 terrestrial habitat types included in the 2004 analysis (Appendix H2). Moist Dwarf Shrub, an uncommon type (0.7% of the terrestrial habitat area), was the only habitat preferred by foxes for denning, even though only 4 dens (9.5%) occurred in this type. No statistical evidence of either preference or avoidance was found for any other habitat in NPRA. One den occurred in Dry Dwarf Shrub, which, along with Moist Dwarf Shrub, composed the Upland and Riverine Dwarf Shrub type in 2002–2003, the only habitat that was preferred in the analysis for those years (Johnson et al. 2004). The habitats used most often for denning by foxes in the NPRA study area were the two most abundant types mapped: Moist Tussock Tundra and Moist Sedge–Shrub Meadow (13 and 11 dens, respectively). Patterned Wet Meadow and Old Basin Wetland Complex, the next most common types, were used to a lesser extent (Appendix H2). Dens in wet habitats such as the latter two types were located in small patches of higher microrelief that were smaller than the minimum-sized habitat mapping unit (0.5 ha for terrestrial habitats).

RED FOX

Colville River Delta

Distribution and Abundance

The red fox is much less abundant than the arctic fox on the outer coastal plain, where its distribution is restricted largely to major drainages such as the Colville and Sagavanirktok rivers (Eberhardt 1977, Johnson et al. 2004). Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Schmidt 1985, Schamel and Tracy 1986, Hersteinsson and Macdonald 1992). Since 1992, red foxes have occupied at least 5 den sites formerly used by arctic foxes on the Colville Delta and adjacent coastal plain tundra, whereas only one den formerly used by red foxes—Den 73 in the northeast delta—has been used recently by arctic foxes (Johnson et al. 2004; this study).

One new red fox den (Den 106) was found in the CD South study area on 29 June 2004 and a site formerly used only by arctic foxes (Den 1) was taken over by red foxes in 2004, bringing the total number of red fox dens on the Colville Delta to 9, all of which were located in upland sandy soils (mostly stabilized dunes; Appendix H1). Red fox dens were located in 3 habitat types: Moist Low Shrub (7 dens), Dwarf Dry Shrub (1 den), and Barrens (1 den). Of these, 2–4 dens have been active annually in recent years (Johnson et al. 2003a, 2004). The density of red fox dens on the entire Colville Delta was 1 den/61 km² in 2004, a density that appears to be unusually high for arctic tundra areas in Alaska and the Yukon (Eberhardt 1977, Smits et al. 1989, Burgess et al. 1993, Smits and Slough 1993). Two of the red fox dens in the CD North study area—Dens 82 and 87—are located 250 m apart on an island in the Elaktoveach Channel (Figure 31) and are alternate sites that have been used in the past by a single denning pair

(Johnson et al. 2000a). Similarly, newly discovered Den 106 was located ~400 m southwest of Den 49, for which it appeared to be an alternate site. Den 106 was not examined on the ground due to the presence of foxes. Although that den did not appear to be newly excavated, it probably had been developed since the area was first searched in 1995.

Based on brief visits at each red fox den on 28–29 June 2004 and ~25 h spent in 9 observation bouts at 6 red fox dens on the delta during 10–11 July, we concluded that 4 dens (44%) were occupied and counted a total of 10 pups at those sites. We concluded that 3 litters were occupying the 4 dens. The only litter that we were confident was a complete count comprised the 5 pups split between Dens 49 and 106; observations at Dens 1 (2 pups) and 60 (3 pups) were not satisfactory for calculating litter size (Appendix H1). Red fox dens are more difficult to observe than arctic fox dens because they tend to be located in sand dunes having high topographic relief and tall shrubs that obscure the den entrances and activity areas. The red fox dens in the CD South study area have had higher occupancy rates each year than have the arctic fox dens there (Burgess et al. 2003a), whereas the opposite is true in the CD North study area. Den 1 was the first natal red fox den confirmed in the CD North area since 1999.

NPRA Study Area

Distribution and Abundance

Of the 42 fox dens known in the NPRA study area in 2004, only 2 (5%) were classified as red fox dens, both of which were located on sand dunes bordering Fish Creek (Figure 31, Appendix H1). In comparison, 13% of the fox dens examined in 2001 between the western edge of the Colville River Delta and the Kuparuk Oilfield were red fox dens (Johnson et al. 2003a).

Den 217 was the only red fox den known in the study area in 2001 and it has been inactive every year since then (Appendix H1). Den 234 was classified as an arctic fox site when first found in 2002, but had been enlarged by red foxes by late June 2003. A pair of red foxes was seen repeatedly along Fish Creek in the general area of this den in 2003. Despite scattered sightings of red foxes in 2004, no new dens were found.

At 1 den/340 km², the density of red fox dens in the NPRA study area was very low in 2003–2004. In contrast, the density of red fox dens on the Colville Delta in 2004 was 5 times higher, reflecting the greater use of major river systems by this species. It should be noted that our den surveys have been biased toward detection of arctic fox dens, which are easier to find in tundra habitats away from the complex riparian habitats along Fish and Judy creeks, the most suitable locations for denning by red foxes in the NPRA study area. Although we expect more red fox dens to be found in the NPRA study area in the future, we do not expect the density to reach that found on the Colville Delta because of differences in the availability of suitable denning habitat.

OTHER MAMMALS

Muskox

No muskoxen were seen on our surveys in the Colville Delta or NPRA study areas in 2004. A mixed-sex group comprising a maximum of 16 adults and 2 calves was seen on 3 occasions in June and August along the east side of the Colville River just east of the delta (Figure 32; Lawhead and Prichard 2005). Most muskoxen recorded in the past in the Colville Delta area have been found along the east side of the Colville River, with fewer occurring on the delta (Johnson et al. 1999a, 2004; Lawhead and Prichard 2003a). A few muskoxen (mostly lone bulls) were seen on the delta during summer 1992–1993 and 1995–1998 (Johnson et al. 1999a), and a group of 10–11 adults (mostly bulls) was found on the northeastern delta in summer 2001 (Lawhead and Prichard 2002). Several instances of notable mortality have been observed in the Colville River region in 2003 and 2004. Near the Colville River south of Nuiqsut, several muskoxen in a single group were killed and others wounded in an attack by at least one grizzly bear in late June 2003 (L. Parrett, Univ. Alaska Fairbanks, pers. comm.). In addition, two unusual instances of group mortality in 2004 were thought to have been caused by spring flooding on the Colville and Kachemach rivers: 6 adult muskox carcasses were found in the Colville River floodplain near Ocean Point (south of Nuiqsut), and 5 yearling and 2 calf carcasses were found together at the mouth of the

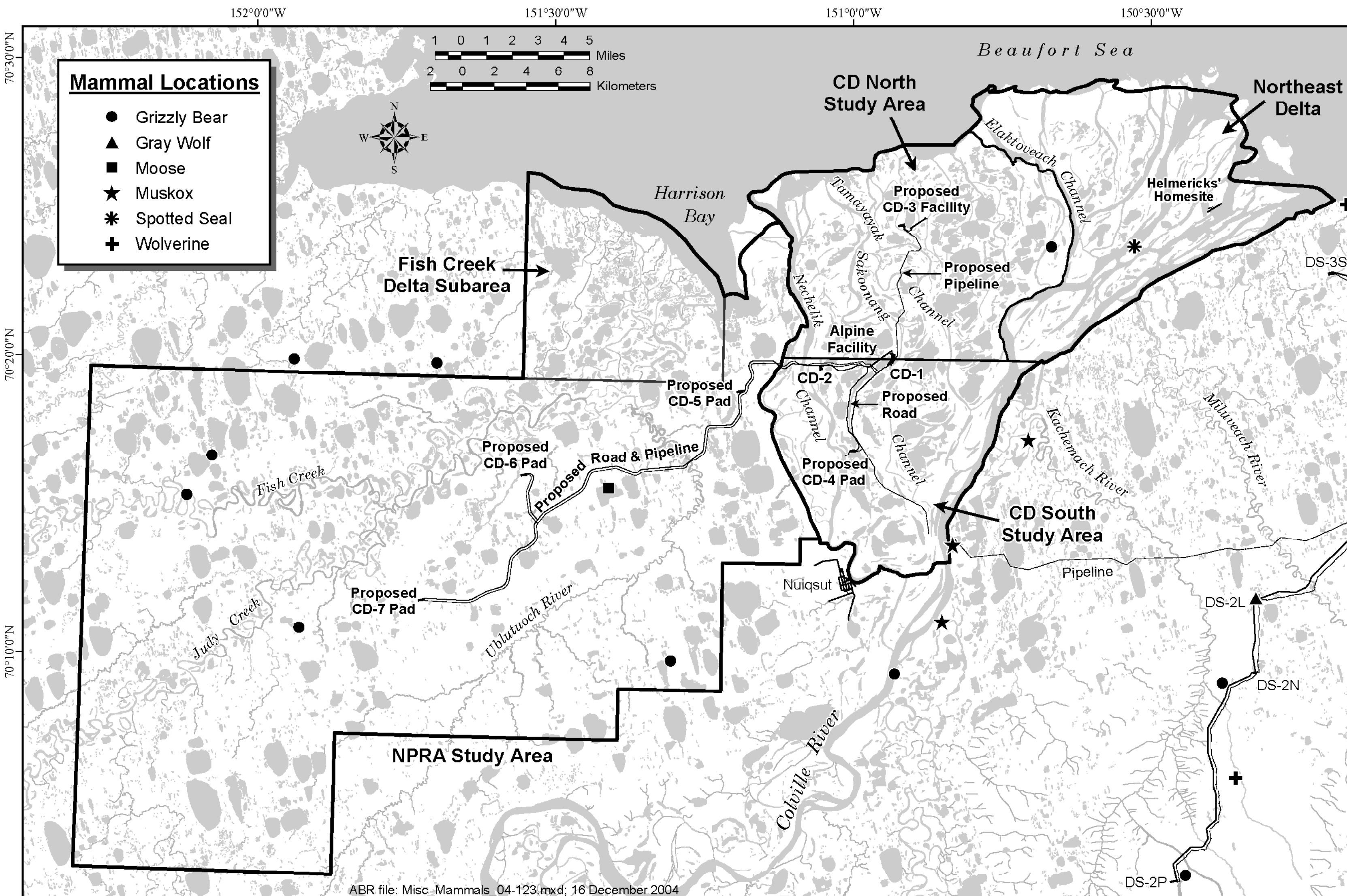

Figure 32. Incidental sightings of other large mammals during aerial surveys for caribou and waterfowl, northeast delta and CD North, CD South, and NPRA study areas, Alaska, May–October 2004.

Kachemach River (R. Shideler, ADFG, pers. comm.).

In the NPRA study area, no muskoxen have been seen on our surveys since 2001 (Burgess et al. 2003b, Johnson et al. 2004). In 2001, a small group of muskoxen, comprising 5–6 adults at various times, passed through the NPRA study area in June (Burgess et al. 2002b). Muskox numbers in northeastern NPRA are not well-documented, but appear to be lower than in the area east of the Colville River. Riparian shrub habitats and Moist Sedge–Shrub Meadow are the most important summer habitats for muskoxen in the region of the Colville Delta and NPRA study area. Thus, suitable habitat exists in northeastern NPRA, which is within the historical range of the species (Bee and Hall 1956), and it is expected that the population will continue to increase in NPRA (BLM 1998, Danks 2000).

Moose

A female moose was seen feeding in the edge of a lake in the NPRA survey area on 12 July 2004 (Figure 32), the first sighting of this species in the NPRA study area since we began our mammal surveys in 2001. Although none were seen on the Colville Delta in 2004, moose have been observed occasionally on our surveys there since 1992 (Johnson et al. 1997, 1999a, 2004) and during summer bird studies by USWFS in the 1980s (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983). The Colville Delta is an area of very low population density for moose (Coady 1979) and the NPRA study area appears to have a similarly low density (BLM 1998).

Brown (Grizzly) Bear

Grizzly bears were seen twice on the Colville Delta and 6 times in the NPRA study area during our surveys in 2004 (Figure 32). The Colville Delta sightings were of single bears on 12 and 20 August. The NPRA sightings involved single animals on 18 May, 25 June, 22 and 24 August, 18 October, as well as a female with a yearling cub on 18 October. In past years, grizzly bears also have been seen more often in the NPRA study area than on the delta (Burgess et al. 2003b, Johnson et al. 2004).

ADFG biologists have marked numerous bears with standard VHF radio-collars in the existing Prudhoe Bay and Kuparuk oilfields since the 1990s (Shideler and Hechtel 2000), of which 8 females and 11 males included the Colville Delta and northeastern NPRA in their annual home ranges (ADFG, unpublished data). Since 2002, ADFG has extended their study area west to mark bears in northeastern NPRA and these bears have begun to provide data on habitat use and den locations (R. Shideler, ADFG, pers. comm.). ADFG has radio-collared 14 females and 6 males in NPRA and the Colville Delta since 2002. ADFG biologists located 9 radio-marked males and 16 radio-marked females, including several with dependent offspring, on the Colville Delta and in northeastern NPRA in 2004 (R. Shideler, ADFG, pers. comm.).

All of the bears on the Colville Delta were observed feeding on natural foods, but one adult female also obtained garbage from the Alpine CD-1 pad in August 2004; that animal was radio-collared in the Prudhoe Bay Oilfield in 1994 as a 2-year-old and roamed between the Colville Delta and Prudhoe Bay (ADFG, unpublished data). Three marked bears spent several weeks in early summer feeding on the carcasses of the 6 adult muskoxen that drowned near Ocean Point during spring breakup of the Colville River.

Two of the marked males roamed widely between the Colville River and the Arctic National Wildlife Refuge (ANWR) in 2003 and 2004 (ADFG, unpublished data). One male was observed in ANWR in August 2003 and was killed at a fish camp on the Chipp River in October 2004. The other male, originally captured on Franklin Bluffs, spent part of summer 2003 on the Colville Delta and then moved back to ANWR in 2004, spending most of the summer there.

Several bears previously radio-collared by ADFG in the oilfield region to the east have denned near the Colville River or on the Colville Delta in past years, but none of those bears have denned in the NPRA study area (ADFG, unpublished data). No bears marked by ADFG have denned on the delta since 1998.

Gray Wolf

In an unusual sighting, an adult wolf was observed on 2 July 2004 outside the ASDP area east of the Colville Delta on Kuparuk Drill Site 2-L, resting under a building (Figure 32; T.

Manson and L. McDaniel, CPAI, pers. comm.). Wolves have been observed by ABR biologists on only two previous occasions in the Colville–Kuparuk region and northeastern NPRA despite extensive aerial surveys since the early 1980s. A single wolf was spotted on 31 July 2003 in the NPRA study area, ~10 km west of Nuiqsut (Johnson et al. 2004), and one was seen pursuing a caribou along the Kachemach River southwest of the Kuparuk oilfield in late July 1997 (Johnson et al. 1998). At least 1 and possibly 2 wolf packs were seen several times in winter 2002–2003 northwest of our study area in northeastern NPRA (M. Ahmakak, KSOP, pers. comm.). Since winter 1993–94, several wolf sightings were reported by workers in the Kuparuk Oilfield (A. Schuyler, CPAI, pers. comm.; ABR, Inc., unpublished data). Wolves probably have never been abundant on the outer coastal plain, and the North Slope population has remained low since federal predator control in the 1950s and early 1960s (R. Stephenson, ADFG, pers. comm.). In the 1990s, however, increases in harvest by Nuiqsut residents and in reports of wolves in northern Alaska indicated the population was increasing (G. Carroll, ADFG, pers. comm.).

Wolverine

Two wolverines were seen east of the Colville Delta during an aerial survey on 19 October 2004 (Figure 32; Lawhead and Prichard 2005). At least one wolverine, and possibly two, were seen repeatedly in the DS-3S vicinity during late winter and early spring 2004 (W. Morris, ADNR, pers. comm.; J. Moser, CPAI, pers. comm.). Lone wolverines have been recorded on five previous occasions by ABR biologists in the vicinity of the Colville Delta and northeastern NPRA in June 1993, 1998, and 1999; late September 2001; and late October 2002 (Johnson et al. 1999; Burgess et al. 2003b; ABR, unpublished data). Two wolverine sightings were reported in the general vicinity of the NPRA study area in 1977–1978 (BLM 1998).

Spotted Seal

A group of 7 spotted seals was hauled out on a sand bar between two islands in the main channel of the Colville River during a caribou survey on 11 August 2004 (Figure 32). Spotted seals also were seen using at least two haulouts in the lower East Channel on surveys between late July and late September in 1996–1998 (Johnson et al. 1997, 1999a). The Colville Delta hosts the farthest eastern concentration of spotted seals in the Alaska Beaufort Sea (Seaman et al. 1981), involving seals from as far west as the Chukchi Sea; a spotted seal marked with a satellite transmitter at Kasegaluk Lagoon on the Chukchi coast moved to the Colville Delta within one summer (L. Lowry, ADFG, pers. comm.). Haulouts occur mainly on the middle and outer delta, particularly between the Tamayayak and East channels, and seals have been seen in the Colville River as far upstream as Ocean Point (Reed 1956; Seaman et al. 1981). Reports summarized by Seaman et al. (1981) suggest that up to several hundred spotted seals may have used haulouts on the Colville River Delta in the 1960s and 1970s. In contrast, the maximal number found on aerial surveys of potential haulout sites along the East and Elaktoveach channels in 1996 and 1997 was 24 seals (Johnson et al. 1999a).

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Appendix A. Common and scientific names of birds and mammals observed on the Colville River Delta, 1992–2004, and in the NPRA study area, 1999–2004, Alaska.

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

[a] Indicates species not observed during NPRA investigations

Appendix B. Classification and descriptions of wildlife habitat types found on the Colville River Delta or in the NPRA study area, Alaska, 2004. Species associations of some habitats vary between the Colville River Delta and the NPRA study area.

Habitat Class	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. An important habitat for some species of waterfowl for molting during spring and fall staging.
Brackish Water (Tidal Ponds)	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. Sediments may contain peat, reflecting a 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 by erosion of banks by adjacent river channels and 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 form important over-wintering habitat for fish.
Tapped Lake with High-water Connection	Similar to Tapped Lake with Low-water Connection 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 channel due to deposition during seasonal flooding. These lakes form 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 tidal flats associated with river deltas. The surface 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 and Halophytic Sedge or Grass Wet Meadows. Moist Halophytic Dwarf Shrub and small barren areas also may occur in patches too small to map separately. Dominant plant species usually include *Carex subspathacea, C. ursina, C. ramenskii, Puccinellia phryganodes, Dupontia fisheri, P. andersonii, Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea*. Salt Marsh is important habitat for brood-rearing and molting waterfowl.
Moist Halophytic Dwarf Shrub	Tidal flats and regularly flooded riverbars of tidal rivers with vegetation dominated by dwarf willow and graminoids. Tide flat communities have brackish, loamy (with variable organic horizons), saturated soils, with ground water depths ~ 25 cm and active layer depths ~50 cm. Vegetation is dominated by *Salix ovalifolia, Carex subspathacea*, and *Calamagrostis deschampsioides*. On sandy sites *Elymus arenarius mollis* is a co-dominant. On active tidal river depostis, soils are loamy, less brackish, and vegetation is dominated by *Salix ovalifolia* with *Carex aquatilis* and *Dupontia fisheri*.

Appendix B. Continued.

Habitat Class	Description
Dry Halophytic Meadow	Somewhat poorly vegetated, well-drained meadows on regularly inundated tidal flats and riverbars of tidal rivers, characterized by the presence of *Elymus arenarius mollis*. Soils are brackish sands with little organic material and deep active layers. Commonly associated species include *Salix ovalifolia, Sedum rosea, Stellaria humifusa*, (on tide flats) and *Deschampsia caespitosa* (on tidal river deposits).
Tidal Flat Barrens	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flat Barrens occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flat Barrens frequently are associated with lagoons and estuaries and may vary widely in actual salinity levels. Tidal Flat Barrens 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 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 originally supported Patterned Wet Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that originally supported Moist Sedge–Shrub Meadow and Dry Dwarf 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 colonizers.
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 and usually are not connected to rivers. Sediments are fine-grained silt in centers with sandy margins. Deep Open Waters without Islands are differentiated from those with islands because of the lack of nest sites for waterbirds that prefer islands.
Deep Open Water with Islands or Polygonized Margins	Similar to above except that they 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's 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. Sediments are loamy to sandy.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex low-center polygon shorelines, otherwise similar to Shallow Open Water without Islands. 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	All permanently flooded channels large enough to be mapped as separate units. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of Fish Creek are slightly saline, whereas other streams are non-saline.

Appendix B. Continued.

Habitat Class	Description
Sedge Marsh	Permanently flooded waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤0.5 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 loam or sand.
Deep Polygon Complex	A habitat associated with inactive and abandoned floodplains and deltas in which thermokarst of ice-rich soil has produced deep (>0.5 m), permanently flooded polygon centers. Emergent vegetation, mostly *Carex 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 *Carex aquatilis, Eriophorum angustifolium, C. bigelowii, Dryas integrifolia, Salix reticulata,* and *S. ovalifolia*.
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 fulva* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in recently drained lake basins and is more productive than Sedge Marsh. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (Ice-poor)	Complex habitat found in recently drained lake basins and characterized by a mosaic of open water, Sedge and Grass Marshes, Nonpatterned Wet Meadows, and Moist Sedge–Shrub Meadows in patches too small (<0.5 ha) to map individually. During spring breakup, basins may be entirely inundated, though water levels recede by early summer. Basins often have distinct banks marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw lake stages. Soils generally are loamy to sandy, moderately to richly organic, and ice-poor. Because there is little segregated ground ice the surface form is nonpatterned ground or disjunct polygons and the margins of waterbodies are indistinct and often interconnected. Ecological communities within young basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating these two types.
Old Basin Wetland Complex (Ice-rich)	Similar to above but characterized by well-developed low- and high-centered polygons resulting from ice-wedge development and aggradation of segregated ice. Complexes in basin margins generally include Sedge Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadows, and small ponds (<0.25 ha). The waterbodies in old basins tend to have smoother, more rectangular shorelines and are not as interconnected as those in more recently drained basins. The vegetation types in basin centers generally include Moist Sedge–Shrub Meadow and Moist Tussock Tundra on high-centered polygons, and Patterned Wet Meadows. Grass Marsh generally is absent. Soils have a moderately thick (0.2–0.5 m) organic layer overlying loam or sand.

Appendix B. Continued.

Habitat Class	Description
Riverine Complex	Permanently flooded streams and floodplains characterized by a complex mosaic of water, Barrens, Dry Dwarf Shrub, Moist Tall Shrub and Moist Low Shrub, Sedge and Grass Marsh, Nonpatterned and Patterned Wet Meadow, and Moist Sedge–Shrub Meadow in patches too small (<0.5 ha) to map individually. Surface form varies from nonpatterned point bars and meadows to mixed high- and low-centered polygons and small, stabilized dunes. Small ponds tend to have smooth, rectangular shorelines resulting from the coalescing of low centered polygons. During spring flooding these areas may be entirely inundated, following breakup water levels gradually recede.
Dune Complex	Complex formed from the action of irregular flooding on inactive sand dunes, most commonly on river point bars. A series of narrow swale and ridge features develop in parallel with river flow that are too small to map separately. Swales are moist or saturated while ridges are moist to dry. Habitat classes in swales typically are Moist Low Shrub, Nonpatterned Wet Meadow, or Sedge Marsh, while ridges commonly are Dry Dwarf Shrub or Moist Low Shrub.
Nonpatterned Wet Meadow	Sedge-dominated meadows that occur within recently 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 strang cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but water remains close to 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 occurs in polygonized habitats. Usually dominated by *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying loam or sand.
Patterned Wet Meadow	Lowland areas with low-centered polygons or strang within drained lake basins, level floodplains, and flats and water tracks on terraces. Polygon centers are flooded in spring and water remains close to the surface throughout the growing season. Polygon rims or strang 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 sedges, usually *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present including *C. rotundata, C. saxatilis, C. membranacea, C. chordorrhiza,* and *E. russeolum*. On polygon rims, willows (e.g., *Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) and the dwarf shrubs *Dryas integrifolia* and *Cassiope tetragona* may be abundant along with other species typical of moist tundra.
Moist Sedge–Shrub Meadow	High-centered, low-relief polygons and mixed high- and low-centered polygons on gentle slopes of lowland, riverine, drained basin, and solifluction deposits. Soils are saturated at intermediate depths (>0.15 m) but generally are free of surface water during summer. Vegetation is dominated by *Dryas integrifolia*, and *Carex bigelowii*. Other common species include *C. aquatilis*, *Eriophorum angustifolium*, *Salix reticulata, S. lanata richardsonii,* and the moss *Tomentypnum nitens*. The active layer is relatively shallow and the organic horizon is moderate (0.1–0.2 m).

Appendix B. Continued.

Habitat Class	Description
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins. Vegetation is dominated by tussock-forming plants, most commonly *Eriophorum vaginatum***.** High-centered polygons of low or high relief are associated with this habitat. Soils are loamy to sandy, somewhat well-drained, acidic to circumneutral, with moderately thick (0.1–0.3 m) organic horizons and shallow (<0.4 m) active layer depths. On acidic sites, associated species include *Ledum decumbens, Betula nana, Salix planifolia pulchra, Cassiope tetragona* and *Vaccinium vitis-idaea*. On circumneutral sites common species include *Dryas integrifolia, S. reticulata, Carex bigelowii,* and lichens. Mosses are common at most sites.
Moist Tall Shrub	Most commonly found on actively flooded banks and bars of meander and tidal rivers dominated by tall (> 1.5 m) shrubs. Sites are nonpatterned and subject to variable flooding frequency, soils are well-drained, alkaline to circumneutral, and lack organic material. Vegetation is defined by an open canopy of *Salix alaxensis*. Understory species include *Equisetum arvense, Gentiana propinqua, Chrysanthemum bipinnatum, Festuca rubra* and *Aster sibiricus*. Moist Tall Shrub occasionally occurs on protected lowland sites where the dominant species may be *Salix* spp.or *Alnus crispa*.
Moist Low Shrub	Any community on moist soils dominated by willows < 1.5m tall. Upland sites are well-drained sands and loams characterized by *Salix glauca* (or infrequently, *Betula nana*), *Dryas integrifolia*, and *Arctostaphylos rubra*. Recently drained basins are somewhat poorly drained loams with moderate organic horizons dominated by either *S. lanata richardsonii* or *S. planifolia pulchra* with *Eriophorum angustifolium* and *Carex aquatilis*. Riverbank deposits also are dominated by either *S. lanata richardsonii* or *S. planifolia pulchra*, but with *Equisetum arvense*, *Arctagrostis latifolia*, or *Petasites frigidus*. Somewhat poorly-drained lowland flats and lower slopes have the greatest organic horizon development and are dominated by *S. planifolia pulchra*. Associated species are similar to those in drained basin communities. Thaw depths are deepest in riverine and upland communities and shallowest in lowland areas.
Moist Dwarf Shrub	Well-drained upland slopes and banks, and the margins of drained lake basins dominated by *Cassiope tetragona*. Soils are well-drained, loamy to sandy and circumneutral to acidic. Vegetation is species rich, associated species include *Dryas integrifolia, Salix phlebophylla, Vaccinium vitis-idaea, Carex bigelowii, Arctagrostis latifolia, Hierochloe alpina, Pyrola grandiflora,* and *Saussurea angustifolia*. Lichens and mosses also are common.
Dry Tall Shrub	Crests of active sand dunes with vegetation dominated by the tall willow *Salix alaxensis*. Soils are sandy, excessively drained, alkaline to circumneutral, with deep active layers (>1 m) and no surface organic horizons. The shrub canopy usually is open with dominant shrubs >1m tall. Other common species include *Chrysanthemum bipinnatum, Festuca rubra*, and *Equisetum arvense*.

Habitat Class	Description
Dry Dwarf Shrub	Well-drained riverbank deposits and windswept, upper slopes and ridges dominated by the dwarf shrub *Dryas integrifolia*. Soils are sandy to loamy, alkaline to circumneutral, with deep active layers. Upland sites are lacking in organics, and in riverine sites organic accumulation is shallow. Riverbank communities have *Salix reticulata, Carex bigelowii, Arctagrostis latifolia, Equisetum variegatum, Oxytropis deflexa, Arctostaphylos rubra,* and lichens as common associates, while upland sites have *S. reticulata, S. glauca, S. arctica, C. bigelowii, Arctostaphylos alpina, Arctagrostis latifolia*, and lichens.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas related to riverine, eolian, or thaw basin processes. Riverine Barrens on river flats and bars are underlain by moist sands and are flooded seasonally. Early colonizers are *Deschampsia caespitosa, Poa hartzii, Festuca rubra, Salix alaxensis*, and *Equisetum arvense.* Eolian Barrens are active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical species include *Salix alaxensis, Festuca rubra,* and *Chrysanthemum bipinnatum*. Lacustrine Barrens occur within recently drained lakes and ponds. These areas may be flooded seasonally or can be well drained. Typical colonizers are forbs, graminoids, and mosses including *Carex aquatilis, Dupontia fisheri, Scorpidium scorpioides*, and *Calliergon* sp. on wet sites and *Poa* spp., *Festuca rubra, Deschampsia caespitosa, Stellaria humifusa, Senecio congestus,* and *Salix ovalifolia* on drier sites. Barrens may receive intense use seasonally by caribou as mosquito-relief habitat.
Human Modified (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, the Alpine facilities, and at the Helmericks' residence near the mouth of the Colville River.

Appendix C1. Number and density of nests on clusters of breeding-bird plots, NPRA study area, Alaska, 2004.

Species	Plots 1–4	Plots 25–28	Plots 33–36	Plots 45–48	Plots 53–56	Plots 101–104	Total Nests	Density (nests/km²)
Greater White-fronted Goose	0	0	1	1	2	3	7	2.9
Canada Goose	0	0	0	0	1	0	1	0.4
Northern Pintail	1	0	0	0	0	0	1	0.4
Greater Scaup	0	1	0	0	0	0	1	0.4
King Eider	0	0	0	1	0	0	1	0.4
Long-tailed Duck	0	0	0	0	1	0	1	0.4
Willow Ptarmigan	1	2	0	1	0	0	4	1.7
American Golden-Plover	1	1	0	0	0	1	3	1.3
Semipalmated Sandpiper	0	4	2	5	3	5	19	7.9
Pectoral Sandpiper	3	2	2	1	13	3	24	10.0
Dunlin	0	1	0	2	2	1	6	2.5
Stilt Sandpiper	0	0	0	1	2	0	3	1.3
Long-billed Dowitcher	4	0	2	0	4	5	15	6.3
Red-necked Phalarope	1	2	7	1	3	1	15	6.3
Red Phalarope	0	1	2	1	3	0	7	2.9
Arctic Tern	0	1	0	1	0	0	2	0.8
Eastern Yellow Wagtail	0	1	0	0	0	0	1	0.4
Savannah Sparrow	0	2	0	0	0	0	2	0.8
Lapland Longspur	7	15	15	12	11	15	75	31.3
Total nests	18	33	31	27	45	34	188	
Density (nests/km²)	45.0	82.5	77.5	67.5	112.5	85.0		78.3
Number of species	7	12	7	11	11	8	19	

Appendix C2. Nest evidence at successful and failed shorebird nests, NPRA study area, Alaska, 2004.

		Eggshell Fragments (%)[a]		Eggshell Parts (%)[a]		
Fate/Species	*n*	Present	Absent	None Found	Piece[a]	Top or Bottom
SUCCESSFUL NESTS						
Black-bellied Plover	1	100	0	0	100	100
American Golden-Plover	2	100	0	50	50	50
Semipalmated Sandpiper	8	75	25	88	13	25
Pectoral Sandpiper	5	100	0	60	40	0
Dunlin	1	100	0	0	100	100
Stilt Sandpiper	1	100	0	0	100	100
Long-billed Dowitcher	2	100	0	0	100	100
Red-necked Phalarope	3	100	0	0	100	100
Red Phalarope	3	100	0	100	0	33
Total	26	92	8	54	46	46
FAILED NESTS						
Black-bellied Plover	3	0	100	100	0	0
American Golden-Plover	3	0	100	100	0	0
Semipalmated Sandpiper	1	0	100	100	0	0
Pectoral Sandpiper	7	14	86	86	14	0
Dunlin	1	0	100	100	0	0
Long-billed Dowitcher	7	0	100	100	0	0
Red-necked Phalarope	4	0	100	100	1	0
Red Phalarope	2	0	100	75	25	0
Total	28	4	96	93	7	0

[a] Eggshell fragments are ≤5 mm; eggshell parts include pieces >5 mm or eggshell tops or bottoms; % = percentage of total nests for each type of evidence

Appendix C3. Mean number of predators per hour on clusters of breeding-bird plots, NPRA study area, Alaska, 2004.

SURVEY METHOD Visit Type (sample size) Predator	Plots 1–4	Plots 25–28	Plots 33–36	Plots 45–48	Plots 53–56	Plots 101–104	Total Count	Overall Mean (no./h)
TIMED COUNT[a]								
Plot marking (no. 10-min counts)	(12)	(12)	(12)	(12)	(12)	(12)	(72)	
Pomarine/Parasitic/Long-tailed Jaeger	1.5	4.0	1.5	3.0	3.5	0.5	28	2.33
Glaucous Gull	0	1.5	0	3.0	0.5	0	10	0.83
Short-eared Owl/Northern Harrier	0	0	0.5	0	1.0	0.5	4	0.33
Common Raven	0	0	0	0.5	0	0	1	0.08
Arctic Ground Squirrel	0.5	0.5	0	1.0	0	0	4	0.33
Caribou	1.5	0	0	0	0	3.5	10	0.83
Nest searching (no. 10-min counts)	(24)	(24)	(24)	(24)	(24)	(24)	(144)	
Pomarine/Parasitic/Long-tailed Jaeger	0.8	0.8	4.3	2.3	1.8	1	43	1.79
Glaucous Gull	0.5	0.5	0	0.8	0	0.3	8	0.33
Northern Harrier	0.5	0	0	0	0.3	0	3	0.13
Common Raven	0	0	0.3	0	0	0	1	0.04
Arctic Ground Squirrel	0	0.8	0	0.3	0	0	4	0.17
Caribou	0.3	0	1.0	0	0	4.0	21	0.88
Nest monitoring (no. 10-min counts)	(24)	(24)	(24)	(24)	(24)	(24)	(144)	
Parasitic/Long-tailed Jaeger	1.3	1.5	0.3	3.3	1.5	1.8	38	1.58
Glaucous Gull	1.0	0.3	0.5	1.5	0	0.3	14	0.58
Northern Harrier	0	0	0	0	0	0.3	1	0.04
Common Raven	0	0	0	0	0.3	0	1	0.04
Arctic Ground Squirrel	0	0.5	0	0.8	0	0	5	0.21
Total predator count	24	29	29	50	25	39	196	
Overall mean predators/h	2.40	2.90	2.90	5.00	2.50	3.90		3.27
INCIDENTAL COUNT[b]								
Plot marking (h)	(8.4)	(7.9)	(5.6)	(5.9)	(6.4)	(8.3)	(42.4)	
Pomarine/Parasitic/Long-tailed Jaeger	1.0	1.3	0.9	1.0	1.9	0.5	45	1.06
Glaucous Gull	0.4	0.5	0	1.2	0.5	0.1	18	0.43
Short-eared Owl	0.1	0.3	0.2	0	0.5	0.1	8	0.19
Common Raven	0	0.1	0	0.2	0.2	0	3	0.07
Arctic Ground Squirrel	0.1	0.3	0	0.3	0	0	5	0.12
Caribou	0.4	0.6	1.4	0	0	0.8	23	0.54
Nest searching (h)	(55.9)	(68.8)	(69.2)	(68.1)	(73.6)	(68.7)	(404.4)	
Pomarine/Parasitic/Long-tailed Jaeger	0.5	0.7	1.9	0.6	0.5	0.6	326	0.81
Glaucous Gull	0.2	0.4	0.2	0.2	0.2	0.1	88	0.22
Short-eared Owl/Northern Harrier	0.1	<0.1	<0.1	0	<0.1	<0.1	12	0.03
Common Raven	0	0	<0.1	0.1	<0.1	0	7	0.02
Arctic Ground Squirrel	0	0.1	0	0.1	0	0	8	0.02
Arctic and Red Fox	0	<0.1	0	<0.1	0	<0.1	5	0.01
Caribou	0.2	0.1	0.1	0.1	0	0.3	51	0.13
Nest monitoring (h)	(7.2)	(9.9)	(9.5)	(10.6)	(12.7)	(8.8)	(58.6)	
Parasitic/Long-tailed Jaeger	0.7	0.8	0.3	1.4	0.6	1.1	48	0.82
Glaucous Gull	0.8	0.2	0.2	0.7	0.1	0.1	19	0.32
Common Raven	0	0	0	0	0.2	0	2	0.03
Arctic Ground Squirrel	0	0.3	0	0.3	0	0	6	0.10
Red Fox	0	0.1	0	0	0	0	1	0.02
Total predator count	80	125	175	114	90	92	676	
Overall mean predators/h	1.12	1.44	2.08	1.35	0.97	1.07		1.34

[a] Predator counts during 10-min scans
[b] Predator counts tallied while working on plot

Appendix C4. Number of predators[a] on 24 breeding-bird plots, NPRA study area, Alaska, 2004.

	Plot Marking[b]						Nest Searching[b]						Nest Monitoring[b]					Total					
Plot	Jaeger	Gull	Raptor	Raven	Squirrel	Caribou	Jaeger	Gull	Raptor	Raven	Squirrel	Caribou	Jaeger	Gull	Raptor	Raven	Squirrel	Jaeger	Gull	Raptor	Raven	Squirrel	Caribou
1	1	0	0	0	1	0	2	1	2	0	0	0	0	0	0	0	0	3	1	2	0	1	0
2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
3	0	0	0	0	0	3	1	0	0	0	0	0	1	3	0	0	0	2	3	0	0	0	3
4	2	0	0	0	0	0	0	1	0	0	0	0	4	1	0	0	0	6	2	0	0	0	0
25	6	1	0	0	1	0	0	0	0	0	1	0	2	0	0	0	2	8	1	0	0	4	0
26	1	2	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	2	2	0	0	2	0
27	1	0	0	0	0	0	0	2	0	0	0	0	4	0	0	0	0	5	2	0	0	0	0
28	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	2	1	0	0	0	0
33	3	0	1	0	0	0	2	0	0	1	0	4	0	0	0	0	0	5	0	1	1	0	4
34	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	5	1	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0
36	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
45	1	3	0	0	0	0	1	1	0	0	0	0	7	0	0	0	0	9	4	0	0	0	0
46	3	2	0	1	1	0	2	1	0	0	0	0	5	1	0	0	0	10	4	0	1	1	0
47	2	1	0	0	0	0	2	1	0	0	0	0	1	1	0	0	1	5	3	0	0	1	0
48	0	0	0	0	1	0	4	0	0	0	1	0	0	4	0	0	2	4	4	0	0	4	0
53	1	0	0	0	0	0	0	0	1	0	0	0	2	0	0	1	0	3	0	1	1	0	0
54	1	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	5	0	0	0	0	0
55	2	1	1	0	0	0	4	0	0	0	0	0	1	0	0	0	0	7	1	1	0	0	0
56	3	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0
101	1	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	4	1	0	0	0	0
102	0	0	0	0	0	7	1	1	0	0	0	15	2	0	1	0	0	3	1	1	0	0	22
103	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
104	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	0
Total	28	10	4	1	4	10	43	8	3	1	4	21	38	14	1	1	5	109	32	8	3	13	31
Mean	1.17	0.42	0.17	0.04	0.17	0.42	1.79	0.33	0.13	0.04	0.17	0.88	1.58	0.58	0.04	0.04	0.21	4.54	1.33	0.33	0.13	0.54	1.29
SE	0.17	0.10	0.04	0.02	0.04	0.18	0.19	0.05	0.04	0.02	0.04	0.26	0.17	0.08	0.02	0.02	0.05	0.15	0.07	0.03	0.02	0.06	0.24
n^c	72	72	72	72	72	72	144	144	144	144	144	144	144	144	144	144	144	360	360	360	360	360	360

[a] Includes Long-tailed, Parasitic, and Pomarine Jaeger; Glaucous Gull; Common Raven; Northern Harrier; Short-eared Owl; Arctic Ground Squirrel; and Caribou

[b] Plot marking included 3 10-min counts per plot, nest searching and nest monitoring included 6 10-min counts per plot.

[c] *n* = number of 10-min counts

Appendix D1. Habitat selection by pre-nesting Spectacled Eider and King Eider groups, Colville River Delta, Alaska, 1993–2004.

SPECIES Habitat	No. Adults	No. Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
SPECTACLED EIDER					
Open Nearshore Water	0	0	0	1.6	ns
Brackish Water	53	23	12.3	1.3	prefer
Tapped Lake with Low-water Connection	29	12	6.4	4.5	ns
Tapped Lake with High-water Connection	10	6	3.2	3.8	ns
Salt Marsh	29	14	7.5	3.3	prefer
Tidal Flat Barrens	2	1	0.5	6.9	avoid
Salt-killed Tundra	35	19	10.2	5.1	prefer
Deep Open Water without Islands	15	10	5.3	4.0	ns
Deep Open Water with Islands or Polygonized Margins	13	8	4.3	1.6	prefer
Shallow Open Water without Islands	5	3	1.6	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	4	3	1.6	0.1	prefer
River or Stream	16	8	4.3	14.1	avoid
Sedge Marsh	0	0	0	<0.1	ns
Deep Polygon Complex	82	44	23.5	2.7	prefer
Grass Marsh	2	2	1.1	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	35	17	9.1	8.2	ns
Patterned Wet Meadow	35	16	8.6	19.6	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.3	avoid
Moist Tussock Tundra	0	0	0	0.6	ns
Tall, Low, or Dwarf Shrub	0	0	0	4.9	avoid
Barrens	2	1	0.5	14.7	avoid
Human Modified	0	0	0	<0.1	ns
Total	367	187	100	100	
KING EIDER					
Open Nearshore Water	11	3	2.5	1.6	ns
Brackish Water	10	7	5.9	1.3	prefer
Tapped Lake with Low-water Connection	19	9	7.6	4.5	ns
Tapped Lake with High-water Connection	8	3	2.5	3.8	ns
Salt Marsh	8	3	2.5	3.2	ns
Tidal Flat Barrens	4	2	1.7	6.8	avoid
Salt-killed Tundra	20	11	9.3	5.1	ns
Deep Open Water without Islands	4	1	0.8	4.0	ns
Deep Open Water with Islands or Polygonized Margins	5	2	1.7	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	163	51	43.2	14.2	prefer
Sedge Marsh	0	0	0	<0.1	ns
Deep Polygon Complex	8	6	5.1	2.7	ns
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	2	3	2.5	8.2	avoid
Patterned Wet Meadow	14	10	8.5	19.5	avoid
Moist Sedge–Shrub Meadow	0	1	0.8	2.3	ns
Moist Tussock Tundra	0	0	0	0.6	ns
Tall, Low, or Dwarf Shrub	2	1	0.8	4.8	avoid
Barrens	11	5	4.2	14.8	avoid
Human Modified	0	0	0	<0.1	ns
Total	289	118	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (groups / total groups) × 100

Appendix D2. Habitat selection by nesting Spectacled Eiders in the CD-3 search area, Colville River Delta, Alaska, 2000–2004.

Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	1	1.7	3.4	ns
Tapped Lake with Low-water Connection	0	0	1.0	ns
Tapped Lake with High-water Connection	1	1.7	4.1	ns
Salt Marsh	0	0	4.6	ns
Tidal Flat Barrens	0	0	<0.1	ns
Salt-killed Tundra	12	20.7	14.1	ns
Deep Open Water without Islands	1	1.7	3.8	ns
Deep Open Water with Islands or Polygonized Margins	5	8.6	9.9	ns
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.8	ns
River or Stream	0	0	<0.1	ns
Deep Polygon Complex	15	25.9	12.4	prefer
Grass Marsh	0	0	0.2	ns
Nonpatterned Wet Meadow	2	3.4	13.6	avoid
Patterned Wet Meadow	21	36.2	24.5	ns
Moist Sedge–Shrub Meadow	0	0	2.6	ns
Tall, Low, or Dwarf Shrub	0	0	1.2	ns
Barrens	0	0	3.7	ns
Total	58	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (nests / total nests) × 100

Appendix D3. Habitat selection by pre-nesting Spectacled Eider and King Eider groups, NPRA study area, Alaska, 2001–2004.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Monte Carlo Results[a]
SPECTACLED EIDER					
Open Nearshore Water	0	0	0	0.4	ns
Brackish Water	4	2	9.5	0.6	prefer
Tapped Lake with Low-water Connection	0	0	0	0.5	ns
Tapped Lake with High-water Connection	0	0	0	0.1	ns
Salt Marsh	2	1	4.8	1.3	ns
Tidal Flat Barrens	0	0	0	0.6	ns
Salt-killed Tundra	0	0	0	0.3	ns
Deep Open Water without Islands	0	0	0	6.8	ns
Deep Open Water with Islands or Polygonized Margins	8	4	19.0	1.0	prefer
Shallow Open Water without Islands	4	3	14.3	5.5	ns
Shallow Open Water with Islands or Polygonized Margins	6	2	9.5	1.6	ns
River or Stream	1	1	4.8	1.0	ns
Sedge Marsh	1	1	4.8	1.7	ns
Deep Polygon Complex	0	0	0	<0.1	ns
Grass Marsh	0	0	0	0.3	ns
Young Basin Wetland Complex	0	0	0	0.3	ns
Old Basin Wetland Complex	10	5	23.8	8.6	ns
Riverine Complex	0	0	0	0.4	ns
Dune Complex	0	0	0	1.1	ns
Nonpatterned Wet Meadow	2	1	4.8	3.2	ns
Patterned Wet Meadow	2	1	4.8	11.2	ns
Moist Sedge–Shrub Meadow	0	0	0	22.5	avoid
Moist Tussock Tundra	0	0	0	26.8	avoid
Tall, Low, or Dwarf Shrub	0	0	0	3.1	ns
Barrens	0	0	0	1.1	ns
Total	40	21	100	100	
KING EIDER					
Open Nearshore Water	4	2	1.3	0.4	ns
Brackish Water	9	5	3.4	0.6	prefer
Tapped Lake with Low-water Connection	8	1	0.7	0.5	ns
Tapped Lake with High-water Connection	0	0	0	0.1	ns
Salt Marsh	11	5	3.4	1.3	ns
Tidal Flat Barrens	2	1	0.7	0.6	ns
Salt-killed Tundra	2	1	0.7	0.3	ns
Deep Open Water without Islands	60	19	12.8	6.8	prefer
Deep Open Water with Islands or Polygonized Margins	47	16	10.7	1.0	prefer
Shallow Open Water without Islands	26	14	9.4	5.5	ns
Shallow Open Water with Islands or Polygonized Margins	57	23	15.4	1.6	prefer
River or Stream	14	7	4.7	1.0	prefer
Sedge Marsh	12	7	4.7	1.7	prefer
Deep Polygon Complex	0	0	0	<0.1	ns
Grass Marsh	2	1	0.7	0.3	ns
Young Basin Wetland Complex	0	0	0	0.3	ns
Old Basin Wetland Complex	69	27	18.1	8.6	prefer
Riverine Complex	0	0	0	0.4	ns
Dune Complex	0	0	0	1.1	ns
Nonpatterned Wet Meadow	5	4	2.7	3.2	ns
Patterned Wet Meadow	17	10	6.7	11.2	ns
Moist Sedge–Shrub Meadow	11	4	2.7	22.5	avoid
Moist Tussock Tundra	2	1	0.7	26.8	avoid
Tall, Low, or Dwarf Shrub	1	1	0.7	3.1	ns
Barrens	0	0	0	1.1	ns
Total	359	149	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (groups / total groups) $\times$ 100

Appendix E1. Habitat selection by nesting (1993–2004) and brood-rearing (1995–2004) Yellow-billed Loons, CD North and CD South study areas, Colville River Delta, Alaska.

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	5.4	avoid
Tapped Lake with High-water Connection	13	7.6	5.4	ns
Salt Marsh	0	0	2.6	avoid
Tidal Flat Barrens	0	0	3.5	avoid
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water without Islands	15	8.8	5.5	ns
Deep Open Water with Islands or Polygonized Margins	45	26.3	1.8	prefer
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	2	1.2	0.1	prefer
River or Stream	0	0	8.8	avoid
Sedge Marsh	3	1.8	<0.1	prefer
Deep Polygon Complex	7	4.1	2.8	ns
Grass Marsh	1	0.6	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	19	11.1	8.7	ns
Patterned Wet Meadow	66	38.6	24.6	prefer
Moist Sedge–Shrub Meadow	0	0	3.2	avoid
Moist Tussock Tundra	0	0	0.9	ns
Tall, Low, or Dwarf Shrub	0	0	6.5	avoid
Barrens	0	0	12.1	avoid
Human Modified	0	0	0.1	ns
Total	171	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	5.4	avoid
Tapped Lake with High-water Connection	13	18.1	5.4	prefer
Salt Marsh	0	0	2.6	ns
Tidal Flat Barrens	0	0	3.5	ns
Salt-killed Tundra	0	0	4.2	ns
Deep Open Water without Islands	41	56.9	5.5	prefer
Deep Open Water with Islands or Polygonized Margins	18	25.0	1.8	prefer
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.8	avoid
Sedge Marsh	0	0	<0.1	ns
Deep Polygon Complex	0	0	2.8	ns
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	24.6	avoid
Moist Sedge–Shrub Meadow	0	0	3.2	ns
Moist Tussock Tundra	0	0	0.9	ns
Tall, Low, or Dwarf Shrub	0	0	6.5	avoid
Barrens	0	0	12.1	avoid
Human Modified	0	0	0.1	ns
Total	72	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid significantly less use than availability. % use = (nests / total nests) × 100 or (broods / total broods) × 100

Appendix E2. Habitat selection by nesting and brood-rearing Yellow-billed Loons, NPRA study area, Alaska, 2001–2004.

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0	0.4	ns
Brackish Water	0	0	0.1	ns
Tapped Lake with Low-water Connection	0	0	0.2	ns
Tapped Lake with High-water Connection	0	0	<0.1	ns
Salt Marsh	0	0	0.4	ns
Tidal Flat Barrens	0	0	0.9	ns
Salt-killed Tundra	0	0	<0.1	ns
Deep Open Water without Islands	6	7.1	7.0	ns
Deep Open Water with Islands or Polygonized Margins	43	50.6	5.4	prefer
Shallow Open Water without Islands	0	0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	3	3.5	1.6	ns
River or Stream	0	0	0.9	ns
Sedge Marsh	13	15.3	1.7	prefer
Deep Polygon Complex	0	0	<0.1	ns
Grass Marsh	2	2.4	0.3	ns
Young Basin Wetland Complex	0	0	0.4	ns
Old Basin Wetland Complex	0	0	8.7	avoid
Riverine Complex	0	0	0.4	ns
Dune Complex	0	0	1.1	ns
Nonpatterned Wet Meadow	5	5.9	3.1	ns
Patterned Wet Meadow	7	8.2	11.3	ns
Moist Sedge–Shrub Meadow	6	7.1	23.2	avoid
Moist Tussock Tundra	0	0	27.7	avoid
Tall, Low, or Dwarf Shrub	0	0	3.1	ns
Barrens	0	0	1.0	ns
Human Modified	0	0	0	ns
Total	85	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	0.4	ns
Brackish Water	0	0	0.1	ns
Tapped Lake with Low-water Connection	0	0	0.2	ns
Tapped Lake with High-water Connection	0	0	<0.1	ns
Salt Marsh	0	0	0.4	ns
Tidal Flat Barrens	0	0	0.9	ns
Salt-killed Tundra	0	0	<0.1	ns
Deep Open Water without Islands	8	24.2	7.0	prefer
Deep Open Water with Islands or Polygonized Margins	24	72.7	5.4	prefer
Shallow Open Water without Islands	0	0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	1	3.0	1.6	ns
River or Stream	0	0	0.9	ns
Sedge Marsh	0	0	1.7	ns
Deep Polygon Complex	0	0	<0.1	ns
Grass Marsh	0	0	0.3	ns
Young Basin Wetland Complex	0	0	0.4	ns
Old Basin Wetland Complex	0	0	8.7	ns
Riverine Complex	0	0	0.4	ns
Dune Complex	0	0	1.1	ns
Nonpatterned Wet Meadow	0	0	3.1	ns
Patterned Wet Meadow	0	0	11.3	avoid
Moist Sedge–Shrub Meadow	0	0	23.2	avoid
Moist Tussock Tundra	0	0	27.7	avoid
Tall, Low, or Dwarf Shrub	0	0	3.1	ns
Barrens	0	0	1.0	ns
Human Modified	0	0	0	ns
Total	33	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (groups / total groups) x 100 or (broods / total broods) x 100

Appendix E3. Habitat selection by nesting Pacific Loons in the CD-3 search area, Colville River Delta, Alaska, 2000–2004.

Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	9	11.8	3.4	prefer
Tapped Lake with Low-water Connection	0	0	1.0	ns
Tapped Lake with High-water Connection	17	22.4	4.1	prefer
Salt Marsh	0	0	4.6	ns
Tidal Flat Barrens	0	0	<0.1	ns
Salt-killed Tundra	4	5.3	14.1	avoid
Deep Open Water without Islands	8	10.5	3.8	prefer
Deep Open Water with Islands or Polygonized Margins	21	27.6	9.9	prefer
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	5	6.6	0.8	prefer
River or Stream	0	0	<0.1	ns
Deep Polygon Complex	3	3.9	12.4	avoid
Grass Marsh	1	1.3	0.2	ns
Nonpatterned Wet Meadow	1	1.3	14.0	avoid
Patterned Wet Meadow	6	7.9	24.1	avoid
Moist Sedge–Shrub Meadow	1	1.3	2.6	ns
Tall, Low, or Dwarf Shrub	0	0	1.2	ns
Barrens	0	0	3.7	ns
Total	76	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (nests / total nests) × 100

Appendix F1. Habitat selection (pooled among years) by nesting and brood-rearing Tundra Swans, Colville River Delta, Alaska, 1992–2004.

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	0.8	1.2	ns
Tapped Lake with Low-water Connection	3	0.8	3.9	avoid
Tapped Lake with High-water Connection	5	1.3	3.8	avoid
Salt Marsh	24	6.4	3.0	prefer
Tidal Flat Barrens	5	1.3	10.6	avoid
Salt-killed Tundra	45	12.0	4.6	prefer
Deep Open Water without Islands	10	2.7	3.8	ns
Deep Open Water with Islands or Polygonized Margins	13	3.5	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	15.0	avoid
Sedge Marsh	1	0.3	<0.1	ns
Deep Polygon Complex	34	9.1	2.4	prefer
Grass Marsh	3	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	40	10.7	7.5	prefer
Patterned Wet Meadow	145	38.8	18.6	prefer
Moist Sedge–Shrub Meadow	20	5.3	2.2	prefer
Moist Tussock Tundra	5	1.3	0.6	ns
Tall, Low, or Dwarf Shrub	6	1.6	5.0	avoid
Barrens	9	2.4	13.8	avoid
Human Modified	0	0	<0.1	ns
Total	374	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	1.8	avoid
Brackish Water	16	6.1	1.2	prefer
Tapped Lake with Low-water Connection	37	14.2	3.9	prefer
Tapped Lake with High-water Connection	25	9.6	3.8	prefer
Salt Marsh	21	8.0	3.0	prefer
Tidal Flat Barrens	3	1.1	10.6	avoid
Salt-killed Tundra	22	8.4	4.6	prefer
Deep Open Water without Islands	21	8.0	3.8	prefer
Deep Open Water with Islands or Polygonized Margins	9	3.4	1.4	prefer
Shallow Open Water without Islands	2	0.8	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	1	0.4	0.1	ns
River or Stream	10	3.8	15.0	avoid
Sedge Marsh	0	0	<0.1	ns
Deep Polygon Complex	6	2.3	2.4	ns
Grass Marsh	5	1.9	0.3	prefer
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	17	6.5	7.5	ns
Patterned Wet Meadow	36	13.8	18.6	ns
Moist Sedge–Shrub Meadow	3	1.1	2.2	ns
Moist Tussock Tundra	1	0.4	0.6	ns
Tall, Low, or Dwarf Shrub	6	2.3	5.0	ns
Barrens	20	7.7	13.8	avoid
Human Modified	0	0	<0.1	ns
Total	261	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (nests / total nests) × 100 or broods / total broods × 100

Appendix F2. Habitat selection by nesting and brood-rearing Tundra Swans, NPRA study area, Alaska, 2001–2004.

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0	0.4	ns
Brackish Water	3	1.6	0.4	ns
Tapped Lake with Low-water Connection	1	0.5	0.5	ns
Tapped Lake with High-water Connection	0	0	0.1	ns
Salt Marsh	4	2.2	0.8	ns
Tidal Flat Barrens	0	0	0.6	ns
Salt-killed Tundra	2	1.1	0.2	ns
Deep Open Water without Islands	2	1.1	6.8	avoid
Deep Open Water with Islands or Polygonized Margins	14	7.7	5.3	ns
Shallow Open Water without Islands	1	0.5	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	12	6.6	1.6	prefer
River or Stream	0	0	1.0	ns
Sedge Marsh	4	2.2	1.7	ns
Deep Polygon Complex	0	0	<0.1	ns
Grass Marsh	8	4.4	0.3	prefer
Young Basin Wetland Complex	4	2.2	0.3	prefer
Old Basin Wetland Complex	21	11.5	8.6	ns
Riverine Complex	0	0	0.4	ns
Dune Complex	2	1.1	1.1	ns
Nonpatterned Wet Meadow	7	3.8	3.1	ns
Patterned Wet Meadow	14	7.7	11.3	ns
Moist Sedge–Shrub Meadow	33	18.1	22.9	ns
Moist Tussock Tundra	49	26.9	27.3	ns
Tall, Low, or Dwarf Shrub	1	0.5	3.2	avoid
Barrens	0	0	1.0	ns
Total	182	100	100	
BROOD-REARING				
Open Nearshore Water	1	1.4	0.4	ns
Brackish Water	2	2.9	0.4	ns
Tapped Lake with Low-water Connection	3	4.3	0.5	prefer
Tapped Lake with High-water Connection	0	0	0.1	ns
Salt Marsh	1	1.4	0.8	ns
Tidal Flat Barrens	0	0	0.6	ns
Salt-killed Tundra	0	0	0.2	ns
Deep Open Water without Islands	21	30.0	6.8	prefer
Deep Open Water with Islands or Polygonized Margins	16	22.9	5.3	prefer
Shallow Open Water without Islands	1	1.4	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	2	2.9	1.6	ns
River or Stream	1	1.4	1.0	ns
Sedge Marsh	1	1.4	1.7	ns
Deep Polygon Complex	0	0	<0.1	ns
Grass Marsh	1	1.4	0.3	ns
Young Basin Wetland Complex	0	0.0	0.3	ns
Old Basin Wetland Complex	1	1.4	8.6	avoid
Riverine Complex	1	1.4	0.4	ns
Dune Complex	0	0	1.1	ns
Nonpatterned Wet Meadow	5	7.1	3.1	ns
Patterned Wet Meadow	3	4.3	11.3	avoid
Moist Sedge–Shrub Meadow	6	8.6	22.9	avoid
Moist Tussock Tundra	2	2.9	27.3	avoid
Tall, Low, or Dwarf Shrub	1	1.4	3.2	ns
Barrens	1	1.4	1.0	ns
Total	70	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (nests / total nests) × 100 or broods / total broods × 100

Appendix G1. Habitat selection by nesting Greater White-fronted Geese in the CD-3 search area, Colville River Delta, Alaska, 2000–2004.

Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
Brackish Water	1	0.1	3.4	avoid
Tapped Lake with Low-water Connection	0	0	1.0	avoid
Tapped Lake with High-water Connection	2	0.2	4.1	avoid
Salt Marsh	27	2.4	4.6	avoid
Tidal Flat	0	0	<0.1	ns
Salt-killed Tundra	117	10.6	14.1	avoid
Deep Open Water without Islands	9	0.8	3.8	avoid
Deep Open Water with Islands or Polygonized Margins	10	0.9	9.9	avoid
Shallow Open Water without Islands	2	0.2	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	13	1.2	0.8	ns
River or Stream	0	0	<0.1	ns
Deep Polygon Complex	314	28.4	12.4	prefer
Grass Marsh	0	0	0.2	ns
Nonpatterned Wet Meadow	154	13.9	14.0	ns
Patterned Wet Meadow	435	39.4	24.1	prefer
Moist Sedge–Shrub Meadow	14	1.3	2.6	avoid
Tall, Low, or Dwarf Shrub	3	0.3	1.2	avoid
Barrens	3	0.3	3.7	avoid
Total	1104	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (nests / total nests) × 100

Appendix G2. Habitat selection by nesting Greater White-fronted and Canada geese, combined search areas, NPRA study area, Alaska, 2004.

SPECIES Habitat	No. of Nests	Use (%)	Availability (%)	Monte Carlo Results[a]
GREATER WHITE-FRONTED GOOSE				
Deep Open Water without Islands	0	0	2.6	ns
Deep Open Water with Islands or Polygonized Margins	0	0	1.3	ns
Shallow Open Water without Islands	1	0.9	1.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	4.3	avoid
River or Stream	0	0	0.2	ns
Sedge Marsh	1	0.9	4.7	avoid
Grass Marsh	0	0	0.1	ns
Young Basin Wetland Complex	4	3.5	6.6	ns
Old Basin Wetland Complex	30	26.5	13.9	prefer
Riverine Complex	1	0.9	1.1	ns
Nonpatterned Wet Meadow	9	8.0	10.8	ns
Patterned Wet Meadow	34	30.1	14.9	prefer
Moist Sedge–Shrub Meadow	21	18.6	17.8	ns
Moist Tussock Tundra	12	10.6	19.5	avoid
Tall, Low, or Dwarf Shrub	0	0	0.9	ns
Barrens	0	0	<0.1	ns
Total	113	100	100	
CANADA GOOSE				
Deep Open Water without Islands	0	0	2.6	ns
Deep Open Water with Islands or Polygonized Margins	0	0	1.3	ns
Shallow Open Water without Islands	3	8.8	1.4	prefer
Shallow Open Water with Islands or Polygonized Margins	18	52.9	4.3	prefer
River or Stream	0	0	0.2	ns
Sedge Marsh	1	2.9	4.7	ns
Grass Marsh	0	0	0.1	ns
Young Basin Wetland Complex	3	8.8	6.6	ns
Old Basin Wetland Complex	8	23.5	13.9	ns
Riverine Complex	0	0	1.1	ns
Nonpatterned Wet Meadow	1	2.9	10.8	ns
Patterned Wet Meadow	0	0	14.9	avoid
Moist Sedge–Shrub Meadow	0	0	17.8	avoid
Moist Tussock Tundra	0	0	19.5	avoid
Tall, Low, or Dwarf Shrub	0	0	0.9	ns
Barrens	0	0	<0.1	ns
Total	34	100	100	

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability. % use = (nests / total nests) $\times$ 100

Appendix H1. Landforms, activity status, and number of pups counted (in parentheses) at arctic and red fox den sites, Colville River Delta[a] and NPRA study area, Alaska, late June–mid-July 2001–2004.

Species	Area	Site No.	Landform	Status[b] 2004	2003	2002	2001
Arctic fox	CD North	10	Dune/lake bank	Inactive	Inactive	Inactive (0)	Inactive
		11	Lake bank	Inactive?	Natal (6)	Natal (2)	Natal (2)
		33	Dune/lake bank	Inactive	Active (0)	Active (0)	Natal (3)
		34	Dune/lake bank	Natal (5)	Natal (3)	Natal (6)	Inactive
		45	Dune ridge	Active? (0)	Natal (2)	Natal (3)	Inactive
		58	Dune/river bank	Inactive	Inactive	Inactive	Active (0)
		59	Dune/lake bank	Inactive	Inactive	Inactive	Inactive
		62	Low dune ridge	Active? (0)	Natal (2)	Inactive (0)	Active (1?)
		102	Polygon rim	Inactive	Inactive	Inactive	Inactive
		107	Polygon rim	Natal (4)	Unknown	Unknown	Unknown
	CD South	2	Old dune	Inactive	Inactive	Inactive	Inactive
		54	Dune mound	Inactive	Inactive	Active	Inactive
		61	Low ridge	Active? (0)	Active (3)	Inactive	Natal (4)
		76	Low mound	Inactive	Inactive	Active	Inactive
		103	Old channel bank	Inactive	Not checked	Inactive	Active
	Northeast delta	73[c]	Sand dune	Natal (5)	Active (1?)	Active (0)	Inactive
	NPRA	200	DLB bank[d]	Inactive	Natal (1 dead)	Inactive	Inactive
		201	DLB bank[d]	Inactive	Inactive	Inactive	Inactive
		202	Lake bank	Active (0)	Inactive	Active (0)	Natal (2)
		203	Low ridge	Inactive	Inactive	Inactive	Inactive
		204	Lake bank	Inactive (0)	Inactive	Active (0)	Inactive
		205	River bank	Inactive	Inactive	Inactive	Inactive
		206	Stream bank	Inactive	Active (0)	Active (0)	Inactive
		207	DLB bank[d]	Inactive	Inactive	Inactive	Inactive
		208	Lake bank	Inactive	Natal (3)	Active (0)	Natal (2)
		209	Low mound	Active? (0)	Inactive	Inactive	Inactive (0)
		210	Pingo	Inactive	Inactive	Inactive	Inactive
		211	Lake bank	Active? (0)	Inactive	Active (0)	Inactive
		212	Lake bank	Inactive	Natal (2)	Inactive	Inactive
		213	Lake bank	Inactive	Secondary (2)	Inactive	Inactive
		214	DLB bank[d]	Inactive	Inactive	Inactive	Inactive
		215	Lake bank	Natal (2)	Natal (3)	Inactive (0)	Natal (5)
		216	Stream bank	Natal (1)	Inactive	Active (0)	Inactive (0)
		218	Low ridge	Inactive	Inactive	Inactive	Inactive (0)
		219	DLB bank[d]	Active? (0)	Inactive	Inactive	Inactive
		220	Low ridge	Inactive	Natal (3)	Inactive	Active (0)
		221	Low ridge	Inactive	Inactive	Active (0)	Inactive
		222	DLB bank[d]	Inactive	Inactive	Inactive	Active (0)
		223	Lake bank	Inactive	Natal (0)	Natal (1 dead)	Inactive
		225	DLB bank[d]	Not checked	Active (0)	Inactive	Unknown
		226	Low mound	Inactive	Inactive	Inactive	Unknown
		227	Low mound	Inactive	Inactive	Inactive	Unknown
		228	DLB bank[d]	Inactive	Inactive	Inactive	Unknown
		229	Lake bank	Active? (0)	Natal (2)	Active (0)	Unknown

Appendix H1. Continued.

Species	Area	Site No.	Landform	Status[b]			
				2004	2003	2002	2001
Arctic fox	NPRA	230	Old beach ridge	Inactive	Natal (2)	Inactive (0)	Unknown
		231	Stream bank	Inactive	Inactive	Inactive	Unknown
		232	Low ridge	Inactive	Natal (0)	Inactive	Unknown
		233	Lake bank	Inactive	Inactive	Inactive	Unknown
		235	Stream terrace	Active?	Inactive	Inactive	Unknown
		236	Polygon rim	Inactive	Active (1)	Unknown	Unknown
		237	Low mound	Active? (0)	Active (1)	Unknown	Unknown
		238	Old beach ridge	Inactive	Unknown	Unknown	Unknown
		239	DLB bank[d]	Inactive	Unknown	Unknown	Unknown
		240	Polygon rim	Inactive	Unknown	Unknown	Unknown
		241	Polygon rim	Active?	Unknown	Unknown	Unknown
		242	Low mound	Inactive	Unknown	Unknown	Unknown
Red fox	CD North	1[e]	Old dune	Natal (2)	Inactive	Inactive (0)	Inactive
		82	Sand dune	Inactive (0)	Inactive	Inactive (0)	Active (0)
		87	Sand dune	Inactive	Inactive	Inactive (0)	Inactive
	CD South	26	Dune/lake bank	Inactive (0)	Inactive	Inactive	Inactive
		49	Sand dune	Active (4)	Natal (1)	Natal (1)	Natal (3)
		106	Sand dune	Active (1)	Unknown	Unknown	Unknown
		55	Dune/riverbank	Inactive	Active (1)	Inactive (0)	Active (0)
		60	Sand dune	Natal (3)	Natal (5)	Inactive (0)	Inactive (0)
	Northeast delta	48	Sand dune	Inactive	Inactive (0)	Inactive	Natal (2)
	NPRA	217	Sand dune	Inactive	Inactive	Inactive	Inactive
		234[f]	Sand dune	Inactive	Inactive	Inactive	Unknown

[a] The Colville River Delta comprises the CD North study area, the CD South study area, and the northeast delta, see Figure 31
[b] Zero indicates that no pups were seen during den observation; ? indicates that pups were suspected but not confirmed at den; dash indicates that den had not yet been found
[c] Site was classified as an inactive red fox den in 2001
[d] DLB = drained-lake basin
[e] Site was an arctic fox den during 1992–2003
[f] Site was classified as an inactive arctic fox den in 2002

Appendix H2. Habitat selection by arctic and red foxes for denning, Colville River Delta, 1992–2004, and NPRA study area, 2001–2004, Alaska.

AREA Habitat	Area[a] (km^2)	No. of Dens	Use (%)	Availability[a] (%)	Monte Carlo Results[b]
COLVILLE RIVER DELTA					
Salt Marsh	16.3	0	0	5.1	ns
Moist Halophytic Dwarf Shrub	0.1	0	0	<0.1	ns
Salt-killed Tundra	25.6	0	0	8.0	ns
Deep Polygon Complex	13.2	1	4.0	4.1	ns
Young Basin Wetland Complex	<0.1	0	0	<0.1	ns
Old Basin Wetland Complex	0.1	0	0	<0.1	ns
Nonpatterned Wet Meadow	41.5	2	8.0	13.0	ns
Patterned Wet Meadow	102.6	3	12.0	32.1	avoid
Moist Sedge–Shrub Meadow	12.3	1	4.0	3.9	ns
Moist Tussock Tundra	3.2	0	0	1.0	ns
Moist Low Shrub	27.1	15	60.0	8.5	prefer
Dry Dwarf Shrub	0.5	2	8.0	0.1	prefer
Barrens	76.1	1	4.0	23.8	avoid
Human-modified	0.4	0	0	0.1	ns
Total	319.2	25	100	100	
NPRA					
Salt Marsh	3.2	1	2.4	0.6	ns
Moist Halophytic Dwarf Shrub	0.4	0	0	0.1	ns
Salt-killed Tundra	0.1	0	0	<0.1	ns
Deep Polygon Complex	0.3	0	0	<0.1	ns
Young Basin Wetland Complex	2.5	0	0	0.4	ns
Old Basin Wetland Complex	60.7	4	9.5	10.9	ns
Riverine Complex	2.8	0	0	0.5	ns
Dune Complex	7.6	0	0	1.4	ns
Nonpatterned Wet Meadow	21.6	0	0	3.9	ns
Patterned Wet Meadow	78.7	6	14.3	14.1	ns
Moist Sedge–Shrub Meadow	159.4	11	26.2	28.6	ns
Moist Tussock Tundra	191.1	13	31.0	34.3	ns
Moist Tall Shrub	1.0	0	0	0.2	ns
Moist Low Shrub	9.6	1	2.4	1.7	ns
Moist Dwarf Shrub	4.0	4	9.5	0.7	prefer
Dry Tall Shrub	1.7	1	2.4	0.3	ns
Dry Dwarf Shrub	4.9	1	2.4	0.9	ns
Barrens	6.8	0	0	1.2	ns
Total	556.5	42	100	100	

[a] Aquatic habitats and Tidal Flat Barrens were assigned zero availability for fox denning

[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant; prefer = use significantly greater than availability; avoid = use significantly less than availability; percent use = (dens / total dens) × 100