WILDLIFE STUDIES IN THE NORTHEAST PLANNING AREA OF THE NATIONAL PETROLEUM RESERVE–ALASKA, 2002

SECOND ANNUAL REPORT

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INTRODUCTION

During 2002, ABR, Inc., conducted wildlife surveys for selected birds and mammals in a portion of the Northeast Planning Area of the National Petroleum Reserve–Alaska (NPRA). This area was opened for oil and gas leasing in 1999 after completion of an Integrated Activity Plan and Environmental Impact Statement (BLM 1998). ConocoPhillips, Alaska, Inc. (CPAI) initiated wildlife investigations in 1999 through a contract with ABR. These studies have been conducted annually by ABR since that date (Anderson and Johnson 1999, Murphy and Stickney 2000, Johnson and Stickney 2001, and Burgess et al. 2002), although survey area boundaries differed among years to encompass various plans for exploration drilling. The surveys reported in this document were designed to gather baseline data on wildlife use in areas that CPAI currently views as potential future oil and gas development sites within the Northeast Planning Area. The 2002 NPRA Study Area (Figure 1) encompassed the 9 exploration wells that were drilled in 1999–2002 and also encompassed most of the sites tentatively proposed for drilling by CPAI in 2002-2003.

As part of long-term monitoring of wildlife species in the Kuparuk Oilfield and surrounding new developments, CPAI (and it's predecessors, ARCO Alaska, Inc. and Phillips Alaska, Inc.) have studied the distribution, abundance, and productivity of Spectacled Eiders (scientific names are listed in Appendix A), Tundra Swans, Brant, other waterbirds, caribou, and foxes over large areas of the central Arctic Coastal Plain since the early 1980s (see Murphy and Anderson 1993, Stickney et al. 1993, Anderson et al. 2001, Johnson et al. 2003a, Lawhead and Prichard 2002, 2003). As development plans expanded westward, wildlife survey areas also have expanded to evaluate pre-development, construction, and operations impacts of oil development on wildlife populations (Smith et al. 1994; Johnson et al. 1999, 2003a, 2003b; Burgess et al. 2002, 2003). The wildlife studies in the NPRA were part of an overall baseline program, comprising investigations of fisheries, hydrology, geomorphology, water quality, air quality, archaeology and cultural resources, and oil spill planning.

ARCO Alaska, Inc. (ARCO) purchased leases in the NPRA in 1999. In summer 1999, in preparation for exploration activities in the Northeast Planning Area of NPRA during winter 1999–2000, ARCO initiated avian studies to evaluate the distribution and abundance of important breeding species in the vicinity of the lease blocks (Anderson and Johnson 1999). In 1999, aerial surveys for waterfowl were conducted in blocks containing proposed exploration sites, and ground searches for eider nests were conducted where Spectacled Eiders were seen on pre-nesting aerial surveys. Eiders and Tundra Swans were selected as the focal species of these surveys because of their special status (threatened status for Spectacled and Steller's eiders) or their interest to management agencies (Tundra Swans).

Prior to the exploration program in winter 2000–2001, Phillips Alaska, Inc. (PAI), purchased ARCO's Alaska assets in the area and requested that additional sites in NPRA be surveyed during summers 2000 (Murphy and Stickney 2000) and 2001 (Johnson and Stickney 2001). In 2000, aerial surveys for eiders and Tundra Swans again were conducted in blocks that included the proposed exploration sites, and (in accordance with BLM permit guidelines) ground searches for nests were conducted in the immediate vicinity (~40 acres) of proposed exploration sites.

Surveys for eiders and swans were expanded in 2001 to cover a broad area referred to as the NPRA Exploration Survey Area (1,022 km^2), which encompassed all additional exploration drill sites (Johnson and Stickney 2001). The avian surveys in the Exploration Survey Area were conducted to support exploration permit applications. Also in 2001, aerial surveys for other waterbird species (see below) and mammals were initiated in the 2001 NPRA Study Area (615 km^2; Figure 1), which was entirely within the boundary of the Exploration Survey Area (Burgess et al. 2002). In addition to aerial surveys in 2001, ground searches for nests and broods were conducted on 3 types of plots that were distributed throughout the 2001 NPRA Study Area: large waterbird ground-search areas, shorebird plots, and Red-throated Loon plots.

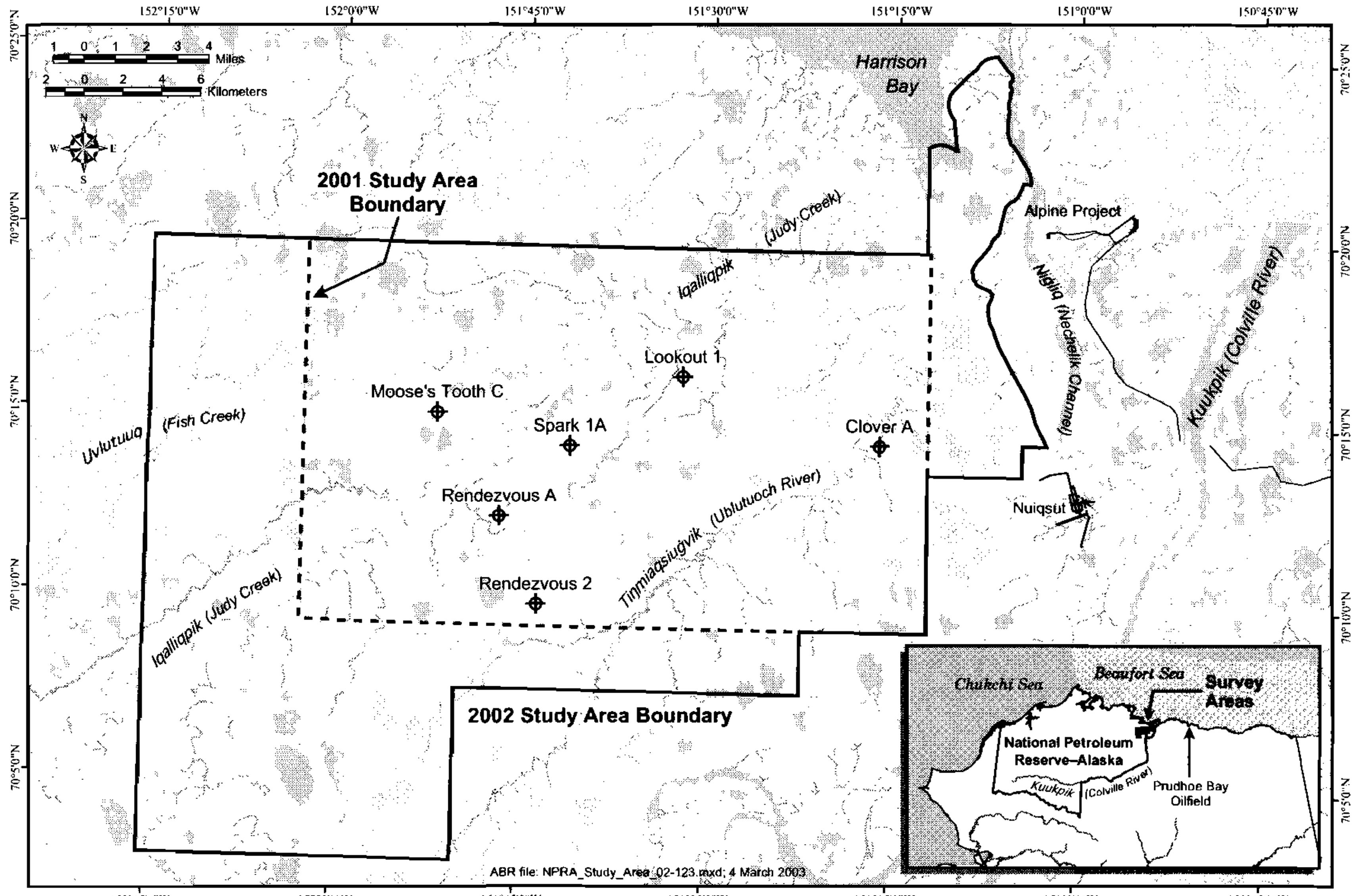

Figure 1. Boundaries of the 2001 and 2002 wildlife study areas and locations of exploratory well sites drilled in the northeastern planning area of the National Petroleum Reserve–Alaska.

In 2002, aerial surveys with broad coverage of the 2001 NPRA Study Area and Exploration Survey Area were continued for waterbird species and mammals and ground searches were again conducted on most of the shorebird plots established in 2001. Four new large waterbird ground-search areas were established in 2002 in the vicinity of 4 proposed development sites: Alpine West, Clover, Lookout 1, and Spark. The Red-throated Loon plot searches were discontinued in 2002, because results. in 2001 demonstrated relatively low densities of breeding pairs in the study area (6 nests [0.07 nests/km^2] on 16 plots [83.2 km^2 total area]). Nests and broods of Red-throated Loons were recorded during all surveys in 2002, as in 2001, but these methods are inadequate to estimate densities of Red-throated Loons in the study area. A new investigation was initiated in 2002 into the potential impacts on avian use of lakes during the breeding season after water withdrawal from lakes the previous winter (for construction of ice roads). We report here the results of the 2002 aerial surveys and ground-searches within the 2002 NPRA Study Area (Figure 1). Results of aerial surveys over the similar 2001 NPRA survey areas also are summarized for comparison. Wildlife observations in the area from previous CPAI investigations (pre-2001) are included where appropriate. Pre-2001 observations are not included in density or habitat selection analyses.

Wildlife study objectives and scopes were developed and study progress was reported through a series of agency 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 Kuukpiŋmiut 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
- 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
- 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

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) and Nuiqsut residents. On 8 May 2001, PAI held a science fair in Nuiqsut to discuss exploration and development in NPRA, as well as the environmental studies scheduled for 2001. On 9 May 2001, PAI 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, PAI published "NPRA Update," a newsletter on NPRA activities, in the "Arctic Sounder" newspaper in December 2001. The newsletter discussed summer field studies, subsistence representatives and ice-road monitors, public meetings, and other information. Mark Ahmakak and Gordon Matumeak, representing the Kuukpiŋmiut Subsistence

Oversight Panel (KSOP), participated in wildlife surveys during July–October 2002, and Doreen Nukapigak participated in July 2001.

The various surveys conducted in 2002 are detailed in Table 1 (avian surveys) and Table 2 (mammal surveys). Surveys in the NPRA Study Area in 2001–2002 were designed to provide baseline information on the distribution, abundance, and habitat use of 9 focal species: Spectacled Eider, King Eider, Tundra Swan, Brant, Yellow-billed Loon, Glaucous Gull, caribou, and arctic and red foxes (Red-throated Loons were an additional focal species in 2001). 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). The following criteria were used to select the focal species and groups: (1) threatened or sensitive status (Spectacled and Steller's eiders); (2) suspected to have declining populations (King Eider and Red-throated Loon); (3) restricted breeding range (Yellow-billed Loon); (4) concern of regulatory agencies for development impacts (Brant, Tundra Swan, shorebirds, and passerines); (5) nest predators (foxes and Glaucous Gull), or (6) subsistence species (caribou and geese). During surveys, information was collected opportunistically on Pacific Loons, Red throated Loons, Steller's Eiders (not anticipated breeders in the area), Sabine's Gulls, Arctic Terns, muskoxen, grizzly bears, and other mammals.

Six specific objectives were identified for wildlife surveys in the NPRA Study Area in 2001 and 2002:

- describe the distribution, abundance, productivity, and habitat use of selected species of waterfowl, loons, and gulls;
- calculate nest density, nesting success, and habitat use of shorebirds and passerines in representative portions of the study area;
- evaluate habitat use and habitat preferences of key wildlife species, using the habitat classification and maps of Jorgenson et al. (2003);
- describe the distribution and abundance of caribou during the calving season, post-calving period (including the insect-harassment season), and late summer through early winter;
- document the distribution, abundance, and occupancy of fox dens and the production of young foxes; and
- record the locations and numbers of muskoxen, grizzly bears, and other mammals encountered opportunistically during surveys.

STUDY AREA

The 2002 NPRA Study Area (1,100 km²) encompassed 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 (Figure 1). The 2002 NPRA Study Area includes the 2001 study area (615 km²), plus an eastward expansion of 80 km² and a westward expansion of 405 km². The area surveyed is located in the northeastern section of the NPRA, 6–39 km west of the village of Nuiqsut and 1–43 km southwest of the Alpine Development operations camp.

Three major streams flow through the study area (Figure 1). On U.S. Geological Survey (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 residents of Nuiqsut. In this report, the 3 drainages will be referred to by their Iñupiaq names: Uvlutuuq (Fish Creek), Iqalliqpik (Judy Creek) and Tiŋmiaqsiuġvik (Ublutuoch River). Uvlutuuq flows into the Iqalliqpik drainage, which is the larger of the 2 streams.

Landforms, vegetation, and wildlife habitats in the northeastern NPRA were described in the recent Environmental Impact Statement for the lease area (BLM 1998) and an ecological land survey (ELS) conducted for CPAI (Jorgenson et al. 2003) and are similar to those of the 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 NE corner of the study area. On the coastal plain,

Table 1. Descriptions of avian surveys conducted in the NPRA Study Area, Alaska, 2002.

AREA SURVEYED Survey Type	Season	Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
LARGE WATERBIRD GROUND-SEARCH AREAS							
Ground Searches for Nests[b]	Nesting	14–27 June	-	-	-	-	4 areas (15.5 km^2 total)
	Brood-rearing	19-20 July	-	-	-	-	Includes loon nest search
	Brood-rearing	21 August					Primarily for loons
SHOREBIRD PLOTS							
Ground Searches for Nests[c]	Nesting	7 June–20 July	-	-	-	-	24 plots (2.4 km^2 total)
LAKE STUDY GROUND-SEARCH AREAS							
Ground Searches for Nests[b]	Nesting	30 June	-	-	-	-	10 areas
	Brood-rearing	19–21 July	-	-	-	-	Includes loon nest search
	Brood-rearing	20-21 August					Primarily for loons
2002 NPRA STUDY AREA[d]							
Eider Survey	Pre-nesting	10–11 June	C185	0.4	0.8	30–35	50% coverage
Yellow-billed Loon Survey[c,f]	Nesting	26–28 June	206L	-	-	60	All lakes ≥10 ha
	Brood-rearing	20–21 August	206L	-	-	60	Lakes where Yellow-billed Loons were observed on nesting survey
Tundra Swan Survey[e]	Nesting	25 June	C185	1.6	1.6	150	100% coverage
	Brood-rearing	23, 25 August	C185	1.6	1.6	150	100% coverage
Brant Survey[e]	Nesting	18 June	206L	-	-	60	Lake-to-lake survey
Goose Survey	Brood-rearing	20 July	C185	0.8	1.6	90	50% coverage
	Fall staging	24, 25 August	C185	0.8	1.6	90	50% coverage

[a] Dash indicates ground search, no aircraft used. C185 = Cessna 185 fixed-wing airplane; PA18 = Piper "Super Cub" fixed-wing airplane; 206L = Bell "Long Ranger" helicopter.
[b] Nest searches included loons and grebes, waterfowl, gulls, terns, jaegers, ptarmigan, and large shorebirds (Whimbrel and Bar-tailed Godwit).
[c] Nest searches included all species, but plot design targeted shorebirds and passerines.
[d] Each aerial survey covered all or most of the 2002 NPRA Study Area. See text for details on aerial survey coverage.
[e] Glaucous Gull nests were recorded during surveys for Yellow-billed Loons, Tundra Swans, and Brant.
[f] Pacific and Red-throated loons and colonies of Sabine's Gulls were recorded incidentally.

Table 2. Descriptions of mammal surveys conducted in the NPRA Study Area, Alaska, 2002.

SURVEY TYPE Season	Date	Aircraft [a]	Transect Strip Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Area Sampled [b] (km^2)
CARIBOU STRIP-TRANSECTS						
Pre-calving	3 May	C206	1.6	3.2	150	654
Pre-calving	25–26 May	C206	1.6	3.2	150	654
Calving	8 June	C206	1.6	3.2	150	654
Calving	18 June	C206	1.6	3.2	150	654
Post-calving	27 June	C206	1.6	3.2	150	654
Insect season	18 July	C206	1.6	3.2	150	654
Insect season	26 July	C206	1.6	3.2	150	654
Insect season	3 August	C206	1.6	3.2	150	654
Late summer	14 August	C206	1.6	3.2	150	654
Fall	26 August	C206	1.6	3.2	150	654
Fall	9 September	C206	1.6	3.2	150	654
Fall	24 September	C206	1.6	3.2	150	654
Fall (rut)	6 October	C206	1.6	3.2	150	654
Fall (post-rut)	25 October	C206	1.6	3.2	150	654
FOX DEN SEARCH						
Denning	30 June; 1–2, 9 July	206B	–	–	60–90	–
FOX DEN OBSERVATIONS[c]						
Denning	10–12 July	206L	–	–	–	–

[a] C206 = Cessna 206 airplane; 206B = Bell "Jet Ranger" helicopter, 206L = Bell "Long Ranger" helicopter.
[b] 50% coverage of 1,310-km^2 survey area.
[c] Typically ground-based observations that relied on helicopter access.

lacustrine processes, basin drainage, and ice aggradation are the primary geomorphic factors that modify the landscape. In riverine areas along Uvlutuuq (Fish Creek) and Iqalliqpik (Judy Creek), fluvial processes predominate, although eolian and ice-aggradation processes also contribute to ecological development (Jorgenson et al. 2003). Twenty-seven wildlife habitat types (based on vegetation and surface form and geomorphology) were identified within the ELS mapped area. Common habitat types included Moist Tussock Tundra, Moist Sedge–Shrub Meadow, Patterned Wet Meadow, Old Basin Complex, and Deep Open Water without Islands.

An ecological land survey was conducted for the NPRA Study Area and is reported under separate cover (Jorgenson et al. 2003). A map of wildlife habitats was derived from the ELS (Figure 2) and was used to evaluate habitat use and habitat preferences for wildlife sightings within the mapped area.

The climate of the northeastern NPRA is typical of other coastal areas in the Arctic. Winters are cold and summers are cool; the thaw period lasts only about 90 days during summer (1 June–31 August) and the mean summer air temperature is 5° C (43° F; Kuparuk Oilfield records: National Oceanic and Atmospheric Administration, unpubl. data). Mean summer precipitation is under 7.5 cm (3 in), 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 0–10° C (32–50° F) during the growing season.

METHODS

HABITAT USE AND SELECTION

As described above, habitat analyses used a map of wildlife habitats (Figure 2) developed from an ecological land survey of the area; the map and supporting data are currently in review (Jorgenson et al. 2003). Wildlife observations from aerial surveys and ground searches (described below) were plotted on this map for analysis of habitat use. 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), 3) the percent availability of each habitat in the study area, and 4) a habitat selection index, described below.

Habitat use was calculated from group locations for species or seasons when birds were in flocks or broods, because we could not reasonably assume independence of selection among individuals in these groups. For fox dens (active and inactive combined), which are static in location, habitat use was calculated from the cumulative number of den locations over both years. For all other species, habitat use was calculated for all observations combined over both the 2001 and 2002 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). Habitat selection was evaluated for pre-nesting Spectacled Eiders and King Eiders, nesting and brood-rearing Yellow-billed Loons and Tundra Swans, and denning arctic foxes, because these aerial survey data sets covered large areas including all or most of the area covered by the habitat map. For analysis of habitat selection, the aerial survey observations were evaluated without any 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). Selection was not evaluated for species studied only through ground searches because of limited sample sizes and because the availability of habitats in ground-search areas was not representative of the entire NPRA Study Area. Also, selection analyses were not conducted on aerial survey data on nesting Brant, brood-rearing geese, or fall-staging geese.

Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat selection and this distribution was used to calculate the percentile scores of observed habitat use (Haefner 1996, Manly 1997). Random habitat selection 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 observations of habitat use greater than the 97.5 percentile of simulated random use, which represents an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observations below the 2.5 percentile of simulated random use. The simulations and calculations of percentiles were conducted in a Microsoft® Excel spreadsheet.

LARGE WATERBIRD GROUND-SEARCH AREAS

Ground-based nest searches were conducted in 2002 in 4 study plots corresponding with 4 potential development areas: Alpine West, Clover, Lookout, and Spark (Figure 3). Ground-based nest searches were conducted to determine the composition and abundance of large waterbirds in the potential development areas and to estimate nesting success, with particular attention to eiders and geese. Methods were similar in 2001, but different areas were searched each year. Nest searches (except those specifically for loons, see below) were conducted between 14 and 30 June 2002. Nests were located by 6–7-person teams that systematically searched study plots by walking more or less abreast and about 10 m apart. Each team member thoroughly searched all dry ground between themselves and adjacent observers for nests of large birds, including loons, grebes, geese, swans, ducks, ptarmigan, cranes, large shorebirds (Whimbrel, Bar-tailed Godwit, and Common Snipe), jaegers, gulls, terns, and raptors. Nests of small shorebirds and songbirds were not sought out or recorded in large waterbird ground-search areas. All nests of target species were mapped on aerial photos and recorded with GPS (Global Positioning System) units. Observers attempted not to flush incubating birds from nests but, when a bird was flushed, the observer counted the eggs and covered them with down and vegetation before leaving the site. If the nest was unattended, a small amount of down (including contour feathers, if present) was collected and the length and width of 1 or 2 eggs were recorded. When possible, unidentified nests later were assigned to a species by comparing feathers and egg measurements with those of known species. Habitat information was recorded at each waterbird nest, including the distance to nearest standing water, distance and waterbody class of the nearest permanent waterbody, the terrestrial habitat in the area, and the landform and vegetation at the nest site.

Ground-search areas were revisited after hatch (on 15–22 July for waterfowl and 16–22 August for loons) to check the fate of marked nests and to scan all waterbodies for the presence of broods. During the July nest check, shorelines and islands were searched for nests of loons, which initiate their nests later than other waterbirds. Observers scanned the area with binoculars and searched on foot all shorelines of waterbodies greater than about 25 m on their long axis (approximately the minimal waterbody size to support nesting Red-throated Loons). The number of adults and young of each brood were recorded and their locations plotted on aerial photos of the study area. Waterfowl nests were classified as successful if thickened egg membranes that had detached from the shell were found in the nest bowl. For loons, nests were considered successful if a brood later was associated with that nest site. Evidence of predation, such as crushed egg remnants, also was recorded. Because nearly all waterfowl nests could be classified as successful or failed, estimates of nesting success were calculated for these species. For other species, nest fate could not be determined solely from evidence at the nest bowl and nests generally were classified as successful or failed only if additional evidence was available, such as observations of young at the nest (or in the nesting lake, for loons), direct observations of a predation event, or other clear evidence of predation. For these species, unbiased estimates of nest success were not possible.

SHOREBIRD PLOTS

In June 2002, 24 shorebird plots (arranged in 6 clusters of 4 plots each) were sampled in representative habitats in the NPRA Study Area to determine nest densities, nesting success, and habitat associations of tundra-nesting birds (Figure 3, Appendix B). Five of these plot clusters were established and surveyed in 2001, the sixth plot cluster was established in 2002 to replace one of the 2001 plot clusters. This decision was made to facilitate a long-term study design to compare plot

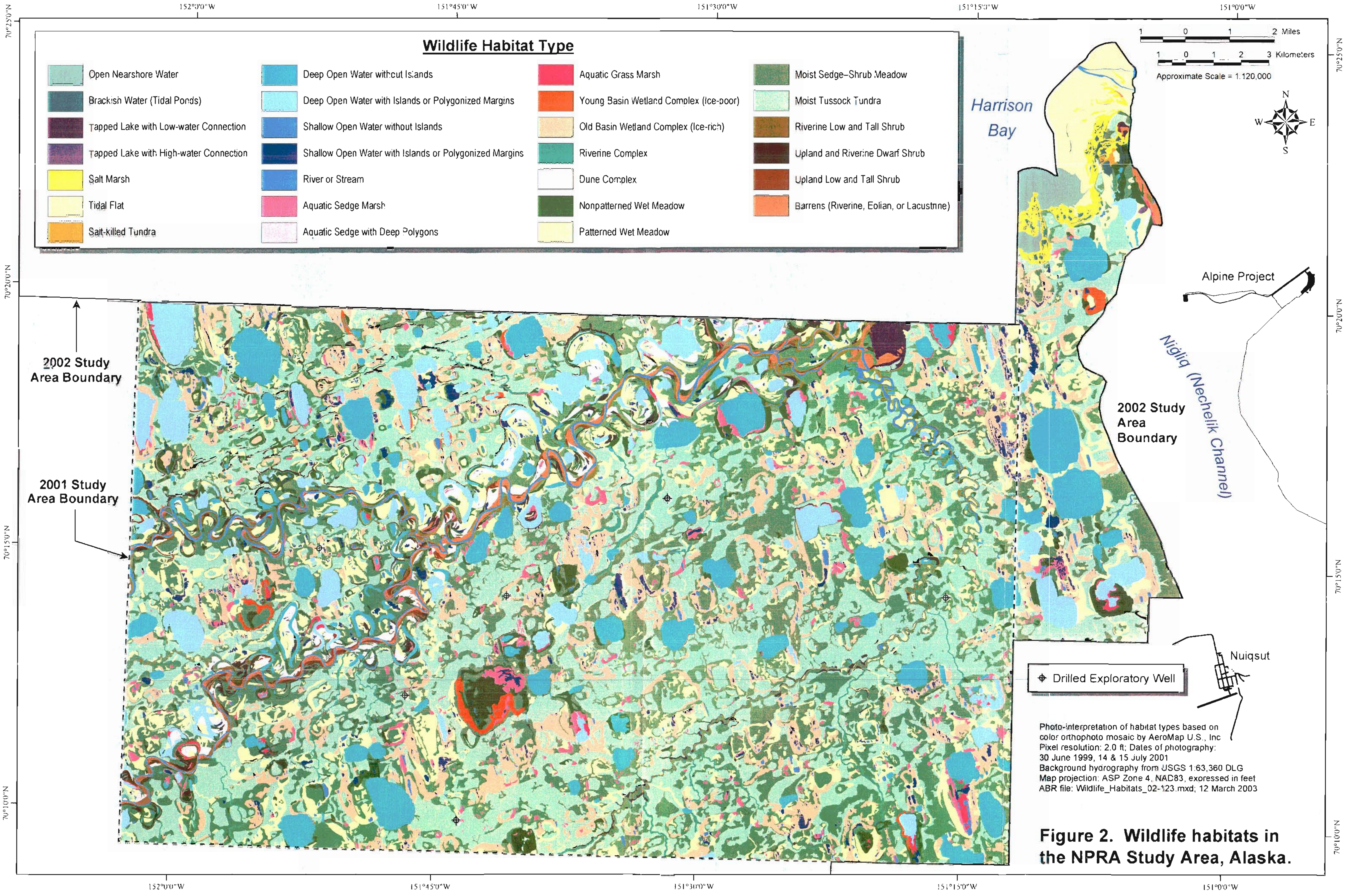

Figure 2. Wildlife habitats in the NPRA Study Area, Alaska.

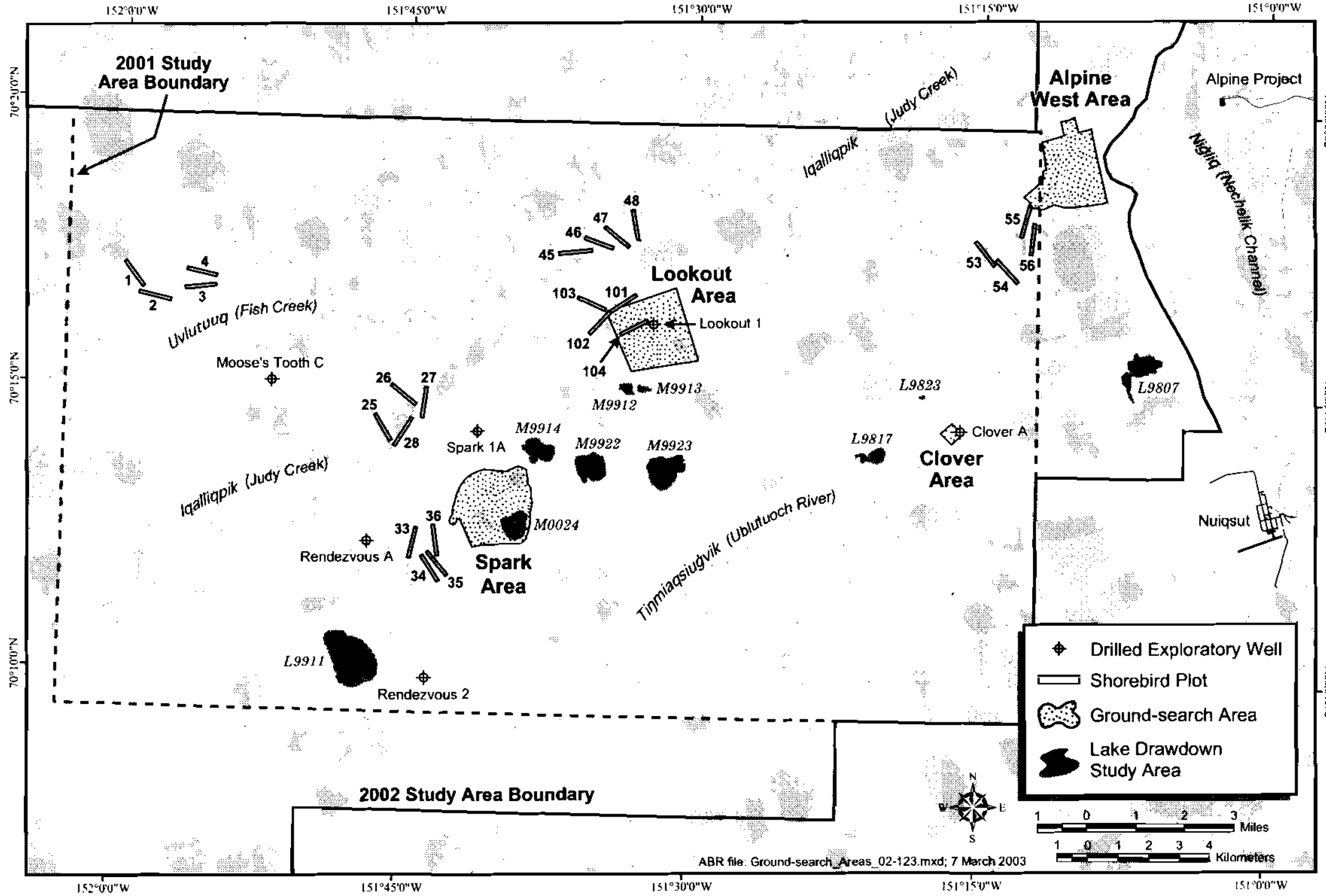

Figure 3. Large waterbird ground-search areas (4), shorebird plots (24), and lake drawdown study areas (10 lakes) in the NPRA Study Area, Alaska, 2002.

clusters near development areas with those at greater distances from development areas. The new plot cluster in 2002 was located in the vicinity of the exploratory well site, Lookout 1 (Figure 3). (However, development plans are dynamic and plot assignments to developed or undeveloped categories are not final, so no such comparison will be conducted until development activities are initiated.) Each cluster of plots also was located to sample representative habitats (as portrayed on the BLM cover map [Ducks Unlimited 1998]) in each of 3 general areas: the Uvlutuuq and Iqalliqpik floodplain, north of Uvlutuuq, and south of Iqalliqpik.

Shorebird plots measured 100 m × 1000 m (0.1 km^2 [10 ha]) and were marked with 1 row of survey lath that delineated 50 m × 50 m grids (40 grids/plot) (Figure 4). Each grid was subdivided into 4 quadrants. Plots were visited up to 11 times in 2002, with 3–7 days between visits. The first visit to remark and set-up the plots occurred 7–8 June, 4 visits to search for new nests and check fate of known nests occurred 11 June–1 July, and up to 6 visits to monitor nests for fate occurred 2–20 July. On the first and third nest-search visits, 2 people dragged a 53-m rope through each plot to flush birds from their nests. During the second and fourth nest-search visits, one person walked a "W" pattern through each plot. With either method, if a bird flushed and the nest was not immediately located, the observer moved farther away or used nearby terrain features as cover until the bird returned and the nest could be located. During nest-monitoring visits, the plot was not systematically searched for new nests, but the length of the plot was walked and new nests were marked if encountered. Known nests were checked during both nest-search and nest-monitoring visits to record egg loss, hatching, and fledging. In 2001, plots were visited only for setup and nest searching (5 visits, no nest monitoring visits).

For each nest found, the observer recorded the species, the number of birds present, the number of eggs or young, the surface form (e.g., polygon rim or center, island, nonpatterned) and habitat at the nest, and its location by grid number, distance from centerline, and quadrant within the grid (Figure 4). To assist in locating known nests, a small orange marker (~2.5 × 15 cm) was placed in the ground on the plot centerline perpendicular to the nest and a white marker (~1 × 10 cm) was placed 1–3 m from the nest toward the plot centerline. Each centerline marker was labeled in indelible ink indicating the perpendicular distance to the nest location. White markers were placed low in vegetation so that they were visible when walking from the centerline, but concealed from other directions.

The number and density (nests/ km^2) of nests found during plot set-up and nest-searching visits were summarized by species and plot for 2002 and by plot cluster and both species and species group for 2001 and 2002. Nests found during nest-monitoring visits were reported but not included in these summaries.

A nest was classified as successful when at least one chick was observed in or near a 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). Eggshell fragments from successful shorebird nests were generally ≤ 3–5 mm in length. A 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 fewer than 2 pieces of evidence (listed above) were confirmed.

Mean daily survival rates (DSR) were calculated for species groups (i.e., shorebirds, passerines, waterfowl) and for individual species in each plot cluster (groups of 4 plots in a similar geographic location) and over all plots combined. DSRs were calculated using 2 methods, the Mayfield method (Mayfield 1961, 1975) and the program, MARK (White and Burnham 1999). The Mayfield method is presented (Appendix G) mainly to facilitate comparisons with other studies of breeding birds on the North Slope of Alaska. However, because certain assumptions may not have been met for the Mayfield method in our study (e.g., regular nest check intervals, nest survival constant through time), the MARK program, which allows a variable nest check

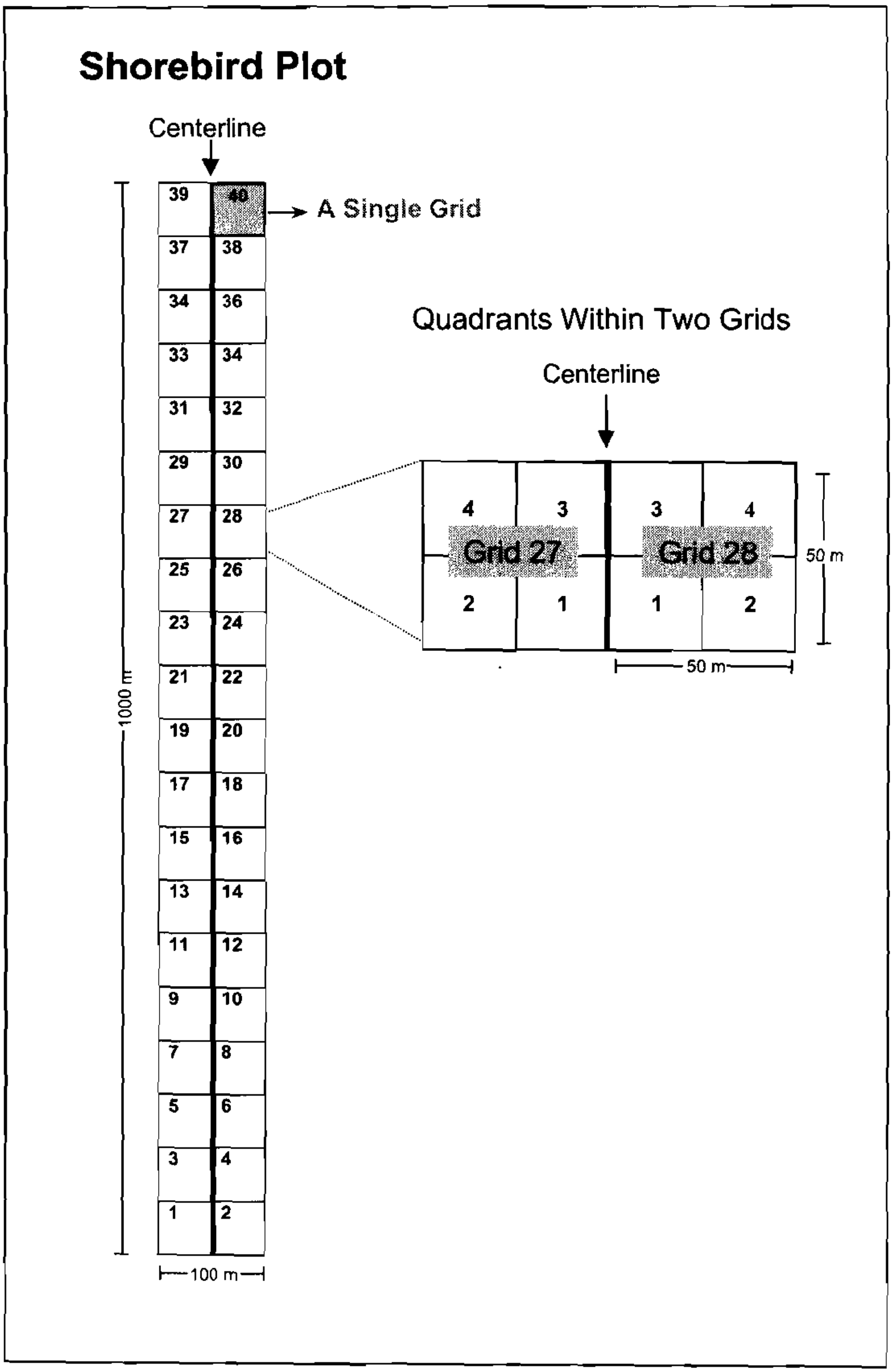

Figure 4. Typical shorebird plot grid system used in the NPRA Study Area, Alaska, 2001–2002.

interval, was considered more appropriate for this data set. The nest survival model in MARK also has its roots in the Mayfield method, so our results with MARK should be comparable to a Mayfield analysis in which the necessary assumptions for that method are met. Johnson (1979) and Bart and Robson (1982) expanded Mayfield's model and developed the theory to estimate time-specific nest survival rates. In turn, the generalized likelihood model developed by Bart and Robson (1982) has been expanded to its current form in the nest survival program of MARK (White and Burnham 1999). MARK allows for increased flexibility in modeling by allowing the use of covariates (e.g., time, age, habitat, weather, predators) that may influence survival rates and by calculating Akaike Information Criterion (AIC; Akaike 1985) metrics to facilitate model selection. These features of MARK (although not necessary for this data presentation) will be useful in future analyses to examine correlations among species in patterns of nest survival and loss.

LAKE DRAWDOWN STUDY

Early in 2002, CPAI initiated a hydrology study on the effects on lakes of the withdrawal of water during winter for ice roads (details in Baker 2002). Ten lakes were selected for evaluation of bird use (Figure 3). Five study lakes had water withdrawn during winter 2001—2002; these lakes (L9911, L9817, M9912, M9922, M9923) are referred to as drawdown lakes. The other 5 study lakes were not pumped and are referred to as reference lakes (L991, L9823, M0024, M9913, M9914). The hydrology team selected 4 of the reference lakes and we added a fifth reference lake (M9913) later in the sampling season to balance the data set. Therefore, hydrology data taken in the early winter will be lacking for Lake M9913. Surface area and shoreline length of each study lake were obtained from a digital georectified photomosaic (also used for the ecological land survey; Jorgenson et al. 2003). Bathymetric and fish data for study lakes were provided by MJM Research (Moulton 2001).

Observers walked the shorelines of each lake (~4 m strip along the lake bank) on 30 June, during the late nesting period for most waterbird species and recorded observations of large waterbird nests. In areas where the lakeshore graded indistinctly into aquatic marshes that could be affected by changes in lake water levels, these adjacent marshes also were searched. Shorelines were searched again on 19–21 July for loon nests (which initiate nesting later than most waterbirds) and for broods of all waterbirds. Lakes containing loon nests were visited a third time during the August loon brood survey (described in the *Loon Survey* section below). Observations of birds foraging or roosting on the shore or lake waters also were recorded during nest and brood searches.

EIDER SURVEYS

One aerial survey for pre-nesting eiders was conducted on 10–11 June 2002. Survey methods in the NPRA in 2001 and 2002 were similar to those used previously in the NPRA (Anderson and Johnson 1999, Murphy and Stickney 2000) and on the Colville River Delta (Burgess et al. 2003, Johnson et al. 2003b), except coverage was 50% of the study area. During the survey, the pilot navigated a Cessna 185 aircraft along east–west transect lines using a GPS receiver. An observer on each side of the aircraft counted eiders in fixed-width strips (200 m) on each side of the transect line. Transect lines were spaced 800 m apart for 50% coverage. A larger area was surveyed for pre-nesting eiders in 2002 than in 2001 (Figure 5). Observers used marks on the airplane's struts and windows to visually delimit the outer edges of the transect strip (Pennycuick and Western 1972). Flight altitude for each survey was 30–35 m above ground level (agl) and flight speed was approximately 145 km/h.

For each eider group location, observers noted on tape recorders the species of eider, number of each sex, number of identifiable pairs, transect number, and whether the birds were flying or on the ground. Each observer also marked their eider locations on 1:63,360 USGS maps of the study area. All observations were digitized and added to a geographical information system (GIS) database.

Density was calculated based on the actual number of birds observed and the total area covered during the survey. Total indicated birds was calculated by the procedures of the U.S. Fish and Wildlife Service (USFWS) survey protocol

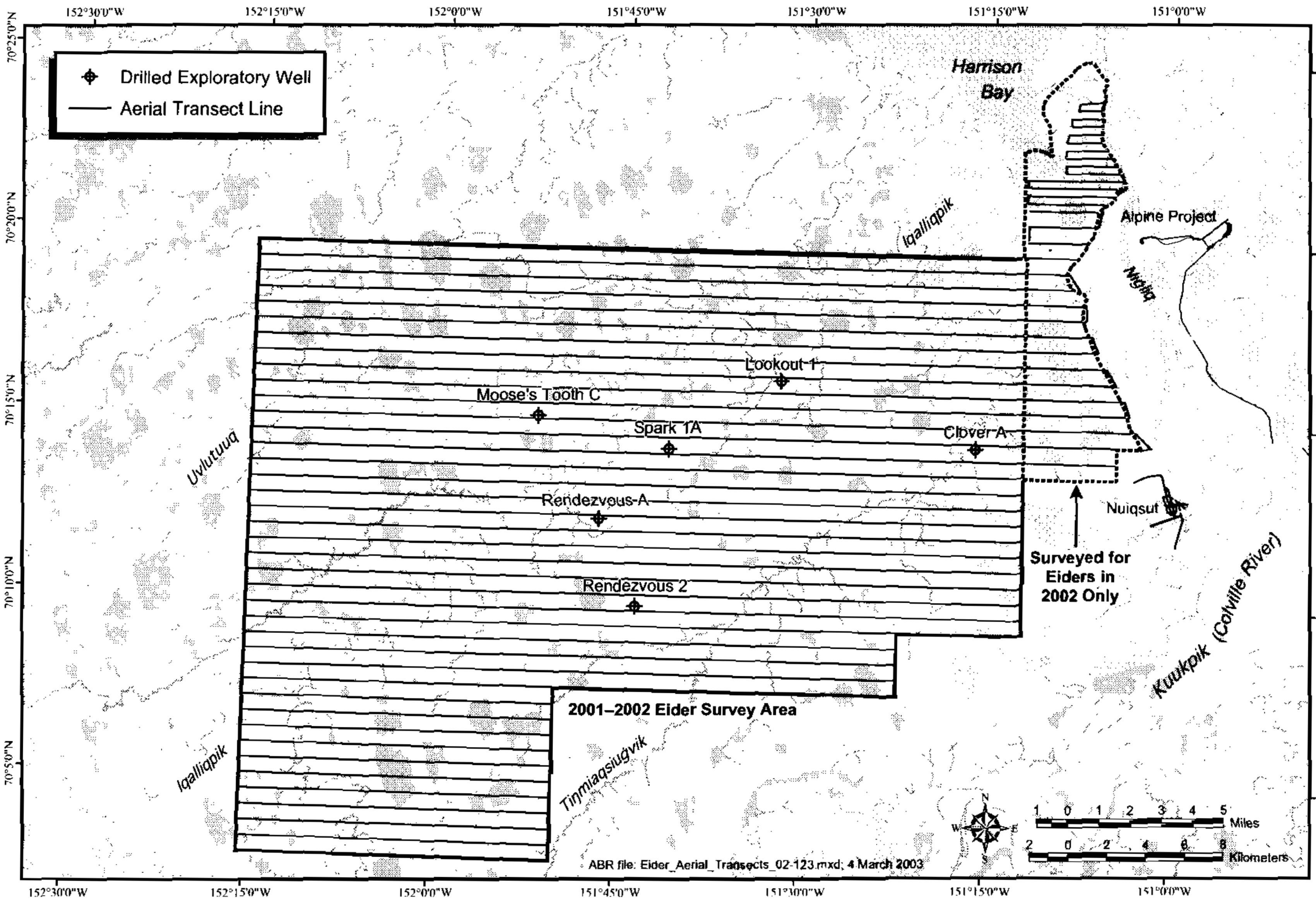

Figure 5. Transect lines and survey areas for pre-nesting eider aerial surveys, NPRA Study Area, Alaska, 2001–2002.

(USFWS 1987a) and an estimate of density also was calculated based on the total indicated birds.

To evaluate the potential for nesting by Spectacled Eiders in the study area, ground-based nest searches (in which all large waterbird nests were censused) were conducted in areas identified for potential development. Search methods were similar to those used in 2001 in NPRA and in 2000–2002 on the Colville River Delta (Burgess et al. 2003, Johnson et al. 2003b) and are presented above (in the section *Large Waterbird Ground Searches*).

LOON SURVEYS

Aerial surveys for nesting Yellow-billed Loons were conducted on 26–28 June 2002 and for brood-rearing loons on 20–21 August 2002. The nesting survey was conducted in a helicopter flying at ~60 m agl in a lake-to-lake pattern covering all lakes ≥10 ha in size (typical lake size for nesting Yellow-billed Loons [Sjolander and Agren 1976, North and Ryan 1989]) and adjacent smaller lakes. A larger area was surveyed in 2002 than in 2001 (Figure 6). Tapped lakes with low-water connections to river channels were excluded, as Yellow-billed Loons are not known to 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 loon locations were recorded on 1:63,360-scale USGS maps, and Yellow-billed Loon nest locations also were recorded on color aerial photos.

The total number of adults, nests, broods, and young by season for all species of loons and the density of Yellow-billed Loon adults, nests, and broods were calculated from aerial survey data. Aerial surveys were not suitable for determining the density of Red-throated and Pacific loons because smaller lakes that are used by these species were not included in the survey.

TUNDRA SWAN SURVEYS

Swan surveys were conducted following the USFWS Tundra Swan Survey Protocol (USFWS 1987b, 1991). This method was designed to give 100% coverage of a survey area and was used previously in the NPRA (Anderson and Johnson 1999, Murphy and Stickney 2000, Burgess et al. 2002).

Aerial surveys were flown along fixed-width, east–west transects in a Cessna 185 aircraft. Transects were oriented along township and section lines, and all observations were mapped on 1:63,360 USGS maps. A larger area was surveyed for swans in 2002 than in 2001 (Figure 7). The aircraft maintained a speed of 145 km/h and an altitude of 150 m agl. Each of the 2 observers scanned a strip 800 m wide on his/her side of the aircraft, while the pilot navigated and scanned ahead of the aircraft. The location and number of swans of each age (adult or young) and the presence of a nest or brood were recorded on the USGS maps. When observers located a nest, the aircraft left the transect line and circled the nest so that they could plot an accurate location and take photographs with a 35-mm camera of the nest site. During the brood-rearing survey, an identical procedure was used for recording data, but the airplane did not circle for photographs.

In 2002, the nesting survey was flown on 25 June and the brood-rearing survey was flown on 23 and 25 August. After each survey, location data were entered into digital maps in a GIS system. Summary statistics for nesting surveys followed the format established for the Kuparuk Oilfield in 1988 and modified in 1990 (Ritchie et al. 1989, 1991), which categorizes adults as either with nests or broods or without nests or broods. The latter 2 categories include nonbreeding subadults, as well as failed or nonbreeding adults. These individuals will be referred to collectively as "nonbreeders."

GOOSE SURVEYS

The aerial survey for nesting Brant in 2002 followed similar methods used for surveys of Brant from the Sagavanirktok River to the Colville River between 1989 and 1998 (Ritchie et al. 1990, Anderson et al. 1999). Using a Bell 206L helicopter and one observer, the nesting survey was flown along a predetermined lake-to-lake path that included lakes with islands, basin wetland complexes, and sites where Brant had been observed in previous years (Figure 8). The Brant survey pattern was non-systematic, so the surveyed area in 2002 differed slightly from that in 2001,

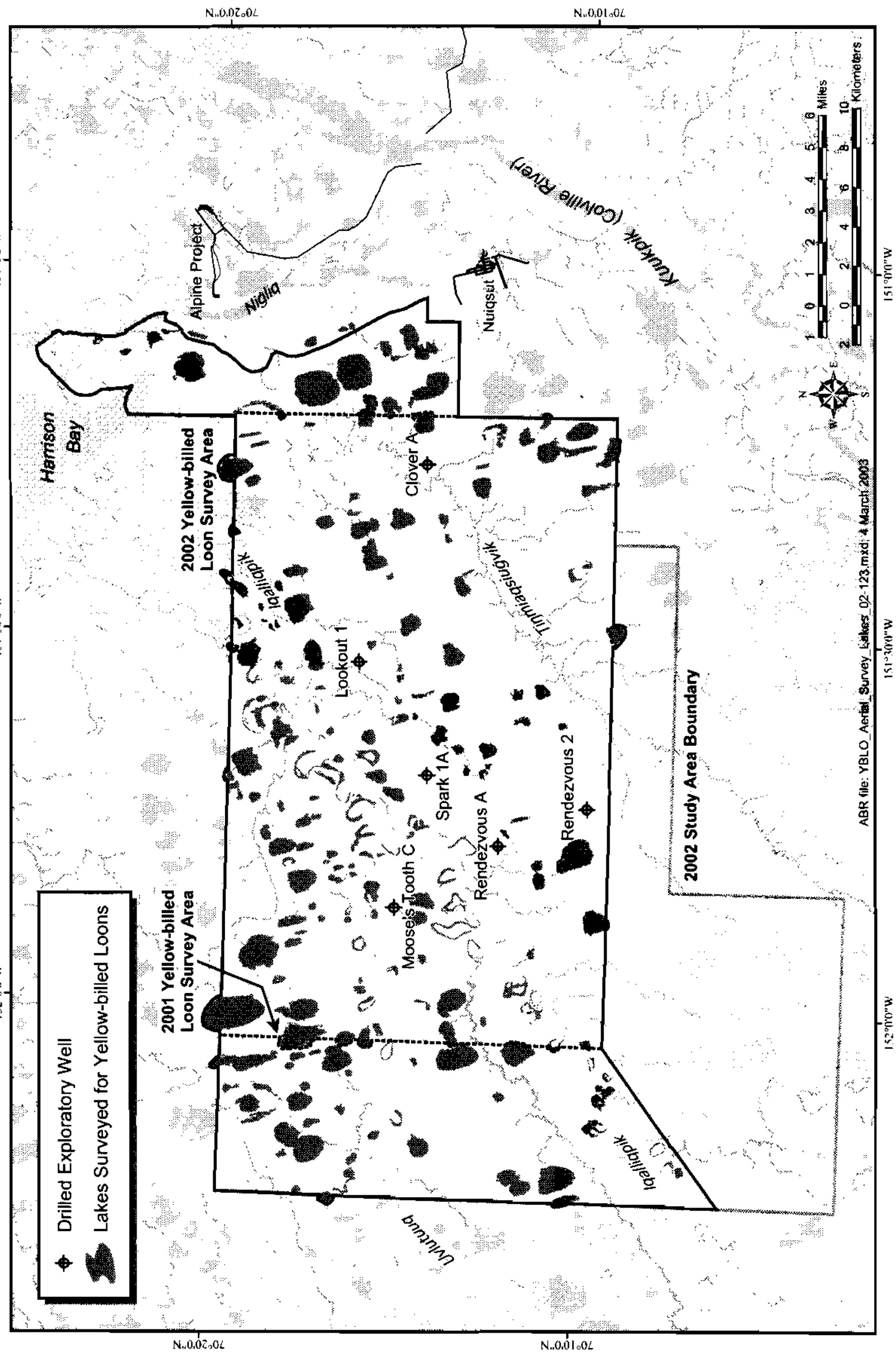

Figure 6. Lakes included in aerial surveys for nesting Yellow-billed Loons, NPRA Study Area, Alaska, 2001–2002.

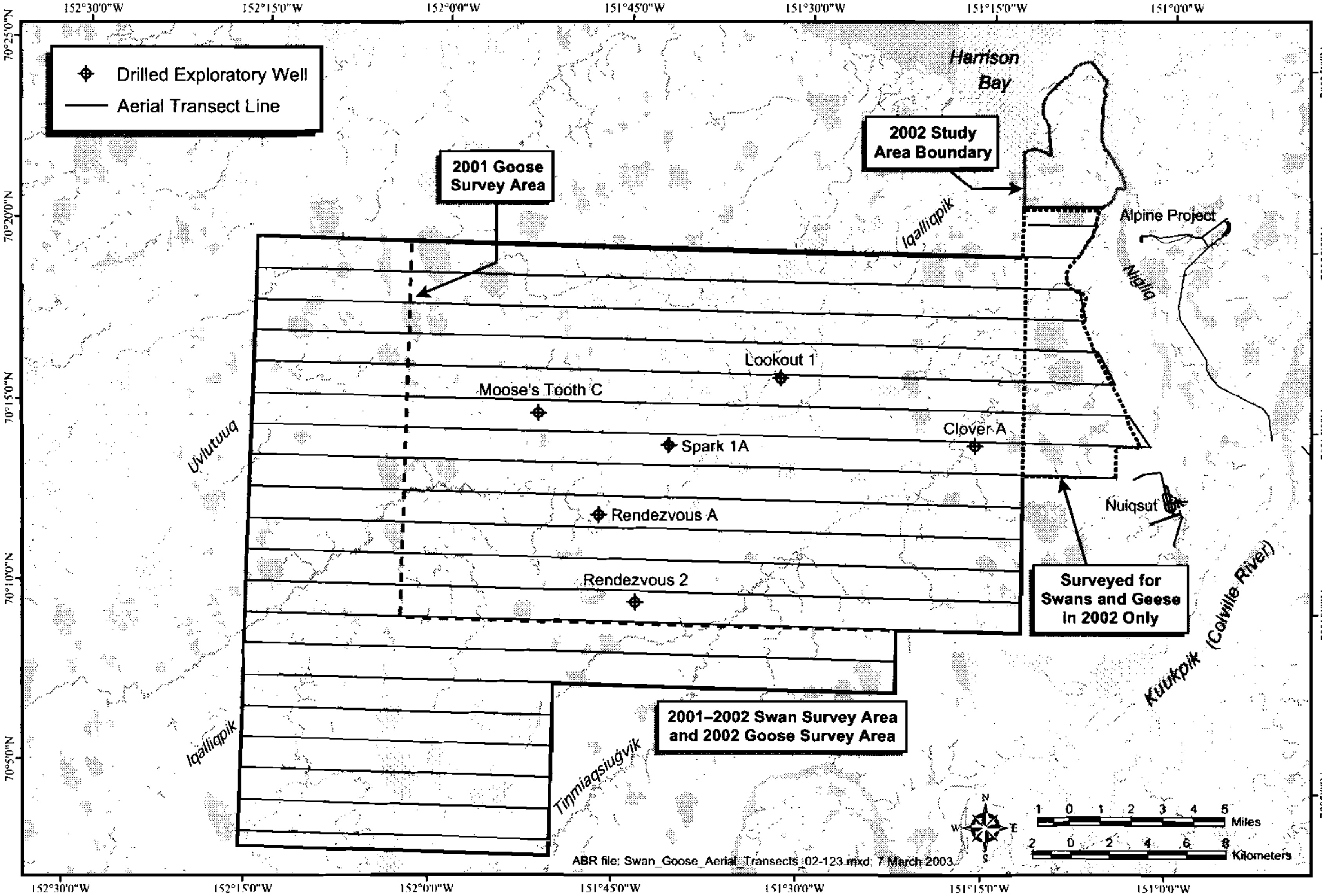

Figure 7. Transect lines and survey areas for aerial surveys of nesting and brood-rearing swans and for brood-rearing and fall-staging geese, NPRA Study Area, Alaska, 2001–2002.

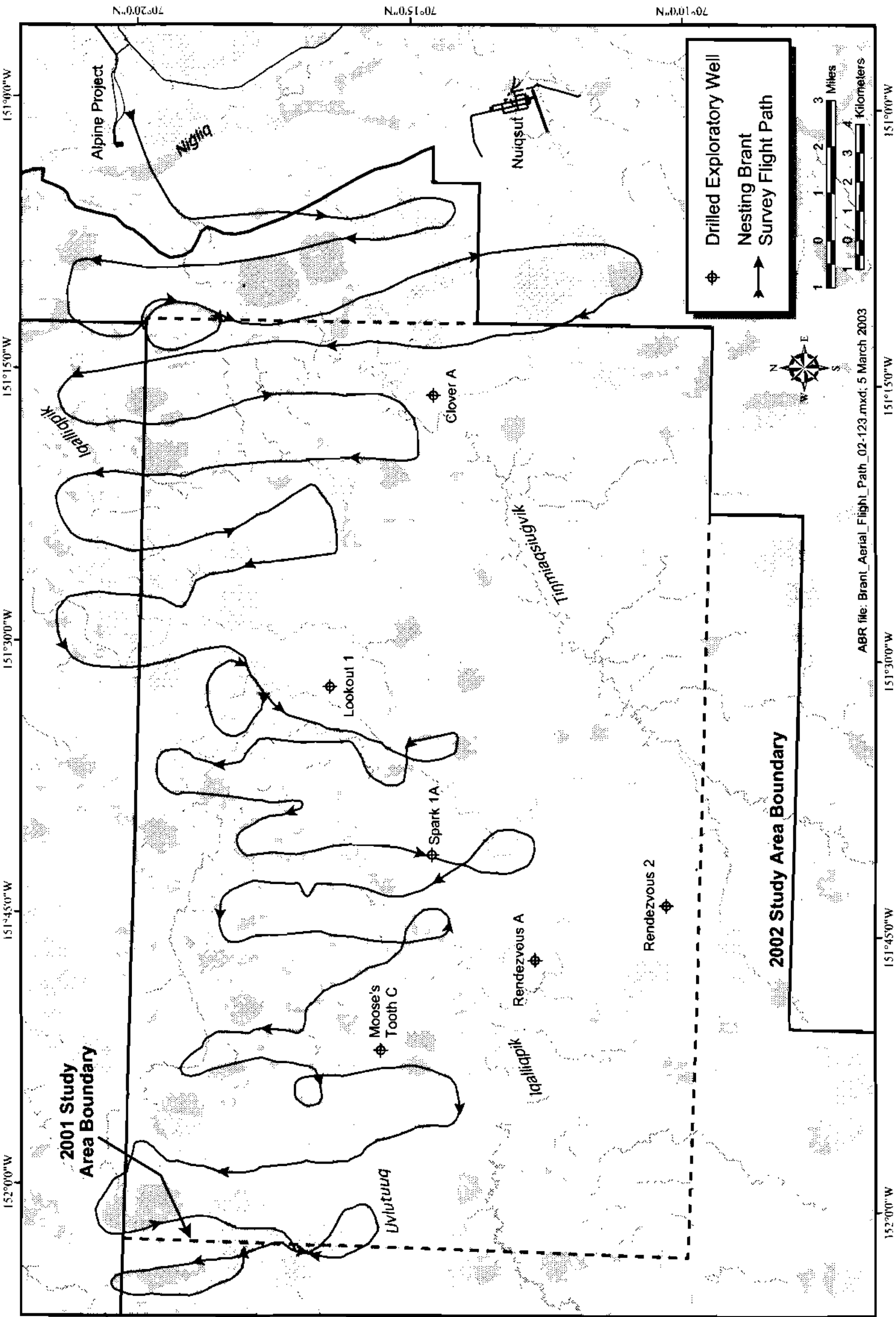

Figure 8. Flight path of the aerial survey for nesting Brant, NPRA Study Area, Alaska, 2002.

although efforts were concentrated in the same general area, largely in the northern half of the 2002 NPRA Study Area. Flight altitude for each survey was 60 m agl and flight speed was approximately 95 km/h, although in 2002, speeds were decreased to 70 km/h over lakes. The survey was conducted on 18 June 2002. In 2002, nests (down-filled bowls or adults in incubation posture) were recorded on 1:63,360-scale USGS maps or on color aerial photos, for areas covered by photos. The resulting counts of Brant and their nests should be considered minimums because incubating Brant are inconspicuous, unattended nests are difficult to see, and the number of passes flown over a nesting location was limited purposely to minimize disturbance. All observations of birds on the ground were recorded, because these may represent nesting locations. However, only confirmed nests were included in summaries. Nests of other species, such as eiders, Canada Geese, and swans, were recorded incidentally during the survey.

Systematic aerial surveys were conducted for all species of geese during the brood-rearing and fall-staging seasons. These surveys were flown in a Cessna 185 aircraft at 90 m agl on east-west flight lines that were 1.6 km apart, the same transects flown for the Tundra Swan surveys (Figure 7). The survey area for brood-rearing and staging geese was larger in 2002 than it was in 2001 (Figure 7). Two observers searched a 400-m-wide strip, one on each side of the plane, yielding 50% coverage of the survey area. The brood-rearing survey was conducted on 20 July 2002 and the fall-staging survey on 24–25 August 2002. During these surveys, species, numbers of adults and young, and their locations were recorded on 1:63,360-scale USGS maps. All observations were digitized and added to a GIS database.

GULL SURVEYS

In 2002, Glaucous Gulls nests were recorded during nesting aerial surveys for Yellow-billed Loons, Tundra Swans, and Brant in the NPRA Study Area (see species sections for survey methods). In 2001, Glaucous Gulls nests were recorded only during the nesting aerial surveys for Yellow-billed Loons. Glaucous Gull broods were recorded opportunistically in both years during brood-rearing surveys for Yellow-billed Loons. All Glaucous Gull nests and broods were recorded on 1:63,360-scale USGS maps. Colonies of Sabine's Gulls also were recorded on 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 in aerial surveys).

Additional information on the abundance of gulls was obtained from results of the various ground-searches. Nest locations of Glaucous and Sabine's gulls were recorded on aerial photos and/or the coordinates stored in GPS units during ground searches in large waterbird and lake study ground-search areas in 2002 and in shorebird plots, red-throated loon plots, and large waterbird ground-search areas in 2001.

CARIBOU SURVEYS

Fourteen aerial surveys were conducted in 2002, beginning on 3 May and ending on 25 October (Table 2). The 1,310-km^2 (506-mi^2) caribou survey area was larger than the 2002 NPRA Study Area (as defined above for avian studies) and encompassed all of that area excluding only the northernmost extension along the Niĝliq Channel of the Colville River, which was covered on Colville River Delta surveys by Lawhead and Prichard (2003). Surveys followed 14 north–south-oriented transect lines that were 26–34 km (16–21 mi) long, in a survey area located between 70.041° and 70.343° N latitude and 151.157° and 152.255° W longitude. The 2002 survey area was larger than was surveyed in 2001 (Appendix H).

All surveys were conducted with 2 observers viewing from opposite sides of a Cessna 206 airplane. During each survey, the pilot navigated along the transect lines using endpoint coordinates programmed into a Global Positioning System (GPS) receiver. The pilot maintained an altitude of 150 m (500 ft) 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, thus sampling ~50% of the survey area. The strip width was delimited visually using tape markers on the struts and windows of the aircraft, as recommended by Pennycuick and Western (1972).

When a caribou group was observed within the transect strip, the location on the transect centerline was recorded using a GPS receiver, the numbers of adults (including yearlings) and calves were recorded, and the distance from the inner edge of the strip was estimated in 200-m intervals. For plotting on maps, the group location was shifted perpendicularly off the transect centerline to the midpoint of the appropriate distance interval (e.g., 300 m for the 200–400 m interval). Thus, the estimated maximum mapping adjustment was ~100 m.

FOX SURVEYS

We used aerial and ground-based surveys to evaluate the distribution and status of arctic and red fox dens in the NPRA Study Area in 2001 and 2002, applying the same methods used in the annual monitoring effort begun in 1992 for the Alpine wildlife studies on the Colville River Delta (Johnson et al. 2003a). Aerial survey by helicopter was the principal method used to search for den sites at the beginning of July 2001, concentrating on tundra habitats away from the major streams. Aerial searches were supplemented with reports of dens from avian nest searches conducted in June of both years. Most of the study area was searched in 2001, except for the northernmost portion and the riverine dunes and banks of Uvlutuuq and Iqalliqpik. Additional search effort was expended in the latter area in July 2002. Continuing survey effort will be required to search those drainages fully due to the abundance of ground squirrel burrow complexes (which interfere significantly with survey efficiency).

We conducted an aerial search for dens and evaluated their status on helicopter-supported ground visits during 1–2 July and 12 July 2001 and 30 June–2 July and 9 July 2002, and then returned to active dens during 12–16 July 2001 and 10–12 July 2002 to count pups (Table 2). 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. 1983a). 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. Thus, late June–early July is a good time to locate den sites from the air.

During ground visits, we evaluated evidence of use by foxes and confirmed the species using the den. Following Garrott (1980), we examined the following fox sign 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 are considered here 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 (determination made 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 with confidence. We invested a fair amount of effort to confirm den occupancy and to count pups. Based on the initial assessment of den activity on 30 June–2 July 2002, our observations during 10–12 July were devoted to counting pups at as many active dens as possible. Observers were dropped off by helicopter at suitable vantage points several hundred meters from den sites, from which they conducted observations with binoculars and spotting scopes over periods of 2.5–4 hr. Observations usually were conducted early and late in the day, when foxes tend to be more active.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

At the time of this writing, the habitat map had been completed for 63% of the 2002 Study Area (Figure 2, Table 3). The habitat map identified 27 habitats in the study area. Wildlife habitats are described in Appendix C. The 2 most abundant habitats in the mapped area were Moist Tussock Tundra (27%) and Moist Sedge-Shrub Meadow (23%). Patterned Wet Meadow composed 11% of the mapped area and no other habitat composed more than 9%. Deep Open Water with Islands and Without Islands, were the sixth and fifth most abundant habitats in the area, respectively. Twelve habitats occurred in only trace amounts (≤1% of the total mapped area). Many of the rare habitats were associated with coastal marine-affected areas or riparian areas, which were relatively uncommon in the NPRA Study Area.

CONDITIONS IN THE STUDY AREA IN 2002

The 2002 breeding season differed from the preceding 2 years in that snowmelt was much earlier and temperatures in May were much warmer. No weather data are collected within the NPRA Study Area, but conditions 55 km to the east in the Kuparuk Oilfield, where weather data have been collected since 1983, are comparable. The mean temperature in May was –2.2° C, which was warmer than the 20-yr mean of –5.6° C, and considerably warmer than the mean May temperature in either 2000 (-9.3° C) or 2001 (-10.8° C). The tundra around the Kuparuk airport (the recording station) was essentially snow-free by 12 May in 2002, which was much earlier than in the late springs of 2000 (11 June) and 2001 (3 June). For the period of bird arrival (approximately 15–31 May) and nest initiation (1–15 June), 91 thawing degree-days accumulated in 2002, compared to 37 and 54 thawing degree-days in 2000 and 2001, respectively (Figure 9). (Cumulative thawing degree-days are calculated by summing the number of degrees that the daily mean temperature was above freezing [0° C] for each day during a particular period.) The total number of thawing degree-days in both early and late spring periods combined in 2002 was the third highest recorded in the Kuparuk Oilfield since avian studies were initiated there in 1988 (Anderson et al. 2002, 2003). The warmer temperatures and lack of snow in 2002 meant that birds encountered favorable conditions at the time they were initiating nests.

WILDLIFE SURVEYS AND HABITAT ANALYSES

LARGE WATERBIRD GROUND-SEARCH AREAS

Alpine West

The Alpine West ground-search area (4.82 km²) was located in the northeast corner of the NPRA Study Area. The most common of the 10 habitat types (Table 4) in Alpine West were Patterned Wet Meadow (32.1%) followed by Moist Tussock Tundra (17.7%), Moist Sedge-Shrub Meadow (16.2%), and Old Basin Wetland Complex (16.2%). No other habitat comprised more than 8% of the total mapped area. Aquatic habitats together covered 16.0% of mapped portions of the Alpine West ground-search area.

Eighty-seven nests of 15 species were located in the Alpine West ground-search area in 2002 (Table 5). Two-thirds of these nests belonged to geese, including Greater White Front Geese (35 nests), Canada Geese (16 nests), Brant (8 nests) and unidentified goose (1 nest). The Alpine West ground-search area had the greatest concentration of nesting Canada Geese so far encountered in the NPRA (Burgess et al. 2002; Johnson and Stickney 2001; Murphy and Stickney 2000). After the geese species, Pacific Loons (6 nests) were the most abundant nesters. All other species had <5 nests in the study area. Half the nests in the Alpine West study plot were located on one large lake complex that contained numerous islands and peninsulas (Figure 10)

Nest density for all species was 18.1 nests/km² in the Alpine West ground-search area in 2002 (Table 5). The density of large water bird nests was 17.4 nests/km². The density of nests in the Alpine West ground-search area was higher than that reported in 2001 for wetland basins

Table 3. Availability of wildlife habitat types in the NPRA Study Area, Alaska, 2002.

Habitat	Area (km^2)	Availability (%)
Open Nearshore Water	3.40	0.5
Brackish Water (Tidal Ponds)	1.34	0.2
Tapped Lake with Low-water Connection	1.70	0.2
Tapped Lake with High-water Connection	0.07	<0.1
Salt Marsh	3.65	0.5
Tidal Flat	8.18	1.2
Salt-killed Tundra	0.14	<0.1
Deep Open Water without Islands	49.95	7.2
Deep Open Water with Islands or Polygonized Margins	36.22	5.2
Shallow Open Water without Islands	7.03	1.0
Shallow Open Water with Islands or Polygonized Margins	11.43	1.6
River or Stream	6.17	0.9
Aquatic Sedge Marsh	11.55	1.7
Aquatic Sedge with Deep Polygons	0.30	<0.1
Aquatic Grass Marsh	1.97	0.3
Young Basin Wetland Complex (Ice-poor)	2.52	0.4
Old Basin Wetland Complex (Ice-rich)	61.18	8.8
Riverine Complex	2.78	0.4
Dune Complex	7.59	1.1
Nonpatterned Wet Meadow	21.47	3.1
Patterned Wet Meadow	78.86	11.3
Moist Sedge–Shrub Meadow	161.55	23.2
Moist Tussock Tundra	190.61	27.4
Riverine Low and Tall Shrub	7.26	1.0
Upland and Riverine Dwarf Shrub	8.97	1.3
Upland Low and Tall Shrub	2.80	0.4
Barrens (Riverine, Eolian, or Lacustrine)	6.84	1.0
SUBTOTAL (Total mapped area)	695.52	100
Unknown (Unmapped areas)	404.68	36.8
TOTAL	1100.20	100

ground-search areas in the NPRA (range 8.4–16.8 nests/km², Burgess et al. 2002). Nest density in the Alpine West ground-search area also was higher than that reported in the Alpine or CD South ground-search areas on the Colville River Delta (Alpine: range 4.0–11.6 nests/km², years 1996-2001, ABR, unpubl. data); CD-South: range 7.9–14.0 nests/km², years 2000-2003, Burgess et al. 2003). In fact, the density of nests in the Alpine West area was closer to the range of nest densities in the CD North ground-search area on the outer Colville River Delta, where nest densities of many birds peak in the region (range 16.7–20.1 nests/km²; years 2000-2002; Johnson et al. 2003b).

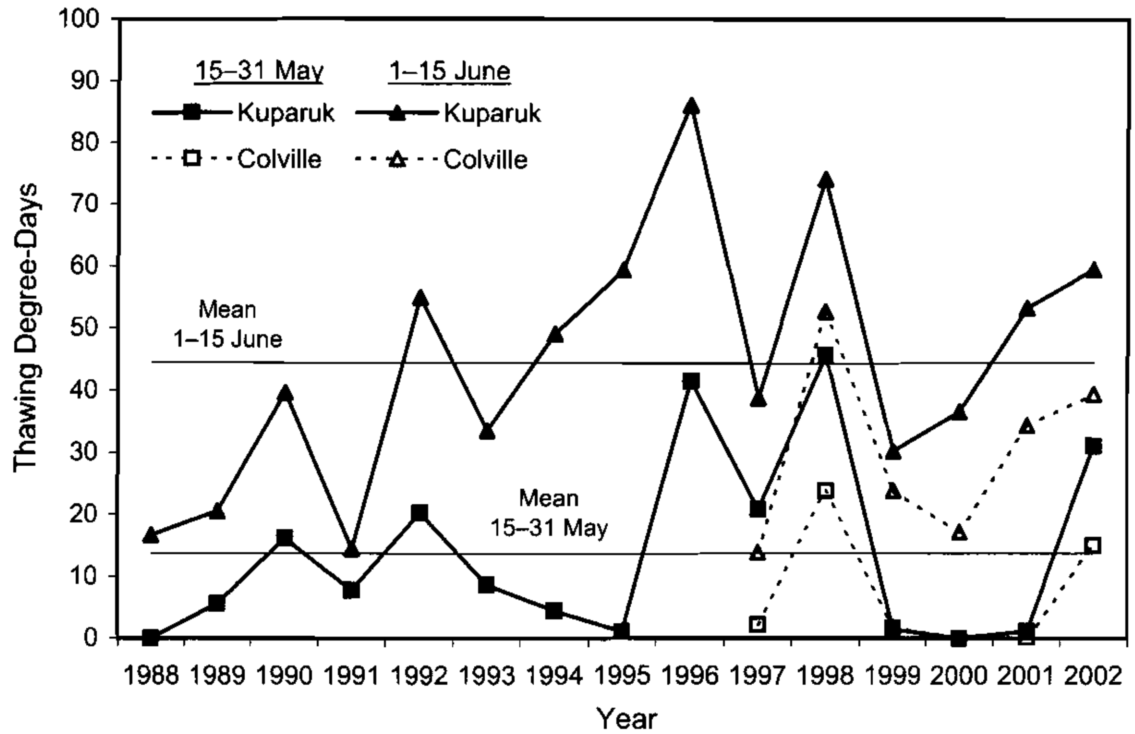

Figure 9. Cumulative number of thawing degree-days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield (1988–2002) and Colville River Delta (1997–2002), Alaska. Mean values computed from Kuparuk data (n = 15 years).

Based on observations of broods, the Red-throated Loon nest and 1 of 6 Pacific Loon nests in the Alpine West ground-search area were successful (Table 6). For waterfowl, nesting success was determined from remains at nests. For geese, nesting success ranged from 80% for Greater White-fronted Geese (n = 35) and 69% for Canada Geese (n = 16) to only 13% for Brant (n = 8). Of 8 duck nests in the Alpine West area, 7 failed; only one King Eider nest was successful.

Two species of loons (Red-throated Loon and Pacific Loon) nested in the Alpine West ground search area. Based on the single nest, the density of Red-throated Loon nests was 0.21 nest/km². No Red-throated Loon nests were found in the other 3 NPRA ground-search areas in 2002. The Red-throated Loon nest was successful and it was located in Old Basin Wetland Complex habitat (Table 7).

The density of Pacific Loon nests in the Alpine West ground-search area in 2002 was quite high by comparison with other ground-search data from the region. The density of Pacific Loon nests in the Alpine West ground-search area (1.24 nest/km²) was the highest among the four 2002 ground-search areas. Nest density of Pacific Loons in the Alpine West area also was higher than was reported in the NPRA in 2001 on Red-throated Loon plots (mean = 0.37 nests/km², n = 16; Burgess et al. 2002) or in the wetland basin ground-search areas (0.81 nests/km², Burgess et al. 2002). Mean nest densities for Pacific Loons on Colville River ground search areas ranged from 0.35 to 0.77 nests/km² (CD North 3-year mean = 0.77 nests/km², Johnson et al. 2003b; Alpine 6-year mean = 0.47 nest/km², Johnson et al. 2003a; CD-South 3-year mean = 0.35, Burgess et al. 2003). The 6 Pacific Loon nests were located in 5 habitat types (Table 7): Deep Open Water without Islands (1 nest), Deep Open Water with Islands or Polygonized Margins (1 nest), Shallow Open Water with Islands or Polygonized Margins (2 nests), Nonpatterned Wet Meadow (1 nest), and Old Basin Wetland Complex (1 nest). The distribution of loon nests and broods across the

Table 4. Habitat availability in 4 ground-search areas in the NPRA Study Area, Alaska, 2002.

	Alpine West		Clover		Lookout		Spark	
Habitat	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Deep Open Water without Islands	0.01	0.3	0	0	0.17	3.2	0.84	15.5
Deep Open Water with Islands or Polygonized Margins	0.28	5.8	0	0	0	0	0.31	5.8
Shallow Open Water without Islands	0.01	0.2	0	0	0.01	0.2	0.06	1.0
Shallow Open Water with Islands or Polygonized Margins	0.39	8.2	0	0	0.06	1.2	0.25	4.6
River or Stream	0	0	0	0	0	0	0.01	0.1
Aquatic Sedge Marsh	0.08	1.6	0	0	0.05	0.9	0.86	15.8
Aquatic Grass Marsh	0	0	0	0	0	0.0	0.05	0.9
Young Basin Wetland Complex	0	0	0	0	0	0	0.09	1.6
Old Basin Wetland Complex	0.78	16.2	0	0	0.24	4.5	0.32	5.9
Riverine Complex	0	0	0	0	0.20	3.8	0	0
Nonpatterned Wet Meadow	0.08	1.7	0.00	0.8	0.01	0.1	1.05	19.3
Patterned Wet Meadow	1.55	32.1	0.02	7.3	0.35	6.6	0.14	2.6
Moist Sedge-Shrub Meadow	0.78	16.2	0.13	52.6	1.23	23.5	1.13	20.9
Moist Tussock Tundra	0.86	17.8	0.10	39.3	2.91	55.7	0.30	5.5
Upland and Riverine Dwarf Shrub	0	0	0	0	0.02	0.3	0.02	0.4
TOTAL	4.82	100	0.25	100	5.23	100	5.42	100

Table 5. Number and density of nests (nests/km²) in 3 ground-search areas in the NPRA Study Area, Alaska, 2002. No nests were found in the Clover ground-search area.

Species	Alpine West		Lookout		Spark	
	Number of nests	Density	Number of nests	Density	Number of nests	Density
Red-throated Loon	1	0.21	0	0	0	0
Pacific Loon	6	1.24	0	0	5	0.92
Yellow-billed Loon	0	0	0	0	1	0.18
Greater White-fronted Goose	35[a]	7.26	8	1.53	5	0.92
Canada Goose	16[b]	3.32	1	0.19	0	0
Brant	8	1.66	0	0	0	0
Unidentified goose	1	0.21	0	0	0	0
Tundra Swan	1	0.21	0	0	0	0
Northern Shoveler	1	0.21	0	0	0	0
Northern Pintail	2	0.41	2	0.38	7[c]	1.29
Spectacled Eider	1[a]	0.21	0	0	0	0
King Eider	2[a]	0.41	0	0	4	0.74
Long-tailed Duck	2[a]	0.41	3[a]	0.57	3[c]	0.55
Unidentified duck	0	0	1	0.19	0	0
Willow Ptarmigan	3	0.62	6	1.15	0	0
Unidentified ptarmigan	0	0	0	0	1	0.18
Parasitic Jaeger	0	0	0	0	1	0.18
Long-tailed Jaeger	1	0.21	0	0	0	0
Glaucous Gull	4	0.83	0	0	1	0.18
Sabine's Gull	0	0	0	0	3	0.55
Arctic Tern	3	0.62	0	0	2	0.37
Area searched (km²)	4.82		5.23		5.42	
Waterbird[d] nest density	17.4		2.9		5.9	
Total nest density	18.1		4.0		6.1	
Total number of nests	87		21		33	
Number of species	15		5		11	

[a] Includes 1 nest identified to species by feather and down sample.
[b] Includes 2 nests identified to species by feather and down sample.
[c] Includes 3 nests identified to species by feather and down sample.
[d] Waterbirds include: loons, grebes, swans, ducks, cranes, jaegers, gulls, terns, and larger shorebirds.

NPRA Study Area is discussed in greater detail in *Loon Surveys*, below.

Three of the 4 species of geese that commonly breed on the Arctic coastal plain (Snow Goose, Brant, Greater White-fronted Goose, Canada Goose) nested in the Alpine West ground-search area. Snow Geese were absent from the NPRA Study Area. The Brant colony in the Alpine West ground-search area was identified during previous investigations and is known to have been used by Brant in the years 1996, 1998, and 2002 (Johnson et al. 1997, 1999; this study). The Alpine West colony comprised 8 nests in 2002 and the overall density of Brant nests in the Alpine West ground-search area was 1.66 nests/km². No Brant nests were found the other 3 ground-search areas in the 2002 NPRA Study Area. The density of nesting Brant in the Alpine West ground-search area falls within range of nest densities for Brant in the CD North ground-search area during the last 3

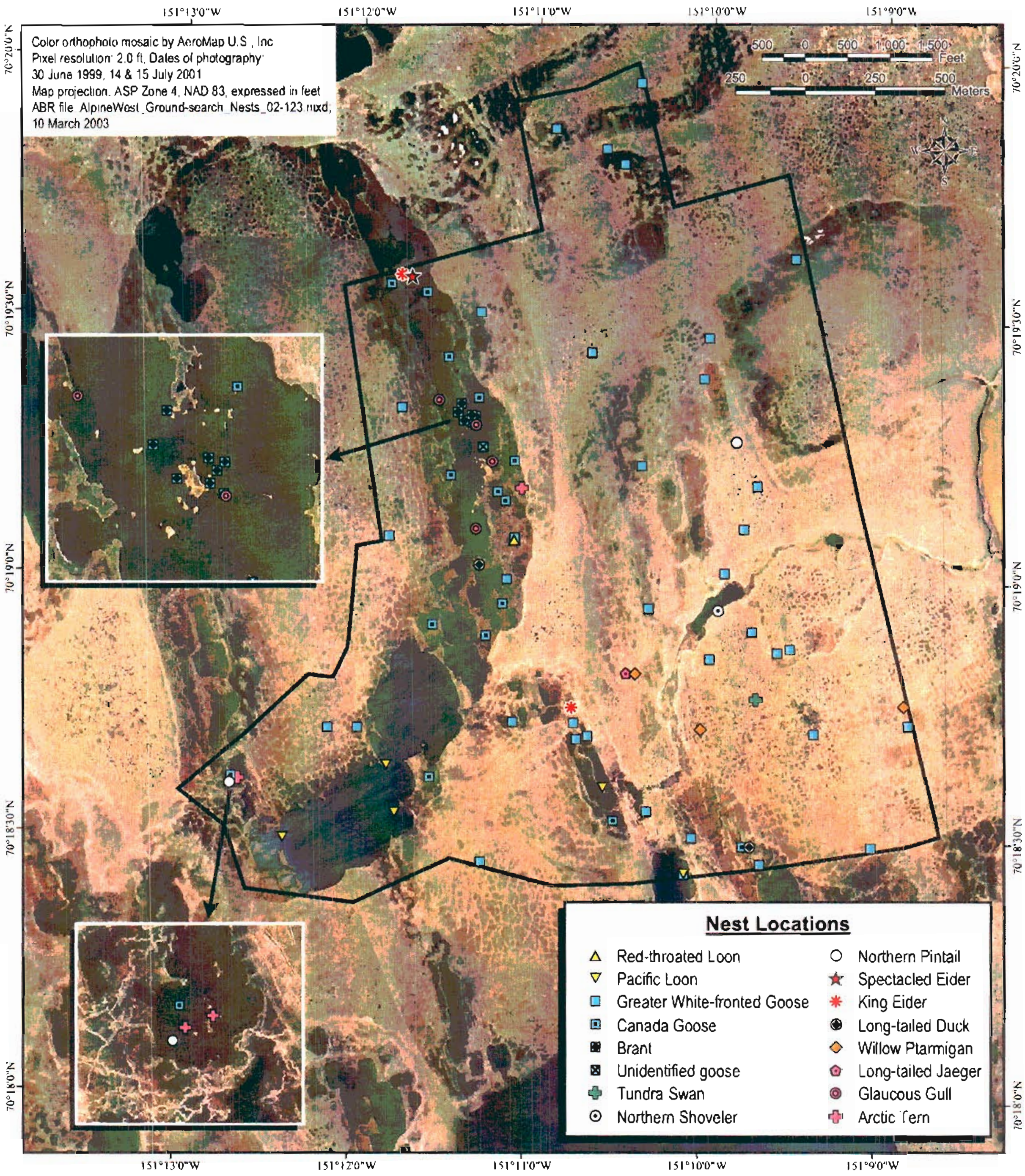

Figure 10. Distribution of waterfowl, loon, and other large waterbird nests in the Alpine West ground-search area, NPRA Study Area, Alaska, 2002.

Table 6. Nest success of birds in 3 ground-search areas in the NPRA Study Area, Alaska, 2002. Nest success is calculated only for waterfowl species, as explained in text

	Alpine West			Lookout			Spark			Nesting Success
Species	Successful	Failed	Unknown	Successful	Failed	Unknown	Successful	Failed	Unknown	(%)
LOONS										
Red-throated Loon	1	0	0	-	-	-	-	-	-	-
Pacific Loon	1	1	4	-	-	-	3	0	2	-
Yellow-billed Loon	-	-	-	-	-	-	1	0	0	-
WATERFOWL										
Greater White-fronted Goose	28	7	0	6	2	0	4	0	1	81
Canada Goose	11	5	0	0	0	1	-	-	-	73
Brant	1	7	0	-	-	-	-	-	-	13
Unidentified goose	0	1	0	-	-	-	-	-	-	0
Total Geese	40	20	0	6	2	1	4	0	1	69
Tundra Swan	1	0	0	-	-	-	-	-	-	100
Northern Shoveler	0	1	0	-	-	-	-	-	-	0
Northern Pintail	0	2	0	0	2	0	0	7	0	0
Spectacled Eider	0	1	0	-	-	-	-	-	-	0
King Eider	1	1	0	-	-	-	2	2	0	50
Long-tailed Duck	0	2	0	0	2	1	0	3	0	0
Unidentified duck	-	-	-	0	1	0	-	-	-	0
Total Ducks	1	7	0	0	5	1	2	12	0	12
OTHER SPECIES										
Willow Ptarmigan	3	0	0	3	1	2	-	-	-	-
Unidentified ptarmigan	-	-	-	-	-	-	1	0	0	-
Parasitic Jaeger	-	-	-	-	-	-	1	0	0	-
Long-tailed Jaeger	0	1	0	-	-	-	-	-	-	-
Glaucous Gull	1	2	1	-	-	-	1	0	0	-
Sabine's Gull	-	-	-	-	-	-	1	0	2	-
Arctic Tern	0	0	3	-	-	-	1	0	1	-
TOTAL NESTS	49	29	9	9	8	4	15	12	6	-

Table 7. Habitat use by nesting waterbirds in the Alpine West ground-search area, NPRA, Alaska, 2002.

Habitat	Red-throated Loon	Pacific Loon	Greater White-fronted Goose	Canada Goose[a]	Brant[a]	Unidentified goose	Tundra Swan	Northern Shoveler	Northern Pintail	Spectacled Eider[a]	King Eider[a]	Long-tailed Duck[a]	Willow Ptarmigan	Long-tailed Jaeger	Glaucous Gull	Arctic Tern	Total Number	Habitat Use (%)
Deep Open Water without Islands		1		1													2	2.3
Deep Open Water with Islands or Polygonized Margins		1		1													2	2.3
Shallow Open Water with Islands or Polygonized Margins		2	1	11	8	1		1	1	1	1	1			4	2	34	39.1
Aquatic Sedge Marsh			1														1	1.1
Old Basin Wetland Complex	1	1	11	3							1	1				1	19	21.8
Nonpatterned Wet Meadow		1															1	1.1
Patterned Wet Meadow			12										1				13	14.9
Moist Sedge-Shrub Meadow			4										2	1			7	8.0
Moist Tussock Tundra			6				1		1								8	9.2
TOTAL	1	6	35	16	8	1	1	1	2	1	2	2	3	1	4	3	87	100.0

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

years (1.22–2.46 nests/km²; Johnson et al. 2003b). Brant nested in one habitat type: Shallow Open Water with Islands or Polygonized Margins (Table 7). The distribution of Brant nests across the NPRA Study Area is discussed in greater detail in *Goose Surveys*, below.

Greater White-fronted Geese were the most abundant large waterbird nesting in the Alpine West ground-search area with a nest density of 7.3 nests/km². Cotter et al. (1998) also reported high densities (8.4 nests/km²) of Greater White-fronted Goose nests in their shorebird ground search plots at Inigok, south of the NPRA Study Area. However much lower densities were reported in the other ground search areas in the NPRA Study Area in 2002 (see below) and 2001 (Burgess et al. 2002). The density of Greater White-fronted Goose nests in the Alpine West ground-search area in 2002 was higher than has been reported in the CD South ground-search area (range 3.4–6.2 nests/km²; years 2000-2002, Burgess et al. 2003) but lower than in CD North (range 9.9–11.3 nests/km², years 2000-2002, Johnson et al. 2003b). Greater White-fronted Goose nests were located in 6 habitat types with the majority of nests in Patterned Wet Meadow (12 nests) and Old Basin Wetland Complex (11 nests). No other habitat had >6 nests (Table 7).

Canada Geese were the second most common nesting bird in the Alpine West ground-search area (3.32 nests/ km²) in 2002. Canada Geese are relatively uncommon in the NPRA and, prior to the 1980s, the Canada Goose was considered a non-breeder in NPRA (Derksen et al. 1981). Nesting Canada geese are common east of the Kuparuk River (Ritchie et al. 1990; ABR, unpubl. data) and in the Prudhoe Bay Area (Troy 1985, Murphy and Anderson 1993). Canada Goose nests were located in 5 habitat types (Table 7) with the majority of nests in Shallow Open Water with Islands or Polygonized Margins (11 nests) and Old Basin Wetland Complex (3 nests). The distribution of Canada Goose nests across the NPRA Study Area is discussed in greater detail in *Goose Surveys*, below.

One Tundra Swan nest was located in the Alpine West ground-search area. This nest hatched successfully and it was located in Moist Tussock Tundra habitat. The distribution of swan nests across the NPRA Study Area is discussed in greater detail in *Swan Surveys*, below.

Two species of eiders and 3 other species of ducks (Northern Shoveler, Northern Pintail, Long-tailed Duck, and one unidentified duck) nested in low densities (≤0.41 nests/km², ≤2 nests per species) in the Alpine West ground-search area. The single Spectacled Eider nest was discovered after the nest failed and it was identified to probable species on the basis of nest contents. The nest was located in Aquatic Sedge Marsh. No other Spectacled Eider nests were located in 2002 ground-search areas in the NPRA. In 2001, ground search efforts focused on Spectacled Eiders and search areas were selected on the basis of Spectacled Eider sightings during aerial surveys, resulting in a higher nest density of Spectacled Eiders (0.49 nests/km², Burgess et al. 2002) than in the Alpine West area in 2002 (0.21 nests/km²). Two King Eider nests were found in the Alpine West ground-search area (0.41 nests/km²), only one of the nests was successful. Nests were located in Shallow Open Water with Islands or Polygonized Margins and Aquatic Sedge Marsh habitat (Table 7). Further discussion of the distribution and abundance of Spectacled and King Eiders is presented under *Eider Surveys*, below.

Seven broods from 6 species were observed in the Alpine West ground-search area during July and August visits (Table 8, Figure 11). Broods of Pacific Loon, Greater White-fronted Goose, Glaucous Gull, Tundra Swan, and Willow Ptarmigan were sighted during the July nest fate survey and one Red-throated Loon brood was identified during August loon brood surveys. Brood-rearing waterbirds used both Deep Open Water habitat types and Old Basin Wetland Complex. Willow Ptarmigan broods used Moist Sedge-shrub Meadow (Table 9).

Clover

The Clover ground search area was located just west of the Clover A exploratory well. The Clover ground-search area lacked waterbodies or other aquatic habitats and was smaller than the other areas (0.25 km²). Only 4 habitats were found in the Clover ground-search area (Table 4): Upland and Riverine Dwarf Shrub (52.6%), Moist Tussock Tundra (39.3%), Patterned Wet Meadow (7.2%), and Nonpatterned Wet Meadow (0.8%).

Table 8. Number of broods observed on 16 and 19 July and 20–21 August in 3 ground-search areas in the NPRA Study Area, Alaska, 2002.

	Alpine West	Lookout	Spark
Red-throated Loon	1	0	0
Pacific Loon	1	0	3
Yellow-billed Loon	0	0	1
Greater White-fronted Goose	1	0	0
Tundra Swan	1	0	1
King Eider	0	0	1
Long-tailed Duck	0	1	1
Unidentified scaup	0	0	1
Willow Ptarmigan	1	0	0
Glaucous Gull	2	0	1
Sabine's Gull	0	0	1
TOTAL	7	1	10

No nests of large waterbirds were found in the 0.25 km² Clover ground-search area (Figure 12). One brood of Willow Ptarmigan was reported incidentally in the Clover ground-search area on 30 June (no location was recorded). No post-hatch visits were made to Clover. The limited size of the area and the lack of waterbodies both contribute to the absence of waterbird nests in Clover ground-search area. Tussock and upland habitats, which are common in the Clover ground-search area (Table 4), generally support fewer breeding large waterbirds than lake basin areas (Cotter and Andres 2000; Cotter et al. 1998).

Lookout

The Lookout ground-search area takes its name from the Lookout exploratory well located near the center of the 5.23 km² ground-search area. With only one large lake and a beaded stream, water bodies and aquatic habitats accounted for only 5.4% of the Lookout ground-search area (Table 4). Eleven habitats occurred and Moist Tussock Tundra (55.7%) and Moist Sedge-Shrub Meadow (23.5%) were the dominant habitat types. No other habitat comprised >7% of the area.

Twenty-one nests of 5 species were found in the Lookout ground-search area in 2002 (Table 5, Figure 13). One-third of these nests belonged to Greater White-fronted Geese (8 nests). Willow Ptarmigan (6 nests) were the second most common nesting species in the Lookout ground-search area. All other species had ≤3 nests. Nest density for all species was 4.02 nests/km² in the Lookout ground-search area in 2002. The density of waterbird nests was 2.87 nests/km². The density of waterbird nests in the Lookout area was lower than that in the Alpine West or Spark ground-search areas in 2002.

Nesting success was relatively low for Greater White-fronted Geese in the Lookout ground-search area (25%, n = 8 nests; Table 6). In contrast, at least 5 of 6 duck nests in the Lookout ground-search area were successful. The fate of one Long-tailed Duck nest was not determined because the nest was still active on 16 July.

Although Greater White-fronted geese were the most abundant nesting species of large waterbird in the Lookout ground-search area, their density (1.53 nests/km²) was low by comparison with the Alpine West ground-search area (7.26 nests/km²) or with ground-search areas in wetland basins in the NPRA Study Area in 2001 (2.11 nests/km²; Burgess et al. 2002). Greater White front goose nests were found in 3 habitat types (Table 10): Moist Tussock Tundra (5 nests),

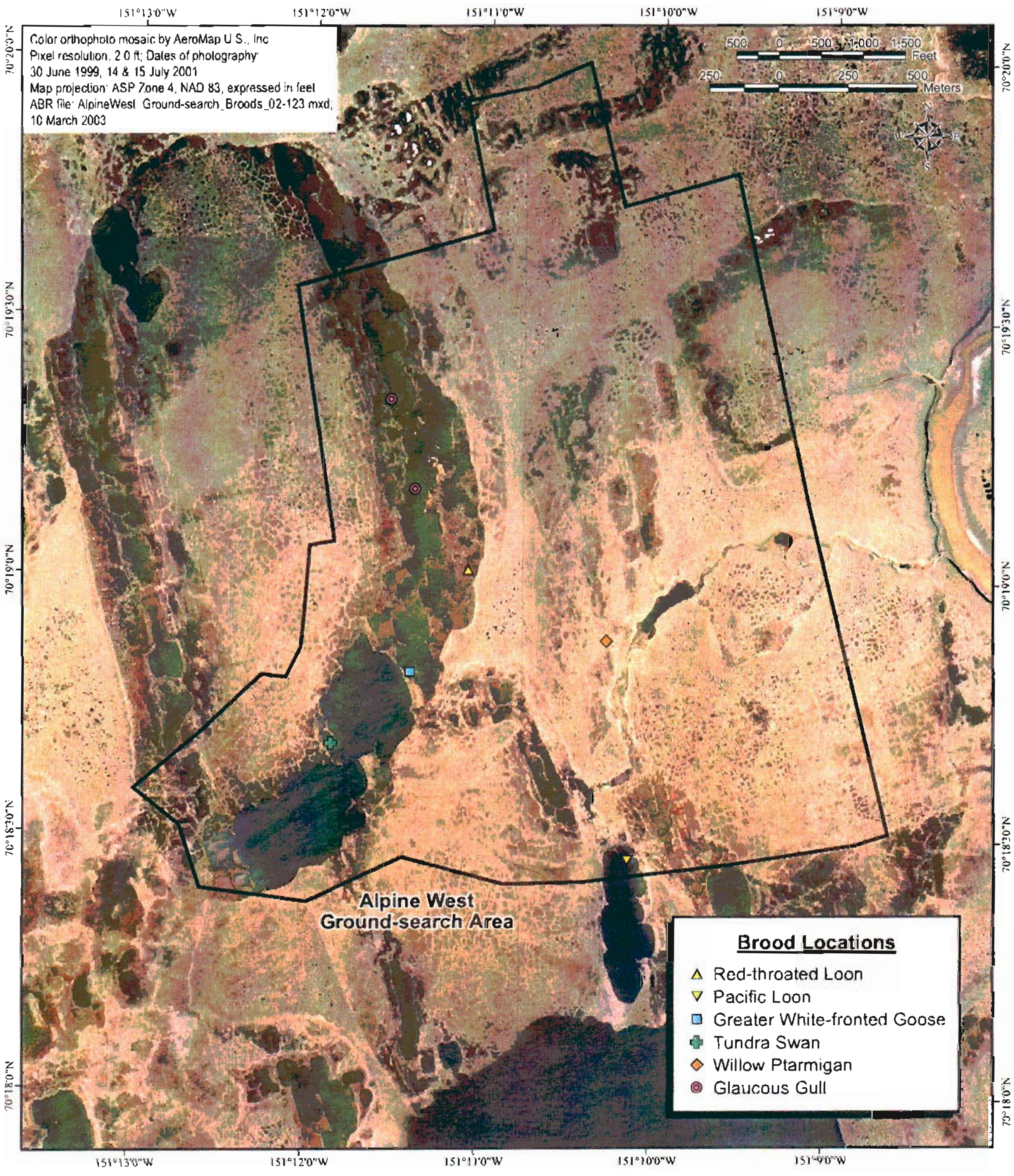

Figure 11. Distribution of broods observed in the Alpine West ground-search area, NPRA Study Area, Alaska, July and August 2002.

Table 9. Habitat use of brood-rearing waterbirds in 3 ground-search areas in the NPRA Study Area, Alaska, 2002.

GROUND SEARCH AREA Habitat	Red-throated Loon	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Tundra Swan	Unidentified scaup	King Eider	Long-tailed Duck	Willow Ptarmigan	Glaucous Gull	Sabine's Gull	TOTAL
ALPINE WEST												
Deep Open Water without Islands		1										1
Deep Open Water with Islands or Polygonized Margins					1							1
Shallow Open Water with Islands or Polygonized Margins				1						2		3
Old Basin Wetland Complex	1											1
Moist Sedge-Shrub Meadow									1			1
LOOKOUT												
Deep Open Water without Islands								1				1
SPARK												
Deep Open Water without Islands			1					1				2
Deep Open Water with Islands or Polygonized Margins					1							1
Shallow Open Water with Islands or Polygonized Margins		2								1		3
Aquatic Sedge Marsh		1				1	1	1			1	5
Aquatic Grass Marsh		1										1
TOTAL	1	5	1	1	2	1	1	3	1	3	1	20

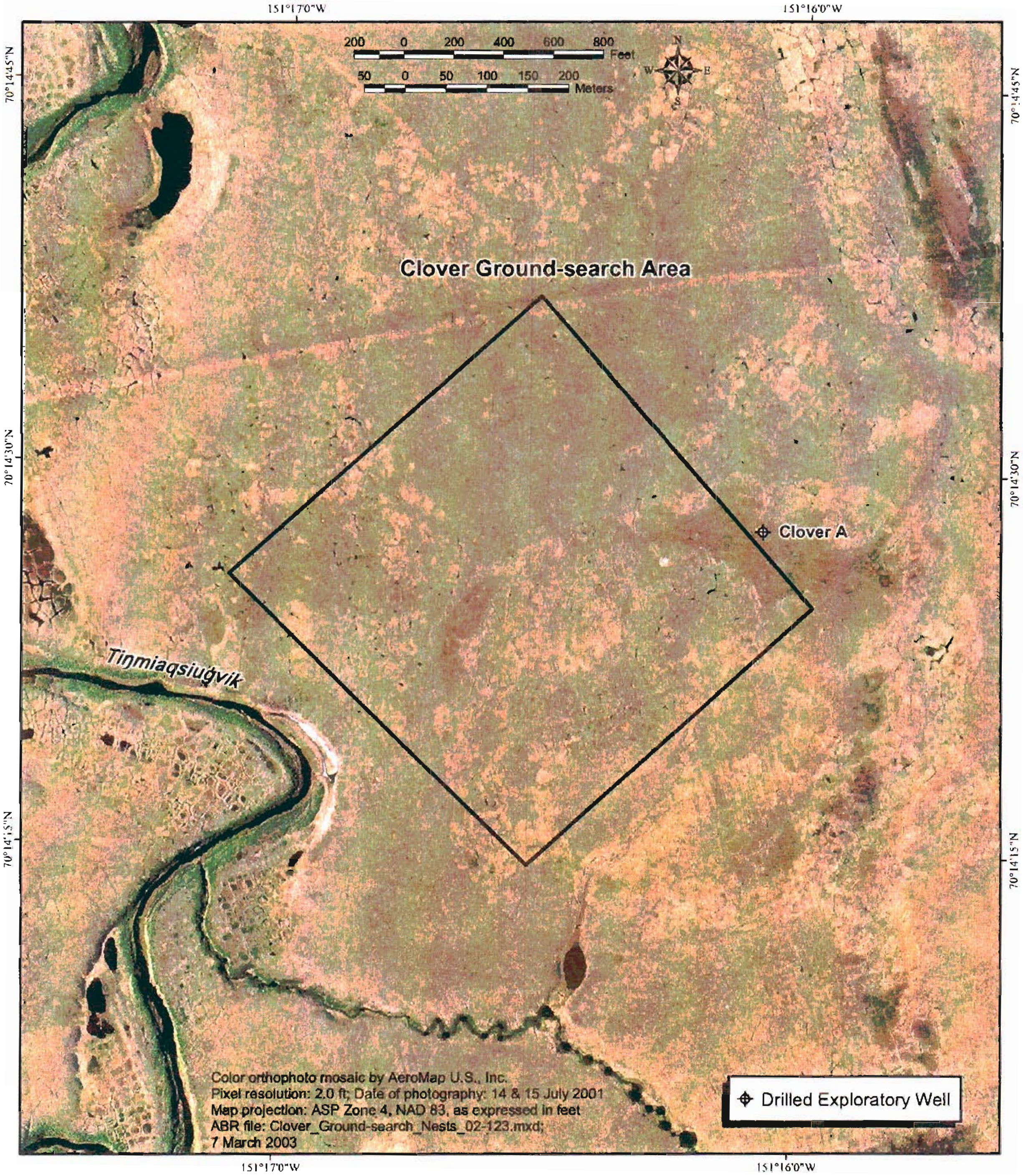

Figure 12. Aerial view of the Clover ground-search area, NPRA Study Area, Alaska, 2002. No waterfowl, loon, or other large waterbird nests or broods were found in the Clover ground-search area.

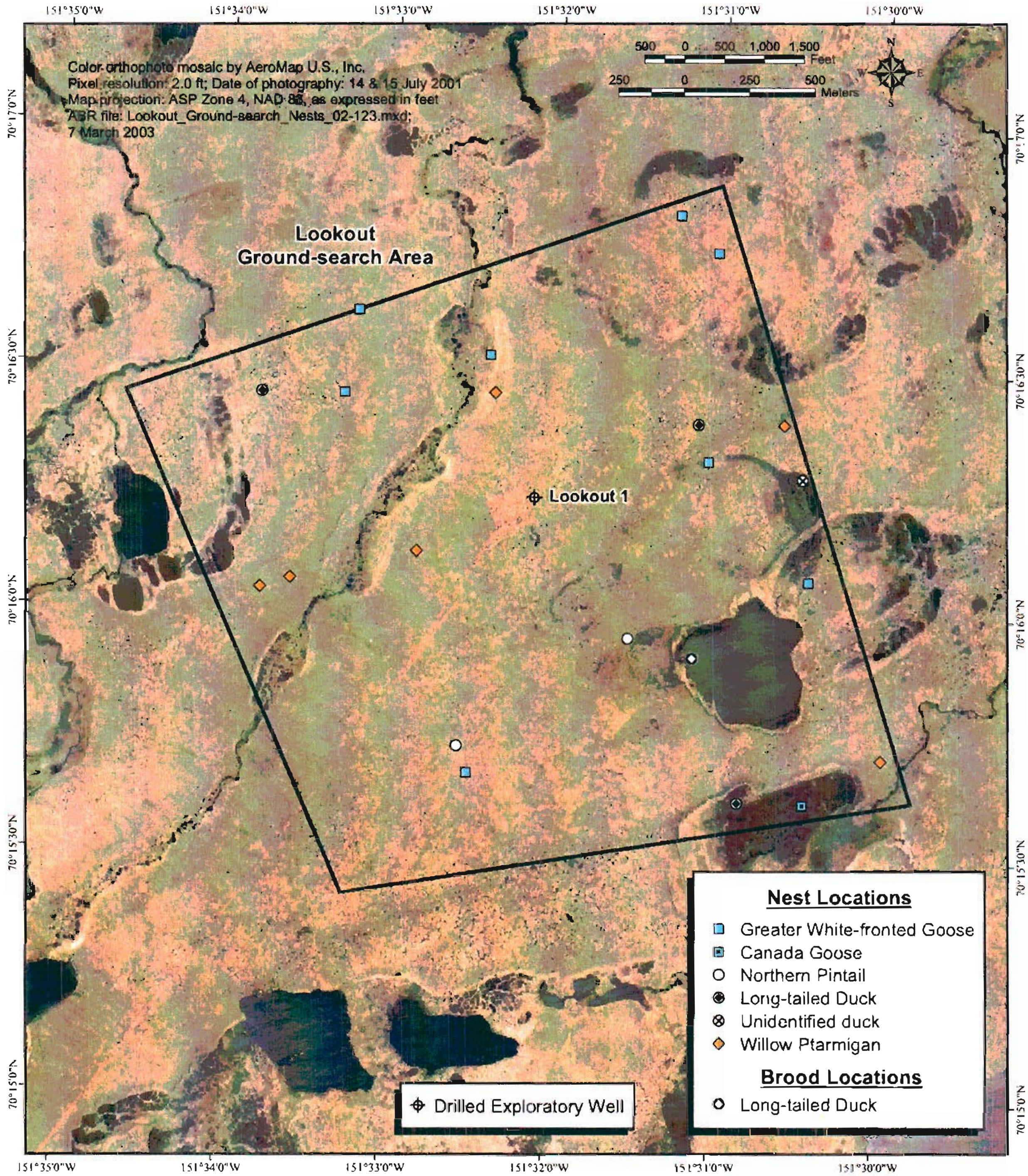

Figure 13 Distribution of waterfowl, loon, and other large waterbird nests and broods in the Lookout ground-search area, NPRA Study Area, Alaska, 2002.

Table 10. Habitat use by nesting waterbirds in the Lookout ground-search area, NPRA, Alaska, 2002.

Habitat	Greater White-fronted Goose	Canada Goose	Northern Pintail	Long-tailed Duck[a]	Unidentified duck	Willow Ptarmigan	Total Number	Use (%)
Shallow Open Water with Islands or Polygonized Margins		1					1	4.8
Aquatic Sedge Marsh				1			1	4.8
Old Basin Wetland Complex					1		1	4.8
Patterned Wet Meadow	2					1	3	14.3
Moist Sedge–Shrub Meadow	1		1			1	3	14.3
Moist Tussock Tundra	5		1	2		4	12	57.1
TOTAL	8	1	2	3	1	6	21	100.0

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

Patterned Wet Meadow (2 nests), and Moist Sedge-Shrub Meadow (1 nest).

Ptarmigan nested at higher densities in the Lookout ground-search area (1.15 nests/km²) than in any other ground-search area in the NPRA in 2001 (Burgess et al. 2002) or 2002. Ptarmigan nest densities in the Lookout ground-search area in 2002 were nearly as high as those in the CD South ground-search area of the Colville River Delta (3-year mean 1.62 nests/km², SD = 1.13 nests/km², range 0.82-2.92 nests/km²; Burgess et al. 2003). Willow Ptarmigan nests were located in 3 habitats with the majority of the nests in Moist Tussock Tundra (Table 10).

One brood of Long-tailed Ducks was observed on the single large lake (habitat type: Deep Open Water without Islands) in the Lookout ground-search area in August (Table 9, Figure 13). However, broods present in other wildlife habitats of Lookout would have been missed, because brood searches were limited to one lake.

Spark

The Spark ground-search area included 5 large waterbodies and numerous ponds. Waterbodies and aquatic habitats comprised 43.7% of the 5.42 km² ground-search area (Table 4). Fourteen habitat types were present and the 4 major habitat types were Moist Sedge-Shrub Meadow (20.74%), Nonpatterned Wet Meadow (19.3%), Aquatic Sedge Marsh (15.8%), and Deep Open Water without Islands (15.5%). No other habitat comprised >6% of the area.

Thirty-three nests of 11 species were found in the Spark ground-search area (Table 5, Figure 14). Northern Pintails were the most abundant nesting species in the Spark ground-search area with 7 nests, followed by Pacific Loon and Greater White-fronted Goose each with 5 nests, and King Eiders with 4 nests. All other species had ≤3 nests. The Spark ground-search area included a relatively high number of loon nests and a low number of Greater White-fronted Goose nests, compared to other ground-search areas in the NPRA or on the Colville River Delta (Burgess et al. 2003, Johnson et al. 2003a, 2003b). The high ratio of loon to White-fronted Goose nests probably reflects the high ratio of aquatic to terrestrial habitat in the Spark ground-search area (Table 4).

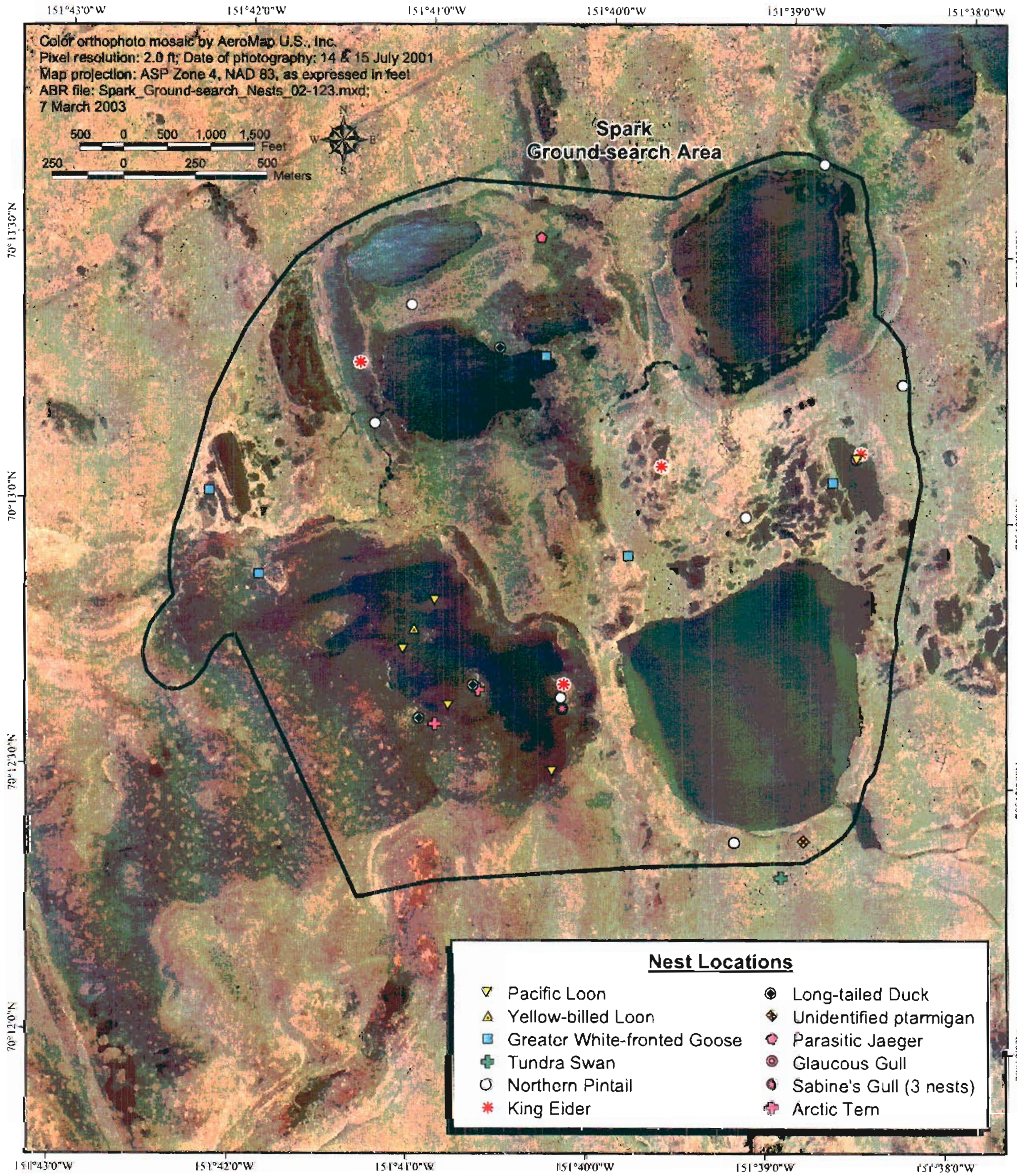

Figure 14. Distribution of waterfowl, loon, and other large waterbird nests in the Spark ground-search area, NPRA Study Area, Alaska, 2002.

Nest density for all species was 6.09 nests/km^2 in the Spark ground-search area in 2002 (Table 5). The density of waterbird nests was 5.90 nests/km^2. The abundance of aquatic habitat in the Spark ground-search area attracted a relatively high number of loons and ducks and relatively low number of nesting Greater White-fronted Geese.

At least 3 of 5 Pacific Loon nests in the Spark ground-search area were successful, 2 were unknown fate (Table 6). The single Yellow-billed Loon nest also was successful. At least 4 of 5 Greater White-fronted Goose nests also were successful (one was unknown fate). In contrast, only 2 of 14 duck nests were successful (both King Eiders).

In the Spark ground-search area, loons nested in 3 habitat types (Table 11). Three Pacific Loon nests and one Yellow-billed Loon nest were located in Aquatic Sedge Marsh. The other 2 habitats used by nesting loons in the Spark area were Shallow Open Water with Islands and Aquatic Grass Marsh (one Pacific Loon nest each). Four of the 5 Pacific Loon nests and the single Yellow-billed Loon nest in the Spark ground-search area were located on the shore of the same waterbody (Figure 14). That waterbody had a complex shoreline, which may have provided more isolated nest sites, and an abundance of aquatic vegetation (or brood cover). Three Pacific Loon broods and one Yellow billed Loon brood were sighted on this same waterbody during July (Figure 15, Table 9). Only 2 Pacific Loon broods were resighted in August.

The density of Greater White-fronted Goose nests in the Spark ground-search area was low (0.92 nests/km^2) compared to other ground-search areas in NPRA in 2002 or 2001 (Burgess et al. 2002). Bird studies in eastern NPRA and Colville River Delta typically report White-fronted Geese as having the highest nest density among the larger waterbirds (Burgess et al. 2002, 2003; Johnson et al. 2003b, Cotter et al. 1998). The relatively low density of White-fronted Goose nests probably reflects the relatively low abundance of drier habitats that are preferred by this species. Greater White-fronted Goose nests were found in 3 habitat types: Old Basin Wetland Complex (2 nests), Nonpatterned Wet Meadow (2 nests), and Moist Sedge-Shrub Meadow (1 nest; Table 11)

Ten broods of 9 species were sighted in July and 6 broods of 5 species were sighted in August (including 3 re-sightings of July broods) in the Spark ground-search area (Table 8, Figure 15). A Tundra Swan brood of 4 young was seen in the Spark ground-search area in July and again in August, although no nests were located in the Spark area. It is likely that this brood was hatched from a Tundra Swan nest that was located adjacent to the southern boundary of the Spark ground search area (Figure 14) in Moist Tussock Tundra habitat. Brood rearing waterbirds used 5 aquatic habitats (Table 9) and the majority of the broods were sighted in Aquatic Sedge Marsh (5 nests).

SHOREBIRD PLOTS

During 5 visits (plot marking and nest searching) to 24 shorebird plots in 2002, we found 197 nests belonging to 21 species of birds (Appendix D). The total number of nests per plot found during these 5 visits in 2002 ranged from 3–15 nests (30–150 nests/km^2) and averaged 8.2 nests per plot (82 nests/km^2). The proportion of all nests in 4 categories of bird species in 2002 was 61% shorebird ($n = 120$ nests), 31% passerine ($n = 61$ nests), 6% waterfowl ($n = 11$ nests), and 2% other birds ($n = 5$ nests; Table 12). The most common breeding birds were Lapland Longspur (55 nests, 28% of all nests), Pectoral Sandpiper (32 nests, 16%), Semipalmated Sandpiper (26 nests, 13%), Red-necked Phalarope (18 nests, 9%), and Long-billed Dowitcher (10 nests, 5%; Appendix D). Lapland Longspur was found nesting on 20 of 24 plots and the number of longspur nests per plot ranged from 0–6 nests (mean = 2 nests/plot). The maximal number of nests found on a plot for the other 4 common species was 6 nests for Semipalmated Sandpiper, 5 nests for Pectoral Sandpiper, 4 nests for Red-necked Phalarope, and 2 nests for Long-billed Dowitcher. During nest monitoring visits, an additional 7 nests were found incidentally: 2 nests of Black-bellied Plover and 1 nest of Northern Pintail, Semipalmated Sandpiper, Pectoral Sandpiper, Red Phalarope, and Lapland Longspur. Inclusion of these nests results in a mean density of 85 nests/km^2.

In 2001, 20 of the same plots and 4 other plots were sampled. Fewer nests were found in 2001 (172 nests) than in 2002, but the number of species was similar between years. The total number of nests per plot in 2001 ranged from 3–12 (30–120 nests/km^2) and averaged 7.2 nests per plot

Table 11. Habitat use by nesting waterbirds in the Spark ground-search area, NPRA, Alaska, 2002.

Habitat	Pacific Loon	Yellow-billed Loon	Greater White-fronted Goose	Northern Pintail[a]	King Eider	Long-tailed Duck[a]	Unidentified ptarmigan	Parasitic Jaeger	Glaucous Gull	Sabine's Gull	Arctic Tern	Total Number	Use (%)
Shallow Open Water with Islands or Polygonized Margins	1								1			2	6.1
River or Stream				1								1	3.0
Aquatic Sedge Marsh	3	1		2	1	2		1		3	2	15	45.5
Aquatic Grass Marsh	1											1	3.0
Old Basin Wetland Complex			2	1	1							4	12.1
Nonpatterned Wet Meadow			2	1	1	1						5	15.2
Moist Sedge–Shrub Meadow			1		1							2	6.1
Moist Tussock Tundra				2			1					3	9.1
TOTAL	5	1	5	7	4	3	1	1	1	3	2	33	100.0

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

(72 nests/km²). The proportion of all nests in the 4 categories of bird species was similar in 2001 (59% shorebird, 31% passerine, 5% waterfowl, and 5% other birds) to 2002 and the 5 most common breeding birds were the same in both years.

The mean density of all nests in shorebird plots in the NPRA Study Area in 2002 (82 nests/km²) was higher than in 2001 (72 nests/km²). Part of this increase is attributable to the higher density of nests on the one new cluster of 4 plots in 2002 by comparison with the cluster of 4 plots that was dropped after 2001 (31 nests on the new 2002 plots versus 23 nests on the old 2001 plots; Appendix E). However, when only plots surveyed in both years are included, mean density still was higher in 2002 (83 nests/km²) than in 2001 (74 nests/km²). These annual densities for the NPRA Study Area were within range of densities reported in other study areas on the Arctic Coastal Plain: Kuparuk Oilfield (76 and 71 nests/km² on 2 plots, $n = 5$ years; Moitoret et al. 1996), the Pt. McIntyre area (64 nests/km², $n = 10$ years; TERA 1993), the Atkasook study area near the Meade River (105 nests/km², $n = 3$ years; Myers et al. 1978c, 1979b, 1980b), the Barrow area (93 nests/km², $n = 5$ years; Myers and Pitelka 1975a, 1975b; Myers et al. 1977a, 1977b, 1978a, 1978b, 1979a, 1979c, 1980a, 1980c), and the Alpine project area on the Colville River Delta (163 nests/km², $n = 4$ years; Johnson et al. 2003a).

Of the 5 clusters of plots that were sampled in the NPRA Study Area in both 2001 and 2002, more nests were found in 2002 on 4 of the 5 clusters (Appendix E). The number of species increased on only 2 of the 5 clusters. Between 1 and 16 more nests were found per cluster in 2002. Most of the difference between years was attributable to an increase in the abundance of shorebirds, except in Plots 1–4, the only cluster that had more nests in 2001 (Table 12). For species groups other than shorebirds, the number of nests per cluster differed little between 2001 and 2002, except for Plots 53–56, which had 5 more passerine nests in 2002 than in 2001.

The number of Pectoral Sandpiper nests increased more than any other shorebird species, from 19 nests (mean = 7.9 nests/km²) in 2001 to 32 nests (mean = 13.3 nests/km²) in 2002. In the NPRA in 1998, a mean density of 30 Pectoral Sandpiper nests/km² were found in drained lake basins (Cotter and Andres 2000). Dramatic variations in annual densities of Pectoral

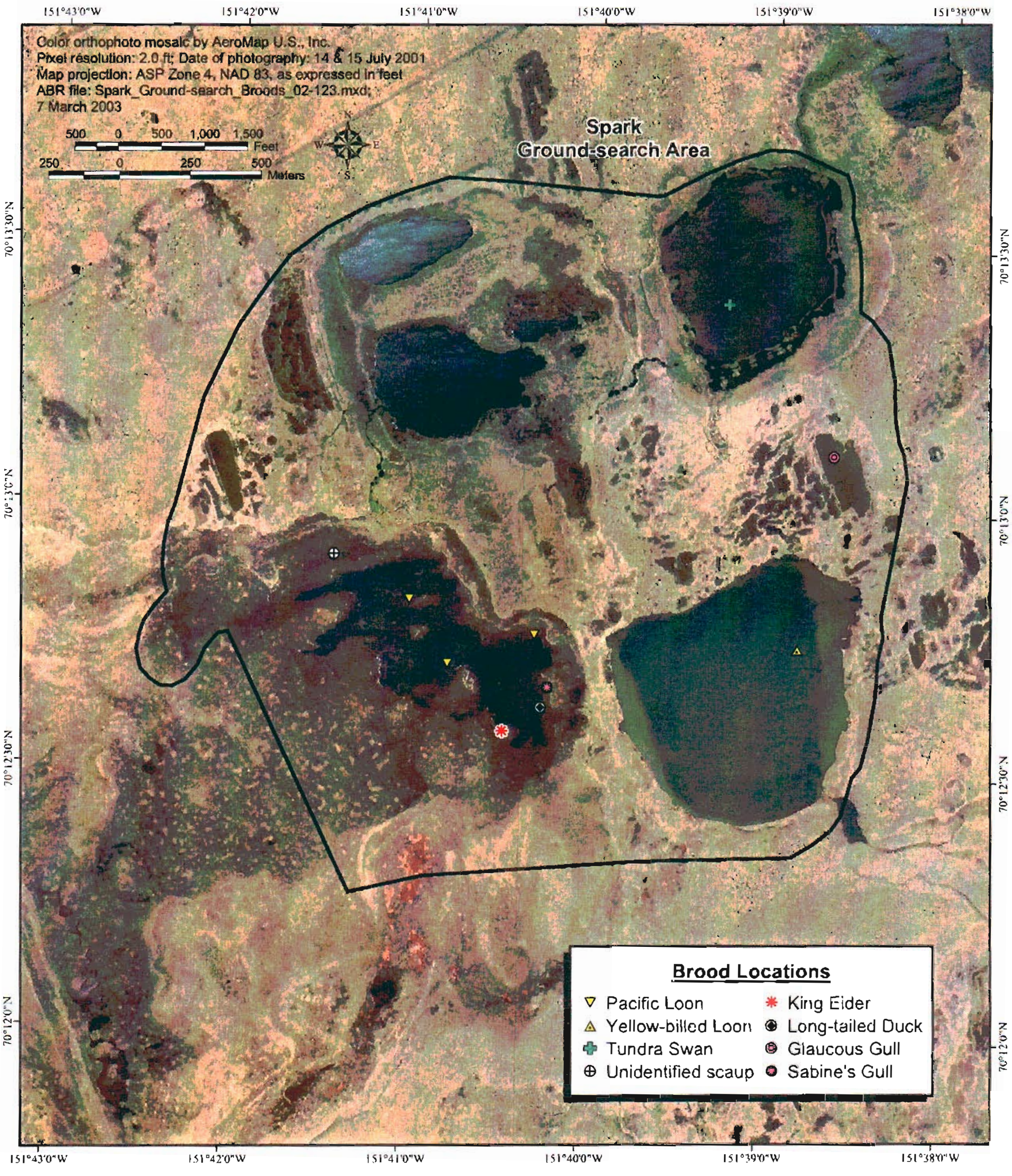

Figure 15. Distribution of broods in the Spark ground-search area, NPRA Study Area, Alaska, July and August 2002.

Table 12. Number and density (number/km²) of nests by species group found on clusters of shorebird plots (4 plots per cluster) during nest-searching visits in the NPRA Study Area, Alaska, 2001–2002.

	Shorebirds				Passerines				Waterfowl				Other Birds[a]			
	2001		2002		2001		2002		2001		2002		2001		2002	
Plots	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density
1–4	13	32.5	5	12.5	13	32.5	14	35.0	1	2.5	0	0.0	2	5.0	0	0.0
25–28	13	32.5	15	37.5	9	22.5	7	17.5	2	5.0	5	12.5	3	7.5	1	2.5
33–36	18	45.0	22	55.0	12	30.0	11	27.5	1	2.5	0	0.0	0	0.0	0	0.0
45–48	17	42.5	30	75.0	6	15.0	6	15.0	0	0.0	1	2.5	0	0.0	2	5.0
53–56	27	67.5	32	80.0	7	17.5	12	30.0	3	7.5	3	7.5	2	5.0	0	0.0
65–68	13	32.5	–	–	7	17.5	–	–	2	5.0	–	–	1.0	2.5	–	–
101–104	–	–	16	40.0	–	–	11	27.5	–	–	2	5.0	–	–	2	5.0
Total Nests	101	42.1	120	50.0	54	22.5	61	25.4	9	3.8	11	4.6	8	3.3	5	2.1
Number of Species	11		11		3		3		3		4		3		3	

[a] Includes loons, ptarmigan, jaegers, gulls, and terns.

Sandpipers have been reported during other studies on the coastal plain. In the Alpine project area, Pectoral Sandpiper densities varied from 20 to 58 nests/km² (mean = 41.0 nests/km², n = 4 years; Johnson et al. 2003a). In the Pt. McIntyre area, Pectoral Sandpiper densities varied from 1 to 33 nests/km² (mean = 8.7 nests/km², n = 10 years; TERA 1993), and in two studies in the Kuparuk Oilfield nesting densities varied over 5 years from 2.9 to 18.4 nests/km² (mean = 7.9 nests/km²) and from 4.0 to 23.5 nests/km² (mean = 12.7 nests/km²) on two different plots (Moitoret et al. 1996).

In both 2001 and 2002, 11 shorebird species nested in the 24 shorebird plots in the NPRA Study Area. Species composition differed by only one species between years: Baird's Sandpiper (1 nest) occurred only in 2001 and Buff-breasted Sandpiper (6 nests) occurred only in 2002. For some shorebird species (Black-bellied Plover, Bar-tailed Godwit, Semipalmated Sandpiper, Dunlin, and Stilt Sandpiper), a similar number of nests was found in 2001 and 2002, while for other shorebird species (American Golden Plover, Pectoral Sandpiper, Buff-breasted Sandpiper, Long-billed Dowitcher, and both phalarope species), the number of nests differed by 3–13 nests between years (Appendix E). The species richness on shorebird plots in the NPRA Study Area was similar to that in other Arctic Coastal Plain studies: 9 species at Inigok (Cotter and Andres 2000); 9 species at Atkasook (Myers et al. 1978c, 1979b, 1980b); 11 species in the Kuparuk Oilfield (Moitoret et al. 1996); 14 species at Pt. McIntrye (TERA 1993); and 11 species in the Alpine project area on the Colville River Delta (Johnson et al. 2003a).

The overall density of shorebird nests in the NPRA Study Area in 2002 (50 nests/km²) was higher than in 2001 (42 nests/km²; Table 12). Mean densities similar to 2001, but less than 2002, were found at Pt. McIntyre (43 nests/km², n = 10 years; TERA 1993) and in the Kuparuk Oilfield (45 and 44 nests/km², n = 5 years; Moitoret et al. 1996). Mean nest densities were lower than in the NPRA Study Area at Inigok (21 nests/km²; Cotter and Andres 2000), but higher at Atkasook (59 nests/km², n = 3 years; Myers et al.1978c, 1979b, 1980b), Barrow (68 nests/km², n = 5 years; Myers and Pitelka 1975a, 1975b; Myers et al. 1977a, 1977b, 1978a, 1978b, 1979a, 1979c, 1980a, 1980c), and in the Alpine project area on the Colville River Delta (98 nests/km², n = 4 years; Johnson et al. 2003a). Much of the difference in density among sites can be attributed to differences in habitats sampled in each study. For example, Cotter and Andres (2000) reported that, among their plots in the NPRA, drained-lake basins or lowland tundra sites had nest densities nearly 8 times greater (80 nests/km²) than the upland tussock/ridge tundra sites (12 nests/km²). The density of shorebirds in the Alpine project area on the Colville River Delta was about twice that in the NPRA Study Area and the Alpine study plots comprised primarily Patterned Wet Meadow, a diverse and productive nesting habitat. In addition, the abundance of wet and aquatic habitats on the Colville River Delta attracts high densities of nesting shorebirds (Johnson et al. 2003a). The Atkasook study site, in the northwest corner of NPRA 1.5 km from the Meade River, also was located in moist lowland tundra (Myers et al 1978c) and the Barrow study area was in wet tundra (Myers and Pitelka 1975a, 1975b). Shorebird nest densities in the NPRA Study Area appear to be in the mid–upper range among values reported for the NPRA (21–59 nests/km²; Cotter and Andres 2000; Myers et al. 1978c, 1979b, 1980c), reflecting the variety of habitats sampled (wet, moist, and dry) by the shorebird plots in this study.

Among the 3 species of passerines nesting in the NPRA shorebird plots in 2002 (Lapland Longspur, Savannah Sparrow, and Common Redpoll), 90% of the nests (55 of 61 nests, 22.9 nests/km²) belonged to Lapland Longspurs (Appendix E). Lapland Longspurs made up a similar proportion of passerine nests found in 2001 (90%, 49 of 54 nests, 20.4 nests/km²). Lapland Longspurs are the most common nesting passerine on the Arctic Coastal Plain (Johnson and Herter 1989), with mean nest densities ranging from 15 nests/km² (n = 10 years, TERA 1993) at Pt. McIntyre to 45 nests/km² in the Alpine project area on the Colville River Delta (n = 4 years, Johnson et al. 2003a). Nest densities of Savannah Sparrow and Common Redpoll in the NPRA shorebird plots were 0.8 and 1.7 nests/km², respectively, in 2002; Appendix E). In 2001, Savannah Sparrow nest densities were higher (1.7 nests/km²) and no Common Redpoll nests were found on plots. One

Yellow Wagtail nest (0.4 nests/km) was found on plot in 2001. In general, the nest density of passerines, other than longspurs, is <2 nests/km² on the Arctic Coastal Plain (TERA 1993; Moitoret et al. 1996; Myers and Pitelka 1975a, 1975b; Myers et al. 1977a, 1977b, 1978a, 1978b, 1979a, 1979c, 1980a, 1980c) except in the Alpine project area, where greater densities have been reported (ABR, unpubl. data.).

Only 4 waterfowl species nested in NPRA shorebird plots in 2002: Greater White-fronted Goose, Northern Pintail, Greater Scaup, and Long-tailed Duck (Appendix D). All species, except for Greater Scaup, also were found in NPRA shorebird plots in 2001 (Appendix E). The shorebird plots were not designed to census low-density waterfowl, so only the most abundant species are likely to appear in plots. Nonetheless, the shorebird plots do provide a reasonable estimate of the overall density of waterfowl species in the areas sampled. The nest density of all waterfowl species in shorebird plots in the NPRA Study Area was 3.8 nests/km² in 2001 and 4.6 nests/km² in 2002 (Table 12). These annual densities for the NPRA Study Area were within range of densities reported in other study areas on the Arctic Coastal Plain: Kuparuk Oilfield (3.7 nests/km², $n = 5$ years, Moitoret et al. 1996), Atkasook (5.3 nests/km², $n = 3$ years; Myers et al.1978c, 1979b, 1980b), Barrow (5.4 nests/km², $n = 5$ years; Myers and Pitelka 1975a, 197b; Myers et al. 1977a, 1977b, 1978a, 1978b, 1979a, 1979c, 1980a, 1980c), Pt. McIntyre (5.7 nests/km², $n = 10$ years, TERA 1993), and the Alpine project area in the Colville River Delta (13.8 nests/km², $n = 4$ years; Johnson et al 2003a).

The most abundant waterfowl species nesting in the NPRA shorebird plots was the Greater White-fronted Goose. The density of Greater White-fronted Goose nests in NPRA Study Area in both years (2.5 nests/km²; Appendix E) was similar to that in the Kuparuk Oilfield (2.1 nests/km², $n = 5$ years; Moitoret et al. 1996) but twice that found at Pt. McIntyre (1.1 nests/km², $n = 10$ years, TERA 1993) and less than the nest density found in the Alpine study area on the Colville River Delta (3.4 nests/km², $n = 6$ years; Johnson et al 2003a).

Other birds occurring on the NPRA shorebird plots in 2002 included Red-throated Loon (1 nest), Willow Ptarmigan (3 nests), and Arctic Tern (1 nest) (Appendix D). Of these species, only Willow Ptarmigan was found nesting on plots in 2001 (6 nests). Additional species found on plots in 2001 included Rock Ptarmigan (1 nest) and Long-tailed Jaeger (1 nest; Appendix E).

All nests found on (204) and off (89) the NPRA shorebird plots in 2002 were checked for nest fate. Of these 293 nests, 213 were determined to be successful, 66 failed, and for 14 nests fate could not be determined. Eggshell evidence found at successful and failed nests during this study (Appendix F) corroborated patterns of evidence found at nests of other shorebird species (Mabee 1997). For calculations of daily survival rate (DSR), the nests of unknown fate and 9 additional nests that had insufficient data (e.g., found on the day of hatch or were found failed) were excluded. Mean DSRs were calculated for each plot cluster for species with ≥4 total nests, and for species groups in each plot cluster and for all plots together.

Point estimates of DSR from the MARK analysis (Table 13) were similar to and often identical to those from using the Mayfield method (Appendix G). The 95% confidence intervals usually were wider with MARK. DSRs during the incubation period were quite variable among shorebirds, passerines, waterfowl, and their respective species in the NPRA Study Area (Table 13). Overall, shorebirds had the highest DSRs, followed by passerines and waterfowl. By raising the DSR to the power of the average incubation period for the species of interest, one can calculate an improved estimate of nest success (% of nests hatched). By the Mark estimates, shorebird nesting success in the NPRA Study Area (assuming an average incubation period of 23 d) was ($0.981^{23} = 64\%$). Among shorebirds, Red-necked Phalaropes had the highest survival rates (all 21 nests hatched), followed by Semipalmated Sandpipers, Long-billed Dowitchers, Pectoral Sandpipers, American Golden-Plovers, and Black-bellied Plovers. The differences in these survival rates were extreme, with 100% nest success for Red-necked Phalaropes and 6% for Black-bellied Plovers. Passerine nest success (composed predominantly of Lapland Longspurs) was moderate overall (66%) and ranged from 100% (in plots 33–36, 45–48, 101–104) to 29% (plots 1–4). Waterfowl nest success was low

Table 13. Daily survival rates (mean ± 1 SE) and 95% confidence intervals calculated using program MARK for nests of shorebirds, waterfowl, and passerines in shorebird plots in the NPRA Study Area, Alaska, 2002. Dashes indicate no data for these species.

	Mean Daily Survival Rate ± SE 95% Confidence Interval Sample Size of Nests						
Species Group/Species	All Plots	Plots 1–4	Plots 21–24	Plots 31–34	Plots 41–44	Plots 51–54	Plots 101–104
Shorebirds[a]	0.981 ± 0.003 0.975 – 0.986 161	0.988 ± 0.009 0.952 – 0.997 12	0.985 ± 0.007 0.964 – 0.994 24	0.986 ± 0.006 0.967 – 0.994 27	0.972 ± 0.007 0.954 – 0.983 38	0.981 ± 0.006 0.966 – 0.990 39	0.984 ± 0.008 0.958 – 0.994 21
American Golden-Plover	0.993 ± 0.007 0.955 – 0.999 10	?	1.000 ± 0.000 1.000 – 1.000 4	?	?	?	?
Black-bellied Plover	0.899 ± 0.031 0.822 – 0.945 12	?	?	?	0.898 ± 0.040 0.790 – 0.954 7	?	?
Long-billed Dowitcher	0.988 ± 0.009 0.952 – 0.997 11	?	?	?	?	?	?
Pectoral Sandpiper	0.979 ± 0.006 0.964 – 0.988 45	0.983 ± 0.016 0.892 – 0.998 5	0.979 ± 0.014 0.921 – 0.995 6	0.986 ± 0.010 0.945 – 0.996 11	?	0.969 ± 0.012 0.936 – 0.985 16	0.986 ± 0.014 0.910 – 0.998 6
Red-necked Phalarope	1.000 ± 0.000 1.000 – 1.000 21	?	1.000 ± 0.000 1.000 – 1.000 4	1.000 ± 0.000 1.000 – 1.000 10	?	?	?
Semipalmated Sandpiper	0.988 ± 0.005 0.973 – 0.995 36	?	1.000 ± 0.000 1.000 – 1.000 4	?	0.987 ± 0.007 0.962 – 0.996 17	0.988 ± 0.012 0.918 – 0.998 6	0.987 ± 0.012 0.917 – 0.998 5

Table 13. (Continued).

Species Group/Species	Mean Daily Survival Rate ± SE 95% Confidence Interval Sample Size of Nests						
	All Plots	Plots 1–4	Plots 21–24	Plots 31–34	Plots 41–44	Plots 51–54	Plots 101–104
Waterfowl[b]	0.931 ± 0.019	?	0.911 ± 0.043	?	?	0.947 ± 0.030	0.946 ± 0.037
	0.882 – 0.960		0.784 – 0.966			0.847 – 0.983	0.807 – 0.986
	17		5			4	4
Passerines[c]	0.966 ± 0.012	0.902 ± 0.067	0.969 ± 0.021	1.000 ± 0.000	1.000 ± 0.000	0.936 ± 0.031	1.000 ± 0.000
	0.933 – 0.983	0.676 – 0.976	0.885 – 0.992	1.000 – 1.000	1.000 – 1.000	0.841 – 0.976	1.000 – 1.000
	37	4	8	4	4	13	4
Passerines[d]	0.986 ± 0.004	0.985 ± 0.010	0.979 ± 0.012	0.991 ± 0.009	0.990 ± 0.009	0.978 ± 0.011	1.000 ± 0.000
	0.975 – 0.992	0.943 – 0.996	0.936 – 0.993	0.937 – 0.999	0.936 – 0.999	0.941 – 0.992	1.000 – 1.000
	83	18	12	13	9	18	13
Lapland Longspur[e]	0.957 ± 0.015	?	0.962 ± 0.026	?	?	0.936 ± 0.031	?
	0.916 – 0.978		0.861 – 0.991			0.841 – 0.976	
	31		6			13	
Lapland Longspur[f]	0.985 ± 0.005	0.985 ± 0.010	0.971 ± 0.016	0. 989 ± 0.010	1.000 ± 0.000	0.978 ± 0.011	1.000 ± 0.000
	0.973 – 0.992	0.943 – 0.996	0.916 – 0.991	0.929 – 0.999	1.000 – 1.000	0.942 – 0.992	1.000 – 1.000
	77	18	10	12	7	18	12
All species[g]	0.976 ± 0.003	0.980 ± 0.010	0.976 ± 0.007	0.985 ± 0.006	0.973 ± 0.007	0.974 ± 0.006	0.972 ± 0.009
	0.969 – 0.981	0.947 – 0.992	0.958 – 0.987	0.967 – 0.993	0.957 – 0.983	0.958 – 0.983	0.948 – 0.986
	224	17	38	33	46	58	32

[a] Also includes Buff-breasted Sandpiper (n = 6), Bar-tailed Godwit (n = 2), Dunlin (n = 5), Red Phalarope (n = 8) and Stilt Sandpiper (n = 5).

[b] Includes Greater Scaup (n = 2), Greater White-fronted Goose (n = 8), Long-tailed Duck (n = 1) and Northern Pintail (n = 6).

[c] Incubation period; also includes Common Redpoll (n = 5) and Savannah Sparrow (n = 1).

[d] Incubation and nestling period; also includes Common Redpoll (n = 5) and Savannah Sparrow (n = 1).

[e] Incubation period.

[f] Incubation and nestling period.

[g] Incubation period; also includes Arctic Tern (n = 2), Red-throated Loon (n = 1) and Willow Ptarmigan (n = 6).

overall (~18%) and ranged from 11% (plots 25–28) to 27% (plots 53–56).

Survival rates of passerine nestlings (throughout incubation and until birds left the nest) were also variable among clusters (again, predominantly Lapland Longspurs; Table 13). Nestling success of Lapland Longspurs was high overall in the NPRA Study Area (89%), ranging from 100% (plots 45–48 and 101–104) to a low of 89% (plots 1–4).

LAKE DRAWDOWN STUDY

As described above, water was removed from drawdown lakes for ice-road construction between early January and late March 2002, well before the nesting season. Engineers estimated that surface levels of the 5 drawdown lakes would fall between 0.3 cm (0.1 in; Lake L9911) and 28 cm (11.2 in; Lake L9912). Actual measurements of surface levels indicated that 4 drawdown lakes dropped from 0.9 to 23 cm (0.4 to 9.2 in) between February and April (pre- and post-drawdown; Baker 2002). Drawdown levels were not recorded for Lake L9817, from which 1.73 million gallons were removed. Over the same period (February and April), changes in water surface elevation were minimal for reference lakes -4 cm to +3 cm (-1.7 in to +1.1 in) (Baker 2002). Water levels peak across the Arctic Coastal Plain in early May to late June, as the winter accumulation of snow melts and drains into lake basins or river systems. By early June, Baker reported that the water surface elevation of both pumped and reference lakes were above the February pre-pumping levels. Water surface elevations declined gradually after the spring recharge through mid-August (Baker 2002) as is typical over the summer as a result of natural drainage, evaporation, and limited gains of water through precipitation. In the natural course of events, shore-nesting species will experience a drop in water level between the time they initiate nesting and the hatching of their young. The incubation period of NPRA waterbird species ranges from 22 to 29 days. Baker (2002) reported declines in water elevation of 2.7 to 10.4 cm (1.1 to 4.1 in) between the 2nd and 28th of June. Winter drawdowns of <5 inches (observed in 3 of the 5 drawdown lakes) are probably within the range of natural variability and likely have little effect on nesting water birds.

Small changes in water level may or may not impact nesting birds and the degree of any impact varies according to the life history pattern of each species. For example, most shore-nesting species select nesting sites that offer protection from mammalian predators (islands and complex shorelines), are near a food source, and/or provide escape cover for young. Of special interest are species that nest within a restricted distance from a shoreline, such as Red-throated Loon, Pacific Loon, Yellow-Billed Loon, Canada Goose, Brant, Glaucous Gull, Red-necked Grebe, and Sabine's Gull. Substantial winter drawdown could affect these birds by causing connection of nesting islands to lakeshores, or increasing the accessibility of islands or shorelines to mammalian predators. Shoreline changes could also affect the availability of emergent vegetation cover or fish or invertebrate food of aquatic or semi-aquatic birds during either nesting or brood-rearing periods.

Unfortunately, statistical comparisons of avian abundance or nesting success were not possible between drawdown and reference lakes. Problems include the small sample size of lakes and the small number of nesting and brood-rearing birds on these lakes; but most importantly, the drawdown and reference lakes were too dissimilar for valid comparison. The mean surface area of drawdown lakes (0.86 km^2) was substantially larger than the mean surface area of the reference lakes (0.35 km^2) (Table 14). However, the investigation did document species composition on drawdown lakes and enable a discussion of potential impacts of water-level changes on aquatic and semi-aquatic birds that were observed there, based on their life histories.

Twenty-eight nests of 9 species were found on the 10 lake study areas (5 drawdown lakes and 5 reference lakes), including 3 Pacific Loon nests presumed from the presence of broods (Table 14). The 10 lakes averaged 2.9 nests/lake or 0.85 nests/km of shoreline and 2.2 broods/lake or 0.69 broods per/km of shoreline. Pacific Loons were the most abundant nesting species (15 nests), accounting for half of the nests found. All other species had ≤2 nests. Two thirds of the total nests belonged to shore-nesting species (Pacific Loon, Yellow-billed Loon, Canada Goose, and Glaucous Gull). Twenty-two broods of 8 species were observed on the 10 lake study areas (Table 15).

Table 14. Number of nests on 10 lake drawdown study areas in the NPRA Study Area, Alaska, 2002.

	Drawdown Lakes					Reference Lakes				
Species	L9817	L9911	M9912	M9922	M9923	L9807	L9823	M0024	M9913	M9914
Pacific Loon	2	1	1	2[a]	2[b]	3	0	0	1	3
Yellow-billed Loon	0	1	0	0	0	0	0	0	0	0
Greater White-fronted Goose	0	0	0	0	0	2	0	0	0	0
Canada Goose	0	0	0	0	0	1	0	0	0	0
Unidentified goose	0	0	0	0	0	1	0	0	0	0
Greater Scaup	0	0	0	0	0	1	0	0	0	0
Unidentified scaup	0	0	0	0	0	1	0	0	0	0
King Eider	0	1[c]	0	0	1	0	0	0	0	0
Long-tailed Duck	0	0	0	0	1	0	0	0	0	0
Red-breasted Merganser	0	1	0	0	0	0	0	0	0	0
Unidentified duck	0	0	0	1	0	0	0	0	0	0
Glaucous Gull	0	0	0	0	0	1	0	0	0	0
Shoreline searched (km)	2.36	6.20	1.67	3.72	4.01	4.82	0.54	2.96	1.22	4.20
Lake surface area (km^2)	0.24	2.19	0.14	0.76	0.93	0.53	0.02	0.56	0.08	0.57
Lake surface area (acres)	58.81	540.67	33.85	188.79	228.57	130.72	4.94	138.63	19.77	141.59
Total number of nests	2	4	1	3	4	11	0	0	1	3
Number of species	1	4	1	2	3	5	0	0	1	1

[a] Includes one nest presumed from the presence of brood.
[b] Includes 2 nests presumed from the presence of broods.
[c] Includes one probable King Eider nest identified by feather and down sample.

Table 15. Number of broods 10 lake drawdown study areas in the NPRA Study Area, July and August, 2002.

Species	Drawdown Lakes					Reference Lakes				
	L9817	L9911	M9912	M9922	M9923	L9807	L9823	M0024	M9913	M9914
Pacific Loon	1	1	0	2	2	2	0	0	0	0
Yellow-billed Loon	0	0	0	0	0	0	0	1	0	0
Greater White-fronted Goose	0	0	0	0	1	0	0	0	0	1
Tundra Swan	0	0	0	0	0	0	0	0	1	0
Unidentified scaup	0	1	0	0	0	1	0	0	0	1
King Eider	0	0	0	1	1	0	0	0	0	0
Long-tailed Duck	0	0	0	1	1	0	0	0	0	2
Glaucous-winged Gull	0	0	0	0	0	0	0	1	0	0
TOTAL BROODS	1	2	0	4	5	3	0	2	1	4

Pacific Loon broods were the most abundant (8 broods), followed by Long-tailed Duck broods (4 broods).

In general, loons nest close to the water's edge and might, therefore, be vulnerable to adverse affects of water surface drawdowns. At Storkersen Point, Bergman and Derksen (1977) reported that the nests of Pacific Loons averaged 9.0 cm above water (SE = 0.8. n = 41) and nests of Red-throated Loons averaged 7.9 cm above water (SE = 0.7, n = 27). In the Northwest Territories, Dickson (1994) reported the mean midsummer measurement of Red-throated Loons nest height above water as 7.4 cm (SD= 3.2 cm, n= 83).

No Red-throated Loons were sighted on any of the 10 study lakes and no nests or broods were found. The study lakes ranged in size from 8 to 219 ha and were larger than the lakes generally used for nesting by Red-throated Loons. In areas where their range overlaps with Pacific Loons, Red-throated Loons select waterbodies <2 ha in size (Dickson 1994). Red–throated Loons are able to nest on smaller ponds than other loons because they require a smaller span of water to become airborne. Because these smaller and shallower waterbodies freeze to the bottom in winter, fish are typically lacking and Red-throated Loons must leave their small nesting ponds to forage in larger lakes or coastal waters to feed themselves and their young (Bergman and Derksen 1977). Because they generally use smaller lakes, winter drawdown of deep open lakes is unlikely to affect Red-throated Loons.

At least one sighting of a Pacific Loon occurred on each of the 10 study lakes, and Pacific Loon nests occurred on 8 lakes, and broods on 5 lakes (Tables 14, 15, and 16). Two reference lakes, L9823 and M0024, did not contain Pacific Loon nests or broods. The 8 NPRA study lakes that Pacific Loons nested on ranged in depth from 1.6 to 2.7 m (Moulton 2001), which is deeper than typical Pacific Loon nesting lakes. For example, Kertell (1996) reported that Pacific Loons did not nest on deep-open lakes in the Prudhoe Bay area. At Storkersen Point, the maximum water depth of wetlands selected by Pacific Loons (n = 22 nests) did not exceed 0.5 m (Bergman and Derksen 1977). Pacific loons feed on both fish and aquatic invertebrates. Pacific Loons often nest on waterbodies lacking fish, and aquatic invertebrates may be particularly important food for young Pacific Loons during the first half of the brood-rearing period (Kertell 1996, Derksen 1977). Older chicks may be fed fish from the nesting lake (Petersen 1989), or from other nearby lakes (Kertell 1996), but few observations of the delivery of fish to broods have been made (Kertell 1996), suggesting that fish are less important for broods than aquatic invertebrates.

Yellow-billed Loons were present in only 2 of 10 study lakes (L9911 and M0024, study lakes are illustrated in Figure 3). These large loons were less common in the NPRA Study Area than Pacific Loons and generally prefer large lakes. A group of 3 Yellow-billed Loons was sighted on Lake L9911 and a nest was located on a small pond adjacent to the lake (see Figure 18). While this nest was not successful in 2002, a brood was observed on Lake L9911 in the previous year (Figure 10 in Burgess et al. 2002). Observations from aerial surveys suggest that the Yellow-billed Loon brood found on Lake M0024 originated from the nest located west of Lake M0024, in the Spark ground-search area (Figure 11). Adult Yellow-billed Loons provide their young with fish obtained from their brood lakes (Sjölander and Agren 1976) or from nearby lakes (Sage 1971). Moulton (2001) sampled lakes in NPRA with gill nets in 1999-2001 and reported finding fish in only one of the 10 lakes in the drawdown study, reference Lake L9807; neither of the study lakes with Yellow-billed Loons were reported to contain fish (Moulton 2001). It is unknown how far from the nest or brood-lake Yellow-billed Loons will forage to feed their young, but observations suggest that preferred nesting and brood-rearing lakes either contain fish or are located near fish-bearing lakes or streams. For example, fish data were available for 12 of the 22 Yellow-billed Loon nest lakes located in the NPRA study area in 2001 (Moulton 2001), and fish were confirmed to be present in 75% of those lakes on which Yellow-billed Loons nested (8 of 12 nest lakes). In addition, Yellow-billed Loon nests in the NPRA Study Area are limited to areas near the fish-bearing streams, Uvlutuuq and Iqalliqpik. These observations suggest that the lack of fish may not exclude Yellow-billed Loons from nesting or rearing broods on a specific waterbody, but that the availability of fish-bearing waters on a broader

Table 16. Number of birds observed on 10 lake drawdown study areas in the NPRA Study Area, Alaska, June–August 2002.

	Number of Birds									
MONTH	Drawdown Lakes					Reference Lakes				
Species	L9817	L9911	M9912	M9922	M9923	L9807	L9823	M0024	M9913	M9914
JUNE										
Pacific Loon	3	4	2	3	1	5	0	0	0	2
Greater White-fronted Goose	2	0	0	6	2	10	0	0	0	0
Canada Goose	0	2	0	0	0	0	0	0	0	0
Tundra Swan	0	2	1	0	4	3	2	0	0	0
Northern Shoveler	0	0	0	0	0	0	1	0	0	0
Northern Pintail	0	0	1	0	0	0	0	0	0	5
Greater Scaup	0	0	0	0	0	2	0	0	0	0
Unidentified scaup	0	1	0	0	0	0	0	0	0	0
King Eider	0	0	0	0	11	8	0	0	0	0
Unidentified eider	0	0	0	0	1	0	0	0	0	0
Long-tailed Duck	0	4	12	13	18	8	2	0	0	0
Red-breasted Merganser	0	1	0	0	0	2	0	0	0	1
Bar-tailed Godwit	0	0	0	0	0	0	0	0	0	1
Parasitic Jaeger	0	1	0	0	0	0	0	0	0	0
Glaucous Gull	1	1	1	0	0	1	0	0	0	1
Sabine's Gull	0	1	0	0	0	0	0	0	0	4
Arctic Tern	1	1	0	0	0	35	0	0	0	16
JULY										
Pacific Loon	2	4	0	2	2	5	2	0	0	2
Yellow-billed Loon	0	3	0	0	0	0	0	2	0	0
Greater White-fronted Goose	0	0	0	2	1	0	0	0	0	0
Canada Goose	0	0	0	0	0	0	0	0	0	0
Unknown goose	0	0	0	0	0	0	0	0	0	0
Tundra Swan	0	0	0	0	2	0	0	0	0	0
Northern Pintail	0	1	0	0	0	0	0	0	0	0
Unidentified scaup	0	0	0	0	0	9	0	0	0	0
King Eider	0	5	0	0	73	0	0	0	0	1
Unidentified eider	0	0	0	9	0	0	0	0	0	0
Long-tailed Duck	2	1	0	0	8	0	0	0	0	1
Red-breasted Merganser	0	0	0	0	0	0	1	0	0	0
Unidentified duck	0	0	0	0	0	1	0	0	0	0
Glaucous Gull	0	0	0	0	0	1	0	0	0	0
Sabine's Gull	0	0	0	0	0	0	0	0	0	0
Arctic Tern	0	5	0	0	3	2	0	0	0	0
AUGUST										
Pacific Loon	8	6	3	0	0	7	2	0	0	0
Yellow-billed Loon	0	2	0	0	0	0	0	1	0	0
Tundra Swan	0	1	0	0	0	2	0	0	0	0
Northern Pintail	1	1	1	0	0	1	0	0	0	0
Unidentified scaup	0	1	0	0	0	0	0	0	0	0
King Eider	0	0	0	0	5	0	0	0	0	0
Glaucous Gull	0	1	2	0	0	0	1	2	0	0
Common Raven	0	0	0	0	0	0	1	0	0	0

scale might identify regions with potential to support higher densities of Yellow-billed Loons. (Distribution of loons is discussed in greater detail in the *Loon Survey* section below.)

Glaucous Gulls adults were sighted flying over 7 of the 10 lakes and one nest was located at Lake L9807. A second nest was suspected on an inaccessible island in Lake M9912 because of the defensive behavior of the adult. However, no broods were noted in later visits to the lake. In 1999, Anderson and Johnson (1999) reported a Glaucous Gull pair nesting on the Lake M9912. In August, a pair of highly mobile Glaucous Gull fledglings and 2 adults were sighted on a Lake M0024. This brood may have belonged to a Glaucous Gull nest found in the Spark ground-search area just north of Lake M0024. Glaucous Gulls prefer to nest on islands. In 2001, 85% of Glaucous Gulls nests in the NPRA study area were located on islands ($n = 30$ nests; Burgess et al. 2002).

Arctic Terns were sighted at 5 lakes, but no nests were found. These birds nest as single pairs or in small colonies. Terns feed on small fish but their diet also contains a significant proportion of invertebrates (North1997, Nisbet 2002). Large flocks of foraging terns (15–35 birds) were recorded at Lake M9914 and M9807on 30 June. These foraging birds were not capturing fish but feeding on smaller prey items. Terns forage in flocks because of the patchy and temporal distribution of their food source.

Canada Geese were noted at 2 study lakes and a Canada Goose nest was found near Lake L9807 in a series of ponds linked to the lake. Canada Geese nest mainly on islands and would be affected by drawdowns that caused their nesting islands to become attached to the lake shore or to become more accessible to mammalian predators.

The avian species discussed above use shorelines and islands for nesting sites and/or lakes for feeding areas. Changes in water levels (both positive and negative) might affect the shore-nesting species by reducing the availability of nest sites or making nest sites more vulnerable to mammalian predators. Changes in water levels could also affect invertebrate and fish availability if water levels dropped enough to change water chemistry, decrease the amount of unfrozen water available during winter, or affect the amount of emergent vegetation on lake margins. Because the drawdown lakes recharged at least to their pre-withdrawal levels by June, when birds begin nesting, the winter drawdown of these lakes probably did not have any substantial effects on nest site availability or prey availability.

EIDER SURVEYS

Background

The Alaska population of Spectacled Eiders declined sharply between the 1970s and 1992, primarily due to a decline in western Alaska on the Yukon-Kuskokwim Delta (Stehn et al. 1993; USFWS 1999). In 1993, the Spectacled Eider was listed by the USFWS as "threatened" under the Endangered Species Act (58 FR 27474–27480). Since 1993, the western Alaska population appears to be sable or declining only slightly (Peterson et al. 2000). On the Arctic Coastal Plain, Spectacled Eider numbers may have declined slightly (<2%) since 1993, but the trend is not significant (Larned et al. 2003). Results of statewide surveys suggest that the Arctic Coastal Plain now supports the main breeding population of Spectacled Eiders in Alaska (USFWS 1996) with a population of at least 6,000–7,000 birds (Larned et al. 2001). Spectacled Eiders are uncommon nesters (i.e., they occur regularly but are not found in all suitable habitats) on Alaska's Arctic Coastal Plain, and tend to concentrate on large river deltas (Johnson and Herter 1989).

The Alaska breeding population of Steller's Eider was listed as threatened in 1997 (62 FR 31748) because it had declined substantially on the Yukon-Kuskokwim Delta in recent years (Kertell 1991, Quakenbush and Cochrane 1993). Currently, Steller's Eiders breed in extremely low numbers on the Yukon-Kuskokwim Delta, and the breeding range has contracted elsewhere in Alaska, likely contributing to the overall population decline. Historically, Steller's Eiders nested across most or all of the coastal plain (Kertell 1991, Quakenbush and Cochrane 1993), but currently they nest primarily around Barrow, although the total breeding range probably extends from Point Lay to near the Colville River Delta (Day et al. 1995, Quakenbush et al. 1995). The Steller's Eider has been recorded periodically in the Prudhoe Bay and

Kuparuk oilfields and on the Colville River Delta (USFWS 1998; ABR, unpubl. data).

Although King Eiders are not listed as threatened in Alaska, their breeding population does appear to be declining at the eastern edges of their breeding range, primarily in western Canada (Dickson et al. 1997, Suydam et al. 2000). In the late 1970s, Derksen et al. (1981) suggested that King Eider densities appeared to decline west of the Colville River, but BLM (1998) reported that some of the highest densities of King Eiders on the coastal plain occurred in the Northeast Planning Area of NPRA. Larned et al. (2001) reported that the number of King Eiders on the Alaska Coastal Plain has remained stable over the last 9 years.

Spectacled Eider

Distribution and Abundance

Twelve Spectacled Eiders, one of which was seen flying, were observed in the eider survey area during the pre-nesting aerial survey on 10–11 June 2002 (Table 17, Figure 16). Both the densities of indicated birds (USFWS 1987a) and of observed birds were 0.02 birds/km^2, about half the density counted in 2001 (Table 18), and both calculations of density were lower than densities recorded in other areas on the Arctic Coastal Plain. For example, the 9-year mean density of pre-nesting Spectacled Eiders in the CD North study area on the Colville River Delta was 0.20 birds/km^2 (Johnson et al. 2003b). The 9-year mean in the Kuparuk Oilfield was 0.08 birds/km^2; Anderson et al. 2003), and the 9-year mean density across the Arctic Coastal Plain was 0.23 birds/km^2; Larned et al. 2001). Earlier studies in northeastern NPRA also have reported low densities (0.03–0.09 birds/km^2) for this species (BLM 1998, Anderson and Johnson 1999, Murphy and Stickney 2000), confirming that this portion of NPRA does not support large numbers of Spectacled Eiders.

Only 4 Spectacled Eider nests were found in the NPRA Study Area in 2001–2002. One nest was located in the Alpine West ground-search area in 2002 (Figure 10) and had failed before it was found. It was, therefore, identified to species based on the color and pattern of contour feathers in the nest. In 2001, 3 Spectacled Eider nests were found during ground searches of wetland basins that were not searched in 2002 (Burgess et al. 2002). No Spectacled Eider nests were located in similar ground searches in the NPRA in 1999 and 2000 (Anderson and Johnson 1999, Murphy and Stickney 2000). No broods of Spectacled Eiders were found in either 2001 or 2002.

Habitat Use

Eleven groups of Spectacled Eiders representing 24 adults were observed (only eiders on the ground were used in the habitat analysis) within the area mapped for wildlife habitat (Figure 2) during pre-nesting surveys in 2001 and 2002 combined. Most of these Spectacled Eider groups occurred in lakes and wetland complexes (Table 19). Of the 6 habitats that were used, 2 were preferred, one was avoided, and the others were used in proportion to their availability. Shallow Open Water with Islands or Polygonized Margins and Old Basin Wetland Complex were the only habitats preferred during pre-nesting. Sample size was small for the selection analysis (i.e., fewer locations than habitats), however, and the results will undoubtedly change with additional locations. Not surprisingly, the selection of habitat in the NPRA Study Area differed from that observed on the Colville River Delta, where Spectacled Eiders preferred habitats in the marine-influenced zone (e.g., Brackish Water, Salt-killed Tundra, Salt Marsh; Johnson et al. 2003b). Marine-influenced habitats are rare in the NPRA Study Area (Table 3). Nonetheless, Shallow Open Water with Islands or Polygonized Margins was preferred in both study areas. The other preferred habitat in the NPRA, Old Basin Wetland Complex, contains mosaics of wet sedge meadows, emergent vegetation, and waterbodies, which were constituents of habitats used or selected by Spectacled Eiders in other locations on the Arctic Coastal Plain (Bergman et al. 1977, Derksen et al. 1981, Warnock and Troy 1992, Anderson et al. 2002).

Similar habitats were used during nesting by Spectacled Eiders (Table 20). A selection analysis was not conducted for nest locations, because sample size was inadequate. Two nests were found in Old Basin Wetland Complex and one nest each was found in Shallow Open Water with Islands or Polygonized Margins and Patterned Wet Meadow. As mentioned earlier, the NPRA Study Area lacks the salt-affected habitats that Spectacled Eiders primarily used for nesting on the Colville River Delta (Johnson et al. 2003b), and the absence of

Table 17. Number and density of eiders during a pre-nesting aerial survey in the NPRA Study Area, Alaska, 10–11 June 2002. Coverage was 50% of the 1,100 km² survey area (Figure 2).

	Number						Density (birds/km²)		
Species	Males	Females	Total Birds	Observed Pairs	Groups	Indicated Total Birds[a]	Breeding Pairs[b]	Total Birds[c]	Indicated Total Birds
SPECTACLED EIDER									
On Ground	7	4	11	4	7	14	0.01	0.02	0.02
Flying	1	0	1	0	1		<0.01	<0.01	
All Birds	8	4	12	4	8		0.01	0.02	
KING EIDER									
On Ground	105	75	180	54	62	207	0.19	0.33	0.38
Flying	16	10	26	8	14		0.03	0.05	
All Birds	121	85	206	62	76		0.22	0.37	
UNIDENTIFIED EIDER									
On Ground	1	1	2	1	1	2	<0.01	<0.01	<0.01
Flying	0	0	0	0	0		0	0	
All Birds	1	1	2	1	1		<0.01	<0.01	

[a] Indicated total birds is calculated according to the standard USFWS protocol (USFWS 1987b); flying birds are not counted.
[b] Density of breeding pairs = total males/550.1 km².
[c] Unadjusted density of total birds = total birds/550.1 km².

Table 18. Numbers and densities of eiders during pre-nesting surveys in the NPRA Study Area, Alaska, 2001–2002.

	Number				Density[a]			
	Total Birds[b]		Indicated Total Birds[c]		Total Birds[b]		Indicated Total Birds[c]	
Species	2001	2002	2001	2002	2001	2002	2001	2002
Spectacled Eider	21	12	20	14	0.04	0.02	0.04	0.02
Steller's Eider	1	0	0	0	<0.01	0	0	0
King Eider	128	206	98	207	0.25	0.37	0.18	0.38
Unidentified eider	5	2	6	2	0.01	<0.01	0.01	<0.01

[a] 2001 survey area 1,022 km²; 2002 survey area 1,100 km². Coverage 50%. Density in 2001 = number/511 km²; density in 2002 = number/550 km².
[b] Total birds includes both males and females and both flying and non-flying birds.
[c] Indicated total is calculated according to the standard protocol (USFWS 1987a) and does not include flying birds.

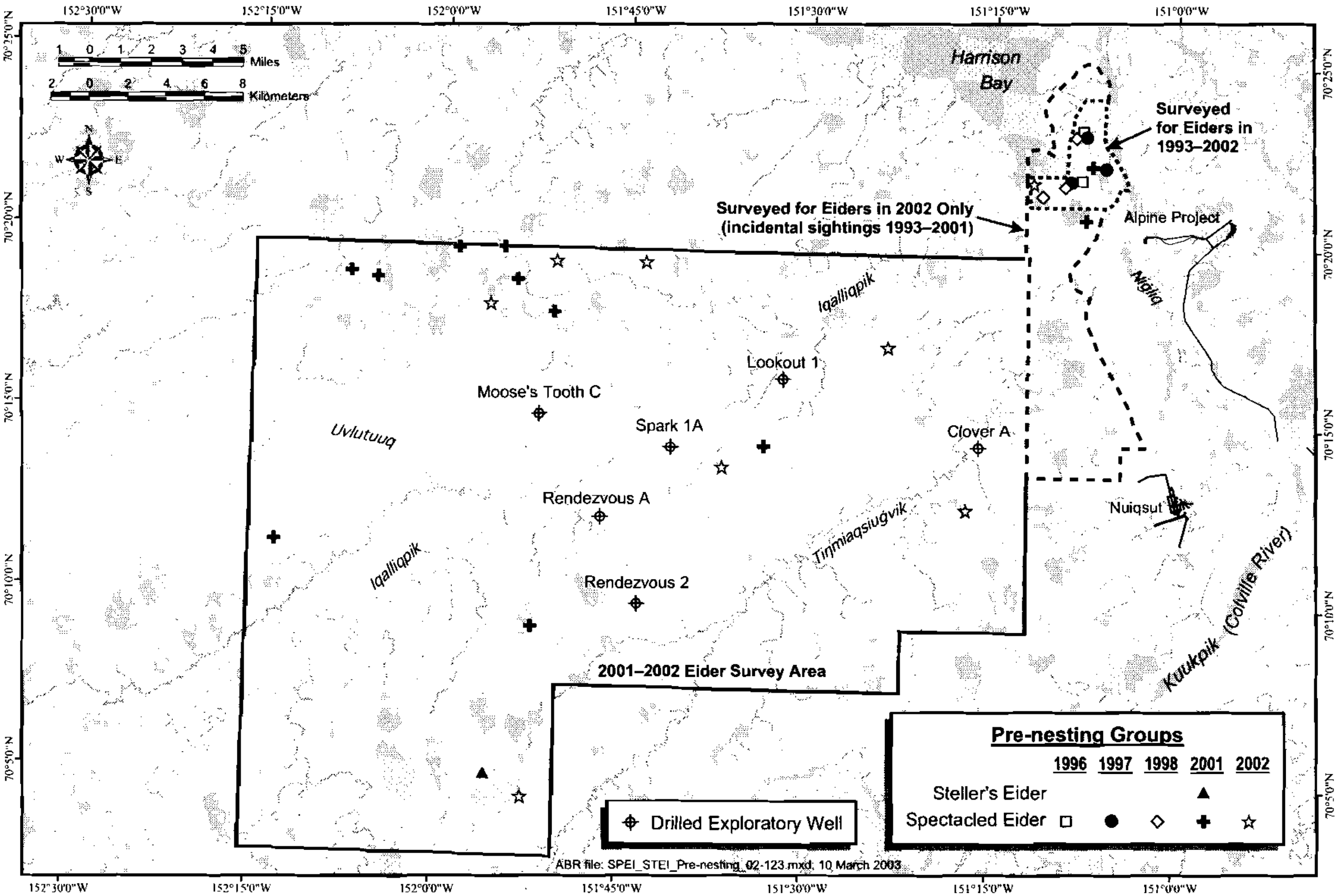

Figure 16. Spectacled Eider and Steller's Eider locations during pre-nesting aerial surveys, NPRA Study Area, Alaska, 2001–2002.

Table 19. Habitat selection (pooled between years) by Spectacled Eiders and King Eiders during pre-nesting in the NPRA Study Area, Alaska, 2001–2002.

SPECIES Habitat	Area (km²)	No. of Adults	No. of Groups	Use (%)	Availability (%)	Monte Carlo[a] Results
SPECTACLED EIDER						
Open Nearshore Water	0.36	0	0	0	0.1	ns
Brackish Water	0.63	0	0	0	0.2	ns
Tapped Lake with Low-water Connection	0.88	0	0	0	0.3	ns
Tapped Lake with High-water Connection	0.04	0	0	0	<0.1	ns
Salt Marsh	1.57	2	1	9.1	0.5	ns
Tidal Flat	0.81	0	0	0	0.2	ns
Salt-killed Tundra	0.07	0	0	0	<0.1	ns
Deep Open Water without Islands	22.32	0	0	0	6.8	ns
Deep Open Water with Islands or Polygonized Margins	17.39	4	2	18.2	5.3	ns
Shallow Open Water without Islands	3.43	1	1	9.1	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	5.44	6	2	18.2	1.7	prefer
River or Stream	2.82	0	0	0	0.9	ns
Aquatic Sedge Marsh	5.89	0	0	0	1.8	ns
Aquatic Sedge with Deep Polygons	0.13	0	0	0	<0.1	ns
Aquatic Grass Marsh	0.93	0	0	0	0.3	ns
Young Basin Wetland Complex	1.04	0	0	0	0.3	ns
Old Basin Wetland Complex	29.54	9	4	36.4	9.0	prefer
Riverine Complex	1.32	0	0	0	0.4	ns
Dune Complex	3.62	0	0	0	1.1	ns
Nonpatterned Wet Meadow	10.58	0	0	0	3.2	ns
Patterned Wet Meadow	37.23	0	0	0	11.3	ns
Moist Sedge–Shrub Meadow	78.55	2	1	9.1	23.9	ns
Moist Tussock Tundra	91.75	0	0	0	27.9	avoid
Riverine Low and Tall Shrub	3.55	0	0	0	1.1	ns
Upland and Riverine Dwarf Shrub	4.14	0	0	0	1.3	ns
Upland Low and Tall Shrub	1.19	0	0	0	0.4	ns
Barrens	3.21	0	0	0	1.0	ns
TOTAL	328.41	24	11	100	100	
KING EIDER						
Open Nearshore Water	0.36	0	0	0	0.1	ns
Brackish Water	0.63	0	0	0	0.2	ns
Tapped Lake with Low-water Connection	0.88	8	1	1.5	0.3	ns
Tapped Lake with High-water Connection	0.04	0	0	0	<0.1	ns
Salt Marsh	1.57	0	0	0	0.5	ns
Tidal Flat	0.81	0	0	0	0.2	ns
Salt-killed Tundra	0.07	0	0	0	<0.1	ns
Deep Open Water without Islands	22.32	45	13	16.7	6.8	prefer
Deep Open Water with Islands or Polygonized Margins	17.39	37	12	18.2	5.3	prefer
Shallow Open Water without Islands	3.43	12	7	13.6	1.0	prefer
Shallow Open Water with Islands or Polygonized Margins	5.44	36	13	19.7	1.7	prefer
River or Stream	2.82	2	1	1.5	0.9	ns
Aquatic Sedge Marsh	5.89	2	1	1.5	1.8	ns
Aquatic Sedge w/Deep Polygons	0.13	0	0	0	<0.1	ns
Aquatic Grass Marsh	0.93	2	1	1.5	0.3	ns
Young Basin Wetland Complex	1.04	0	0	0	0.3	ns
Old Basin Wetland Complex	29.54	18	7	10.6	9.0	ns
Riverine Complex	1.32	0	0	0.0	0.4	ns
Dune Complex	3.62	0	0	0	1.1	ns
Nonpatterned Wet Meadow	10.58	2	2	3.0	3.2	ns
Patterned Wet Meadow	37.23	6	3	4.5	11.3	avoid
Moist Sedge–Shrub Meadow	78.55	10	3	4.5	23.9	avoid
Moist Tussock Tundra	91.75	2	1	1.5	27.9	avoid
Riverine Low and Tall Shrub	3.55	1	1	1.5	1.1	ns
Upland and Riverine Dwarf Shrub	4.14	0	0	0	1.3	ns
Upland Low and Tall Shrub	1.19	0	0	0	0.4	ns
Barrens	3.21	0	0	0	1.0	ns
TOTAL	328.41	183	66	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.

those habitats may partially explain the low numbers of Spectacled Eiders nesting in this portion of the NPRA.

Steller's Eider

Steller's Eiders were not observed during the pre-nesting aerial survey in 2002. In 2001, one male Steller's Eider was observed flying during the pre-nesting aerial survey in the southern portion of the NPRA Study Area (Johnson and Stickney 2001). Two other investigations reported Steller's Eider sightings in the region in 2001: one confirmed sighting of a pair of Steller's Eiders was reported on the Colville River Delta (Johnson et al. 2002), and an unconfirmed sighting was made in the Kuparuk Oilfield (ABR, unpubl. data). Observations of Steller's Eiders are rare in the general area of the NPRA Study Area. No Steller's Eiders were seen during the pre-nesting aerial surveys in either 1999 or 2000 (Anderson and Johnson 1999, Murphy and Stickney 2000). However, 2 Steller's Eiders observations were recorded during the early 1990s—one to the south of the NPRA Study Area in 1993 and one to the northeast in 1995 (BLM 1998). Observations suggest that Steller's Eiders probably visit the NPRA Study Area less than annually, but that nesting is uncommon.

King Eider

Distribution and Abundance

King Eiders were ~20 times more abundant than Spectacled Eiders in the NPRA Study Area during pre-nesting in 2002 (Table 17, Figure 17). The density of King Eiders was 0.38 indicated birds/km², which was almost 50% higher than in 2001 (Table 18). The density in 2002 was lower than the mean density of King Eiders in both the Kuparuk Oilfield (mean = 0.47 indicated birds/km², n = 9 years; Anderson et al. 2003) and in the Alpine Transportation Corridor in 1997 (0.47 indicated birds/km²; Johnson et al. 1998). The density of King Eiders in the NPRA Study Area in 2002 was within the range of densities (0.07–0.47 birds/km²) previously reported for the Northeast Planning Area of NPRA (BLM 1998). Maps of King Eider density indicate that the highest concentrations (1.00–4.32 birds/km²) of King Eiders in the northeast planning area are north of the NPRA Study Area and southeast of Teshekpuk Lake (BLM 1998).

Eight King Eider nests were located during ground searches in the NPRA Study Area in 2002. Two King Eider nests were found in the Alpine West ground-search area (Figure 10) and 4 nests were found in the Spark ground-search area (Figure 14, Table 5), one nest was found at lake M9923 and another at lake L9911 (Table 14). Only one brood was found (at Spark) during nest checks in July (Figure 15, Table 8). The mean clutch size was 4.8 eggs/nest (n = 4 nests at which females were flushed) and hatching success was 50% (n = 8 nests). The overall density of nests in the 4 ground-search areas was 0.38 nests/km². King Eider nests were found in all 4 NPRA ground-search areas in 2001 (Burgess et al. 2002), yielding a density of 1.3 nests/km² (n = 8 nests). However, the density of nests in 2001 was probably an overestimate for the NPRA Study Area, because only wetland basins were searched, and drier areas likely supported fewer nests. King Eiders are reported as common nesters to the east of the Colville River Delta, especially in the Kuparuk Oilfield (Anderson et al. 2002), at Storkersen Point (Bergman et al. 1977), near Point McIntyre (TERA 1993), and near Prudhoe Bay (Troy 1988), but are rare nesters on the Colville River Delta (Johnson et al. 2003b).

Habitat Use

King Eiders used 14 of 27 habitats during pre-nesting in 2001–2002 (Table 19). Four common waterbody habitats were preferred and the 3 most abundant terrestrial habitats were avoided. Both types of Deep Open Water and Shallow Open Water were significantly preferred, and each of these habitats was used by >10% of the King Eider groups. The only other habitat used by >10% of the groups was Old Basin Wetland Complex, but use of this habitat did not differ significantly from its availability. Virtually the same habitats were preferred and avoided in the Alpine Transportation Corridor, just east of the Colville River; the exceptions were that in the Transportation

Corridor. River and Stream was preferred and Deep Open Water with Islands or Polygonized Margins was used in proportion to its availability (Johnson et al. 1998).

Of the 14 King Eider nests found during 2001–2002, 43% occurred in Old Basin Wetland Complex. Shallow Open Water without Islands, Nonpatterned Wet Meadow, and Moist Tussock Tundra each contained 14% of all nests (Table 20). Habitat selection was not calculated because the areas searched were relatively small and were not a representative sample of the study area. King Eiders appear to use a wide range of habitats. At Storkersen Point, King Eiders preferred shallow and deep *Arctophila* wetlands, basin complexes, and coastal wetlands during pre-nesting and nearly the same habitats during nesting (Bergman et al. 1977). At Prudhoe Bay, pre-nesting King Eiders used almost all habitats but preferred wet, aquatic nonpatterned; aquatic strangmoor; and water with and without emergents (Warnock and Troy 1992).

LOON SURVEYS

Background

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

Red-throated and Pacific loons are common breeders along the Beaufort Sea coast in Alaska (Johnson and Herter 1989). Red-throated Loons nest on small tundra ponds (~0.4 ha) that have a moderate amount of vegetative cover, while Pacific Loons prefer to nest on larger (~3.0 ha) and deeper waterbodies than those used by Red-throated Loons (Bergman and Derksen 1977, Dickson 1994). Egg-laying for both species typically begins during the third week of June, hatch occurs in mid-late July, and young fledge in September (Rothe et al. 1983; ABR, unpubl. data). The Red-throated Loon is restricted to nesting near the coast or near large lakes due to its reliance on large waterbodies for fish to feed its young (Bergman and Derksen 1977, Douglas and Reimchen 1988, Dickson 1994). Pacific Loons feed their young mostly invertebrates from the nesting lake or the wetlands that they inhabit (Bergman and Derksen 1977). In 2001, all Red-throated Loon adults and nests were found in the northern part of the NPRA Study Area within 8 km of Uvlutuuq whereas Pacific Loons were distributed throughout the study area.

Yellow-billed Loons

Distribution and Abundance

During the nesting aerial survey in 2002, 64 Yellow-billed Loons and 26 nests were recorded in the NPRA Study Area (Table 21, Figure 18). One additional nest was found 0.16 km north of the NPRA Study Area in a lake that bisects the study area boundary. No additional nests were found during ground searches. Both loons and nests were concentrated in lakes adjacent to Uvlutuuq and Iqalliqpik, leaving much of the northwestern and southeastern portions of the study area unoccupied by Yellow-billed Loons (Figure 18). The density of loons was 0.07 birds/km^2 in the 2002 Yellow-billed Loon survey area (878 km^2). A similar distribution and density was found in the 2001 Yellow-billed Loon survey area (621 km^2; Table 21). During 8 years of surveys, densities of Yellow-billed Loons on the Colville River Delta were ~2 times higher than in the NPRA Study Area (mean = 0.14 birds/km^2, range 0.11–0.17 birds/km^2), with the highest density recorded in 2001 (ABR, unpubl. data). Previously recorded densities in other nesting areas on the Arctic Coastal Plain appear to be similar to those observed on the Colville River Delta: 0.14 birds/km^2 at Square Lake in the NPRA (Derksen et al. 1981) and 0.16 birds/km^2 in the Alaktak region south of Smith Bay (McIntyre 1990).

In 2002, the nest density of Yellow-billed Loons was 0.03 nests/km^2 in the Yellow-billed

Table 20. Habitat use by nesting Spectacled Eiders and King Eiders in the NPRA Study Area, Alaska, 2001–2002.

SPECIES Habitat	No. of Nests	Use (%)
SPECTACLED EIDER		
Shallow Open Water with Islands or Polygonized Margins	1	25
Old Basin Wetland Complex	2	50
Patterned Wet Meadow	1	25
TOTAL	4	100
KING EIDER		
Shallow Open Water with Islands or Polygonized Margins	2	14
Aquatic Sedge Marsh	1	7
Old Basin Wetland Complex	6	43
Nonpatterned Wet Meadow	2	14
Moist Sedge–Shrub Meadow	1	7
Moist Tussock Tundra	2	14
TOTAL	14	100

Loon survey area (Table 21). The same density of nests was found during aerial surveys in the 2001 Yellow-billed Loon survey area. Nest density on the Colville River Delta was estimated to be 0.06 nests/km² in 2002 using the same aerial survey methods (ABR, unpubl. data). Higher densities of loons and nests on the Colville River Delta reflect the greater abundance of large, deep waterbodies, which are preferred for nesting and brood-rearing (Burgess et al. 2003). Although the NPRA Study Area supports a lower overall density of nesting Yellow-billed Loons than the Colville River Delta, the concentration of nests found in lakes adjacent to Uvlutuuq and Iqalliqpik (25 of 27 nests in 2002) comprises a larger number of nests than typically occurs on the entire Colville River Delta (mean = 18.1 nests, range 13–23 nests, $n = 8$ years; ABR, unpubl. data), meaning that the Uvlutuuq and Iqalliqpik area is an important breeding area for the species. The mean distance of nests to Uvlutuuq or Iqalliqpik was 0.97 km (range 0.15–4.00 km) and the mean distance of nest lakes to either creek was 0.52 km (range 0.05–3.94 km). Each nest lake in 2002 contained one pair of Yellow-billed Loons, except for one large lake that contained 2 nests, which were 1.8 km apart. In 2001, a different large lake contained 2 nests, which were 1.2 km apart. Sixteen of the 22 nesting locations found in 2001 were active again in 2002, including 12 nests that were near (<10 m) or at the same nest site where a Yellow-billed Loon was found nesting in 2001 and four nests were on the same nest lake but >10 m from the 2001 nest site (Figure 18). Yellow-billed Loons on the Colville River Delta have been known to reoccupy the same nest bowl in consecutive years (ABR, unpubl. data).

During the brood-rearing aerial survey in 2002, 47 adult Yellow-billed Loons and 6 broods were seen in the NPRA Yellow-billed Loon survey area (Table 21, Figure 18). Five broods had 1 young each and 1 brood had 2 young. Each brood was seen in a lake near a known nest location. The density of adult loons on the brood-rearing survey (0.05 loons/km²) was less than the density of adult loons on the nesting survey (0.07 loons/km²) and less than the density of adult loons seen on the 2001 brood-rearing survey (0.08 loons/km²). The density of adult loons on the Colville River Delta during the 2002 brood-rearing aerial survey was 0.20 loons/km², which was above the 8-yr average of 0.15 loons/km² (ABR, unpub. data.). Loons whose nests failed in the NPRA Study Area in 2002 may have moved to the Colville River Delta

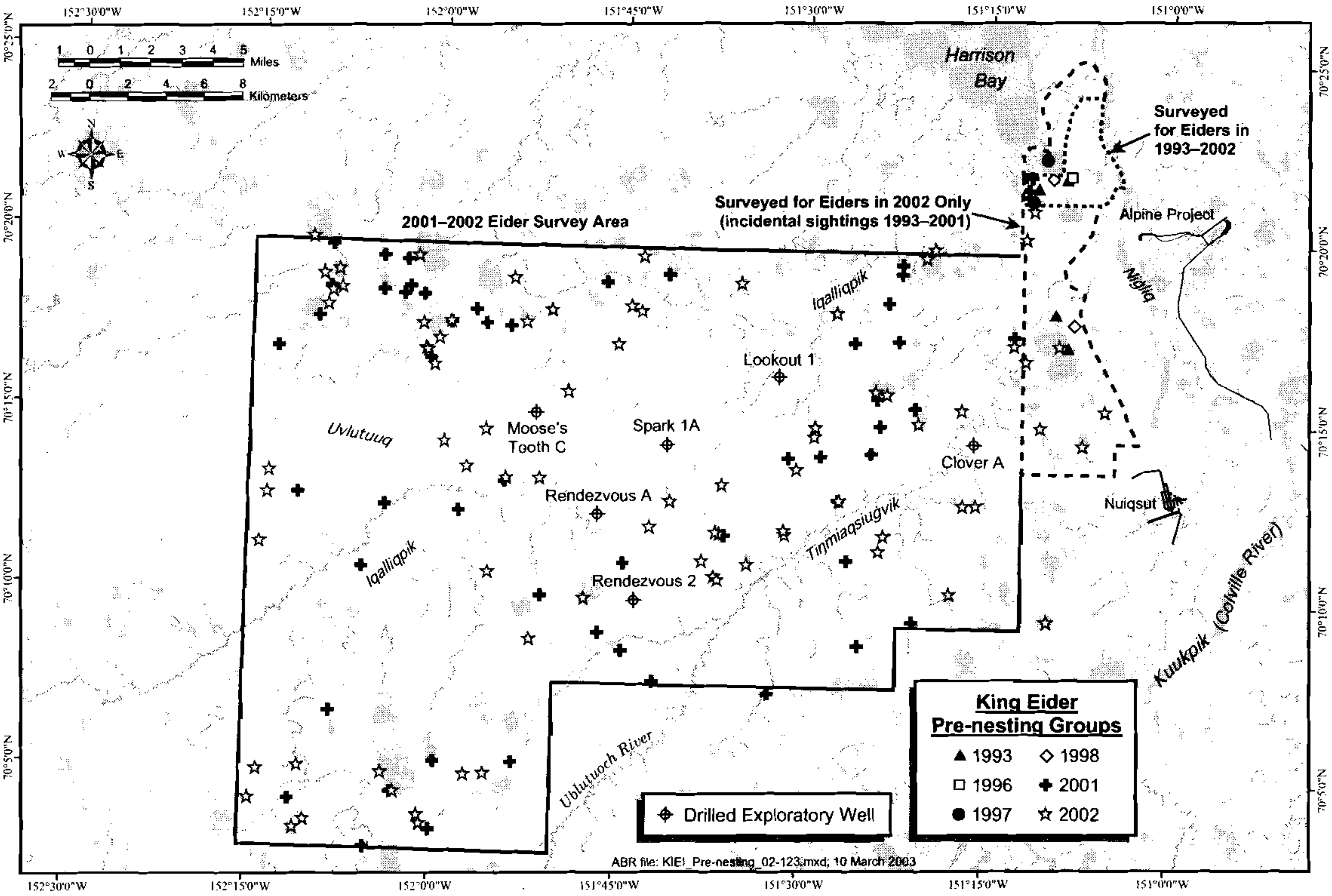

Figure 17. King Eider locations during pre-nesting aerial surveys, NPRA Study Area, Alaska, 2001–2002.

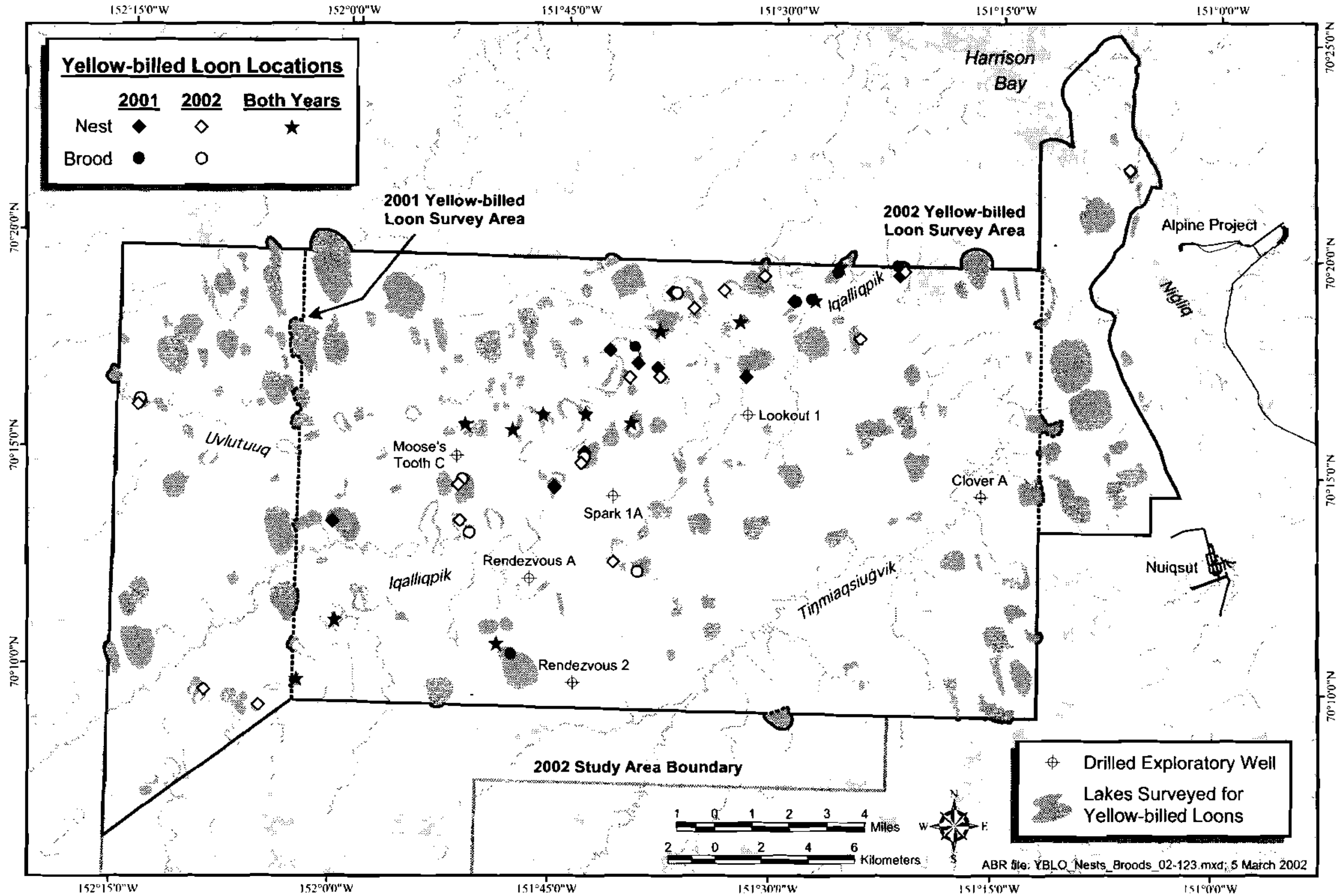

Figure 18. Yellow-billed Loon nests and broods during aerial and ground surveys, NPRA Study Area, Alaska, 2001–2002.

Table 21. Numbers and densities (number/km²) of loons and their nests, broods, and young during aerial surveys of the NPRA Study Area, Alaska, 2001–2002.

	Yellow-billed Loon					Pacific Loon[a]			Red-throated Loon[a]		
	Number			Density (no/km²)		Number			Number		
Year	Adults	Nests/ Broods	Young	Adults	Nests/ Broods[b]	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
NESTING[b]											
2001	43	18		0.07	0.03	362	96		10	0	
2002	64	26		0.07	0.03	492	123		9	0	
BROOD-REARING[c]											
2001	47	5	5	0.08	0.01	94	10	10	6	0	0
2002	47	6	7	0.05	0.01	127	15	16	8	2	3

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and only lakes ≥10 ha were surveyed.
[b] In 2002, the nesting survey included 878 km² of the NPRA Study Area. In 2001, the nesting survey included 615 km² of the NPRA Study Area.
[c] Only lakes where Yellow-billed Loons were observed during the nesting survey were surveyed.

for staging. The density of broods in the NPRA Yellow-billed Loon survey area in 2002 was 0.01 broods/km², the same density as in the 2001 survey area. In both years, broods were associated with known nest locations (Figure 18). Brood density on the Colville River Delta ranged from 0.01–0.04 broods/km² during 8 years of aerial surveys (ABR, unpubl. data). North and Ryan (1988a, 1989) found that adults with young remained on or near the nest lake during brood-rearing, and non-nesting and failed breeders also maintained their territories throughout the summer.

Habitat Use

Forty-one of the 47 Yellow-billed Loon nests that were found in the NPRA Study Area in 2001 and 2002 were included in the habitat selection analysis. Three nests that occurred in areas outside of the habitat map and 3 other nests that were found during ground searches in 2001 were excluded from the analysis. During 2 years of aerial surveys in the NPRA Study Area (2001 and 2002), 41 Yellow-billed Loon nests were found in 8 of 27 available habitats (Table 22). Twenty-three nests (56%) were located in Deep Open Water with Islands or Polygonized Margins, which was the only habitat preferred for nesting. Four other aquatic and 3 terrestrial habitats also were used for nesting: Deep Open Water without Islands (10%), Shallow Open Water with Islands or Polygonized Margins (2%), Aquatic Sedge Marsh (7%), Aquatic Grass Marsh (2%), Nonpatterned Wet Meadow (7%), Patterned Wet Meadow (7%), and Moist Sedge–Shrub Meadow (7%). Moist Sedge–Shrub Meadow was the second most abundant habitat in the NPRA Study Area (24%) and it was significantly avoided by nesting Yellow-billed Loons despite 3 nests occurring in it (Table 22). Two other habitats were significantly avoided by nesting Yellow-billed Loons—Moist Tussock Tundra, which was the most abundant habitat in the NPRA Study Area (28%), and Old Basin Wetland Complex—and both were unused. Nesting Yellow-billed Loons on the Colville River Delta also preferred Deep Open Water with Islands or Polygonized Margins (31 of 123 nests, 25%) and Patterned Wet Meadow (47 or 123 nests, 38%), which was the most abundant habitat on the delta (25% of all habitats) (Burgess et al. 2003).

Most Yellow-billed Loon nests in the NPRA Study Area in 2001 and 2002 were located on islands (33 of 47 nests, 70%). Other nests were built on peninsulas, shorelines, or in emergent vegetation. All but 1 pair of Yellow-billed Loons in 2002 and 3 pairs in 2001 nested on large lakes

(>10 ha). During 8 years of surveys on the Colville River Delta, most Yellow-billed Loon pairs were found nesting on large lakes (>10 ha; ABR, unpubl. data).

In the NPRA Study Area in 2001 and 2002, 10 Yellow-billed Loon broods were found in 2 different habitats—Deep Open Water without Islands and Deep Open Water with Islands or Polygonized Margins—and both were preferred (Table 22). Deep Open Water with Islands or Polygonized Margins was used by most broods (60% of total). Both types of Deep Open Water also were preferred during brood-rearing on the Colville River Delta (Burgess et al. 2003). The third preferred habitat on the Colville River Delta, Tapped Lake with High-water Connection, was rare in the NPRA Study Area, accounting for <0.1% of all available habitats.

Other Loons

Distribution and Abundance

In 2002, Red-throated and Pacific loons were recorded incidentally during the Yellow-billed Loon aerial survey (Figure 19, Table 21). Because the survey focused on larger lakes, counts of Red-throated and Pacific loons and their nests were incomplete and densities could not be calculated. Nine Red-throated Loon adults were seen on the aerial survey in 2002 and no nests were found. Nests of Red-throated Loons are not easily detected from the air. During ground searches in 2002, 4 Red-throated Loon nests were found (2 of these were near Shorebird Plots but not within a plot) (Table 21, Figure 19, Figure 10, Table 5; see discussion in *Large Waterbird Ground-search Areas*). In the 2001 NPRA Study Area, ground searches were conducted specifically for Red-throated Loons in 4 plots and densities were 0.10 birds/km² and 0.07 nests/km² (Burgess et al. 2002). The nest density in the Red-throated Loon plots in 2001 was near the bottom of the range that has been reported in most other studies in the region. In order of nest density, other studies have reported 0.10–0.20 nests/km² in 2000–2003 at CD South (inland Colville River Delta; Burgess et al. 2003); 0.08–0.49 nests/km² (1996–2000) in the Alpine project area (central Colville River Delta; Johnson et al. 2003a); 0.40 nests/km² (1972–1975) at Storkersen Point (Bergman and Derksen 1977); and 0.50–0.82 nests/km² at CD North (coastal Colville River Delta; Johnson et al. 2003b).

Pacific Loons were the most abundant and widespread loon species breeding in the NPRA Study Area (Figure 19). On the nesting aerial survey in 2002, 492 adult Pacific Loons and 123 nests were found (Table 21). In 2001, a smaller area was surveyed and 362 adult Pacific Loons and 96 nests were found (Table 21). Pacific Loons occupied small and large lakes, sometimes nesting on the same lakes as Yellow-billed Loons. During ground searches in 2002, 26 Pacific Loon nests were found (Table 21, Figure 19, Figure 10, Figure 14, Table 5, Table 14; see discussion in *Large Waterbird Ground-search Areas*). During 2001, the density of Pacific Loons in the 4 Red-throated Loon plots was 0.37 nests/km² and 0.66 birds/km² (Burgess et al. 2002). The density of Pacific Loon nests in 2001 was low relative to other densities in the region. For example, the mean nest density of Pacific Loons over 3 years of study (2000–2002) was 0.77 nests/km² in the CD North ground-search area (coastal Colville River Delta; Johnson et al. 2003b) and the mean nest density over 4 years of study (1972–1975) was 0.8 nests/km² at Storkersen Point (Bergman and Derksen 1977). Derksen et al. (1981) reported densities of 0.6–2.1 birds/km² for Pacific Loons on 5 study plots within the NPRA (nest densities were not reported).

During the brood-rearing aerial survey in 2002, 8 adult Red-throated Loons and 2 broods were observed (Table 21). An additional 2 broods were observed during ground searches (one was near, but not within, a lake study ground-search area) (Table 21, Figure 19, Figure 11, Table 8). In 2001, 6 adults were seen on the aerial survey and 1 brood with one young was found during ground searches (Burgess et al. 2002). For Pacific Loons, 127 Pacific Loons and 15 broods were counted during the brood-rearing aerial survey. An additional 9 broods were observed during ground searches (Table 21, Figure 19, Figure 11, Figure 15, Table 8, Table 15). In 2001, 94 adult Pacific Loons and 10 broods were observed during the aerial survey. The smaller number of birds observed during 2001 surveys is probably attributable to the smaller area surveyed (Table 21).

Table 22. Habitat selection (pooled among years) by Yellow-billed Loons during nesting and brood-rearing in the NPRA Study Area, Alaska, 2001–2002.

SEASON Habitat	Area (km^2)	No. Nests or Broods	Use (%)	Availability (%)	Monte Carlo[a] Results
Nesting					
Open Nearshore Water	1.70	0	0	0.3	ns
Brackish Water	0.67	0	0	0.1	ns
Tapped Lake with Low-water Connection	1.66	0	0	0.3	ns
Tapped Lake with High-water Connection	0.04	0	0	<0.1	ns
Salt Marsh	1.82	0	0	0.3	ns
Tidal Flat	4.09	0	0	0.6	ns
Salt-killed Tundra	0.07	0	0	<0.1	ns
Deep Open Water without Islands	45.29	4	9.8	6.9	ns
Deep Open Water with Islands or Polygonized Margins	33.85	23	56.1	5.2	prefer
Shallow Open Water without Islands	6.73	0	0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	10.61	1	2.4	1.6	ns
River or Stream	6.01	0	0	0.9	ns
Aquatic Sedge Marsh	11.25	3	7.3	1.7	ns
Aquatic Sedge with Deep Polygons	0.28	0	0	<0.1	ns
Aquatic Grass Marsh	1.83	1	2.4	0.3	ns
Young Basin Wetland Complex	2.27	0	0	0.3	ns
Old Basin Wetland Complex	57.98	0	0	8.8	avoid
Riverine Complex	2.75	0	0	0.4	ns
Dune Complex	7.59	0	0	1.2	ns
Nonpatterned Wet Meadow	19.97	3	7.3	3.0	ns
Patterned Wet Meadow	73.70	3	7.3	11.2	ns
Moist Sedge–Shrub Meadow	156.60	3	7.3	23.9	avoid
Moist Tussock Tundra	183.53	0	0	28.0	avoid
Riverine Low and Tall Shrub	7.24	0	0	1.1	ns
Upland and Riverine Dwarf Shrub	8.94	0	0	1.4	ns
Upland Low and Tall Shrub	2.79	0	0	0.4	ns
Barrens	6.55	0	0	1.0	ns
TOTAL	655.83	41	100	100	
Brood-rearing					
Open Nearshore Water	1.70	0	0	0.3	ns
Brackish Water	0.67	0	0	0.1	ns
Tapped Lake with Low-water Connection	1.66	0	0	0.3	ns
Tapped Lake with High-water Connection	0.04	0	0	<0.1	ns
Salt Marsh	1.82	0	0	0.3	ns
Tidal Flat	4.09	0	0	0.6	ns
Salt-killed Tundra	0.07	0	0	<0.1	ns
Deep Open Water without Islands	45.29	4	40.0	6.9	prefer
Deep Open Water with Islands or Polygonized Margins	33.85	6	60.0	5.2	prefer
Shallow Open Water without Islands	6.73	0	0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	10.61	0	0	1.6	ns
River or Stream	6.01	0	0	0.9	ns
Aquatic Sedge Marsh	11.25	0	0	1.7	ns
Aquatic Sedge w/Deep Polygons	0.28	0	0	<0.1	ns
Aquatic Grass Marsh	1.83	0	0	0.3	ns
Young Basin Wetland Complex	2.27	0	0	0.3	ns
Old Basin Wetland Complex	57.98	0	0	8.8	ns
Riverine Complex	2.75	0	0	0.4	ns
Dune Complex	7.59	0	0	1.2	ns
Nonpatterned Wet Meadow	19.97	0	0	3.0	ns
Patterned Wet Meadow	73.70	0	0	11.2	ns
Moist Sedge–Shrub Meadow	156.60	0	0	23.9	ns
Moist Tussock Tundra	183.53	0	0	28.0	ns
Riverine Low and Tall Shrub	7.24	0	0	1.1	ns
Upland and Riverine Dwarf Shrub	8.94	0	0	1.4	ns
Upland Low and Tall Shrub	2.79	0	0	0.4	ns
Barrens	6.55	0	0	1.0	ns
TOTAL	655.83	10	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.

TUNDRA SWAN SURVEYS

Background

Tundra Swans are common breeders across the Arctic Coastal Plain of Alaska. Pairs typically mate for life and defend a nesting territory to which they return annually. Tundra Swans begin arriving on the Arctic Coastal Plain while the ground is mostly snow-covered (late-May) and, as snow melt progresses, breeding pairs move to territories and begin nesting by early June. After eggs hatch in early July, the family groups remain together during brood-rearing, although they may range widely to find suitable foraging habitat (Johnson and Herter 1989). While the young are flightless, adults molt their flight feathers and also become flightless for about 3 weeks. Although brood-rearing swans remain in single-family flocks until departure in fall, nonbreeding swans may form large staging flocks of up to several hundred birds during September (Rothe et al. 1983, Smith et al. 1994, Johnson et al. 1998). The young are ready to fledge by mid-to-late September, and fall migration peaks along the Beaufort Sea coast in late September and early October (Johnson and Herter 1989).

Distribution and Abundance

Nesting

During the aerial survey for nesting Tundra Swans on 25 June 2002, 76 breeding adults were associated with 43 nests (Table 23, Figure 20). An additional 8 nests were found by ground searchers and helicopter-based surveys for nesting Yellow-billed Loons and Brant (Figure 20). Nest density in the 2002 survey area was 0.04 nests/km². In the slightly smaller survey area in 2001, 54 breeding adults were associated with 31 nests and the density of nests was 0.03 nests/km². Swan nesting density in the NPRA Study Area is comparable to the 14-year mean nest density recorded in the Kuparuk Oilfield (2247 km² survey area; mean = 0.04 nests/km²; range = 0.01–0.05 nests/km²; 1989–2002; Anderson et al. 2003) but below the 9-year mean nest density recorded on the Colville River Delta (551 km² survey area; mean = 0.06 nests/km²; range = 0.03–0.10 nests/km²; years: 1992–1993, 1995–1998, and 2000–2002; Johnson et al 2003b). Nesting density of swans in the NPRA Study Area is also within the range of nest densities recorded on the eastern Arctic Coastal Plain (0.04–0.06 nests/km²; Platte and Brackney 1987).

In 2002, densities of breeding adults (0.07 birds/km²), nonbreeders (0.16 birds/km²), and total swans (0.23 birds/km²) all increased over 2001 (Table 23), and differed only slightly from the Kuparuk Oilfield in 2002 (0.09, 0.13, and 0.22 birds/km², respectively) (Anderson et al.2003). The density of adult swans in the NPRA Study Area during the nesting season in 2001 and 2002 was within the range of densities reported by BLM (1998) for the northeastern NPRA (0–0.59 birds/km²). As was the case for nest densities, the Colville River Delta supported greater densities of all categories of swans in 2002: breeding swans, 0.17 birds/km²; non-breeding, 0.34 birds/km²; and total birds, 0.51 birds/km².

In 2002, Tundra Swans nesting between the Kuparuk River and the western edge of the NPRA Study Area (total area surveyed, 3819 km²) increased in number over that of the past several years (ABR, unpubl. data). On the Colville River Delta, 55 swan nests were found in 2002, more nests than had been counted in 8 previous years of aerial surveys (Johnson et al. 2003b). In the Kuparuk survey area, 115 swan nests were recorded, the second largest number in 13 years of surveys (Anderson et al.2003). Although we have only 2 years of survey data for the NPRA Study Area, the increase in nests from 32 in 2001 to 41 in 2002 is suggestive of a similar trend.

Brood-rearing

We counted 302 Tundra Swans in the survey area during the brood-rearing aerial survey in August 2002 (Table 24, Figure 20). This total included 27 broods comprising 55 young and 53 breeding adults. An additional 194 non-breeding adults were counted, primarily in pairs scattered throughout the survey area. In 2001, 21 broods (53 young, 40 adults) were recorded in the common survey area.

Although the number of swan nests appeared to increase across the region in 2002, nesting success apparently was low. A rough estimate of nest success, calculated as the number of observed broods divided by the number of observed nests, suggests a minimum nesting success of 63% in the NPRA in 2002 (27 of 43 nests successful). Similar

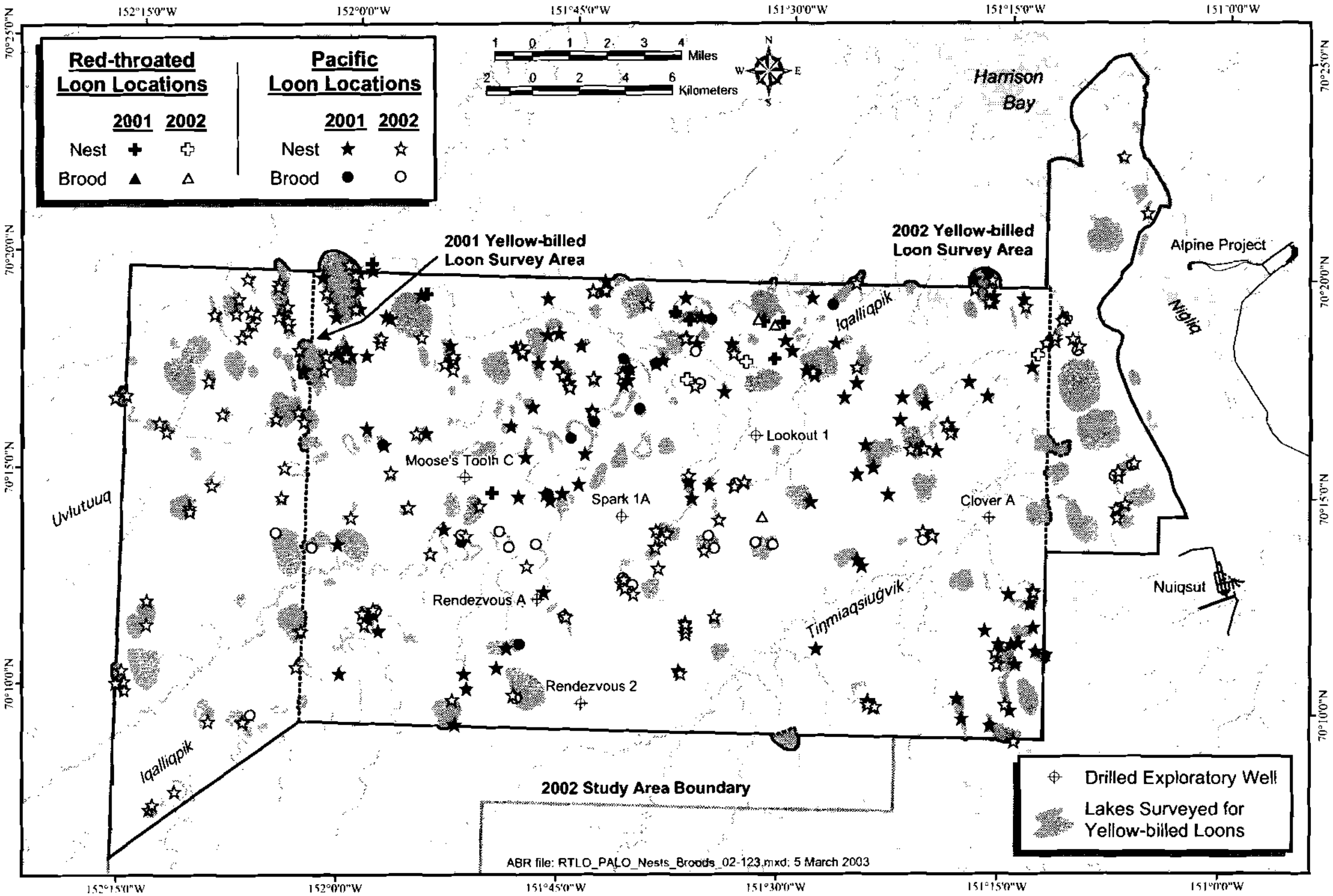

Figure 19. Red-throated Loon and Pacific Loon nests and broods during aerial and ground surveys, NPRA Study Area, Alaska, 2001–2002.

calculations yielded an estimate of 68% nesting success in the NPRA study area in 2001. Comparable brood-rearing surveys in the Kuparuk Oilfield and on the Colville River Delta indicated minimum nesting success rates of 58% and 31%, respectively, in 2002 (ABR, unpubl. data.). These are the lowest success rates that have been recorded in the Kuparuk and Colville River Delta areas, where mean nesting success is 81% (*n* = 13 years) and 71% (*n* = 9 years), respectively. Although nesting success was somewhat higher in the NPRA than in either Kuparuk or Colville areas in 2002, both the 2001 and 2002 estimates of nesting success in NPRA were below the long-term averages for those areas.

In 2002, the mean brood size of 2.0 young/brood (range 1–4), for the NPRA Study Area was less than the mean of 2.5young/brood found in 2001. Over 13 years of aerial surveys in the Kuparuk Oilfield, the mean brood size was 2.5 young/brood, and over 9 years of surveys of the Colville River Delta, the mean was 2.7 young/brood. However, brood sizes in both the Kuparuk and Colville River Delta areas were near or above average in 2002. On the Colville River Delta, brood size averaged 3.2 young (*n* = 17), the highest mean since 1996. In the Kuparuk survey area, broods averaged 2.4 young (*n* = 67), also the highest value since 1996. The healthy average size of surviving broods throughout the region surveyed indicates that the loss of entire broods, rather than partial brood loss, was a widespread occurrence. Although the nest success rate for NPRA in 2002 was higher than either the Colville River Delta or the Kuparuk Oilfield study area, the mean brood-size was smaller, and exhibited an opposite trend compared with the neighboring areas.

Habitat Use

Nesting

Forty-six of 74 total Tundra Swan nests in 2001 and 2002 were located inside the mapped portion of the NPRA Study Area. Swan nests occurred in a wide variety of habitats (Table 25). Nine nests were found in the 2 preferred habitats: Deep Open Water with Islands or Polygonized Margins and Aquatic Grass Marsh. Moist Sedge-Shrub Meadow was found to be avoided by nesting swans. Although not identified as preferred, Moist Tussock Tundra was the most widely available habitat in the study area and was used by the largest percentage (30.4%) of nesting swans.

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

Brood-rearing

Tundra Swans with broods used 10 of 27 available habitats in the NPRA Study Area (Table 25). The majority (64%, 21 of 33) of broods in the NPRA Study Area were found in two preferred habitats: Deep Open Water with Isands or Polygonized Margins and Deep Open Water without Islands (Table 25). Four broods were found in Non-Patterned Wet Meadow, the third preferred habitat. Four broods were found in the 3 avoided habitats: Patterned Wet Meadow, Moist Sedge-Shrub Tundra, and Moist Tussock Tundra.

Swan broods in northeast Alaska used different habitats as the brood-rearing season progressed (Monda et al. 1994). Early in the brood-rearing season on the Kongakut River delta, Tundra Swans grazed mainly in saline graminoid marsh and aquatic-marsh habitats. Later in the season, surface and sub-surface foraging concentrated more in aquatic-marsh habitat. Changes in habitat and foraging methods may be related to nutritive quality of different plants or the increasing ability of older, larger cygnets to feed on submerged vegetation (e.g., pondweed [*Potamogeton* spp.]) in deeper water. Several studies have identified salt-affected habitats as important for Tundra Swans during the brood-rearing and molting periods. Spindler and Hall (1991) found swans feeding on various species of submergent pondweed in late August and September in brackish water on river deltas of

Table 23. Number and density (number/km²) of Tundra Swans and nests during aerial surveys of the NPRA Study Area, Alaska, June 2001–2002.

	Number		Density	
	2001	2002	2001[a]	2002[b]
NESTS	31	43	0.03	0.04
BREEDING SWANS				
Singles	8	10	0.01	0.01
Pairs	23	33	0.02	0.03
Total Adults	54	76	0.05	0.07
NON-BREEDING SWANS				
Singles	23	25	0.02	0.02
Pairs	44	55	0.04	0.05
In Flocks	24	34	0.02	0.03
Total Adults	135	169	0.13	0.16
TOTAL SWANS	189	245	0.19	0.23

[a] 2001 density based on a survey area of 1,021 km².
[b] 2002 density based on a survey area of 1,100 km².

the Kobuk-Selawik Lowlands. On the Colville River Delta, swans also favor pondweed during the brood-rearing and molting periods (Johnson and Herter 1989) and salt-affected habitats (Brackish Water, Salt Marsh, and Tapped Lake with Low-water Connection) were identified as preferred by brood-rearing swans on the Colville River Delta (Burgess et al. 2003). Wilk (1988) described spring-staging swans feeding on abundant pondweed in tidally influenced habitat in the Naknek River. Monda et al. (1994) also found that pondweed and alkali grass (*Puccinellia phryganodes*) were important component of the diet of swans in salt-affected habitats of the Kongakut and Canning river deltas. The NPRA Study Area contains very little salt-affected habitat (e.g., Tapped-lake with Low-water Connection) yet swans successfully rear broods there.

GOOSE SURVEYS

Background

Nesting colonies of Brant and their brood-rearing areas have received special consideration during oilfield planning because of declining populations of this species throughout its range in Alaska. Brant are traditional in their selection of nesting and brood-rearing areas and, hence, potentially vulnerable to changing conditions in those areas. Brant arrive in the region in late May and early June, and nest initiation begins as soon as suitable nesting habitat is available (Kiera 1979, Rothe et al. 1983). After eggs hatch in early July, most brood-rearing birds move from nesting areas to salt marshes along the coast. The fall migration of Brant along the arctic coast of Alaska usually begins in mid-to-late August (Johnson and Herter 1989). Salt marshes and major river deltas, such as the Colville River Delta, provide important resting and feeding areas for Brant at that time (Johnson and Richardson 1981).

Greater White-fronted Geese commonly breed along the Beaufort Sea coast (Johnson and Herter 1989) and were reported to be the most abundant nesting goose in the vicinity of Point Barrow in the early 1900s (Anderson 1913, see Johnson and Herter 1989). In earlier investigations in 1977–1978, weekly ground censuses of large birds in 6 locations in the NPRA yielded mean seasonal

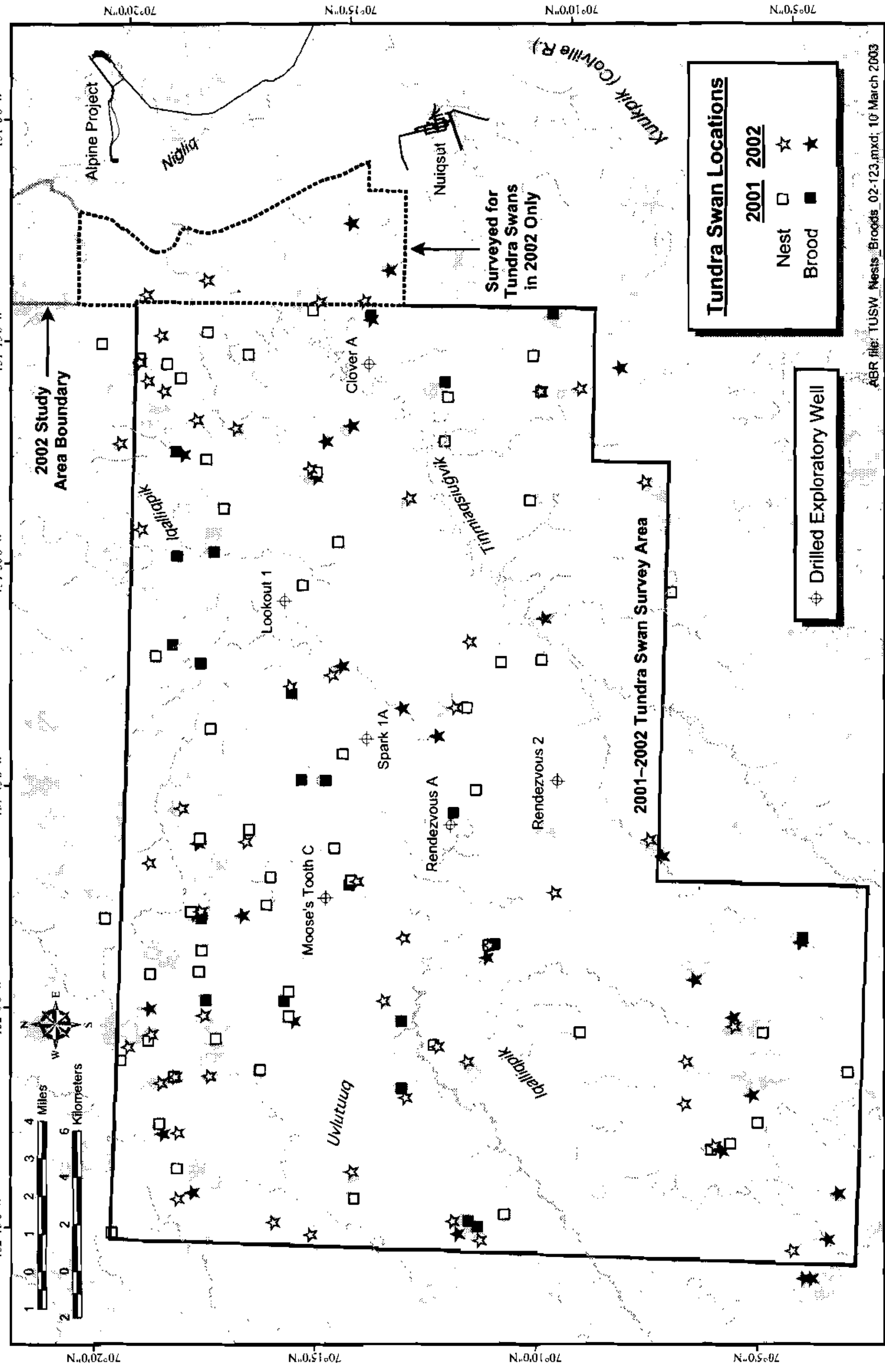

Figure 20. Tundra Swan nest and brood locations during aerial and ground surveys, NPRA Study Area, Alaska, 2001–2002.

Table 24. Number and density (number/km²) of Tundra Swans and broods during aerial surveys of the NPRA Study Area, Alaska, August 2001–2002.

	Number		Density	
	2001	2002	2001[a]	2002[b]
BROODS	21	27	0.02	0.03
BREEDING SWANS				
Singles	2	1	0.00	0.00
Pairs	19	26	0.02	0.03
Young	53	55	0.05	0.05
Total Adults	40	53	0.04	0.05
NON-BREEDING SWANS				
Singles	15	19	0.01	0.02
Pairs	52	57	0.05	0.05
In Flocks	58	61	0.06	0.06
Total Adults	177	194	0.17	0.18
TOTAL SWANS				
Adults	217	247	0.21	0.23
Young	53	55	0.05	0.05
Total Swans	270	302	0.26	0.28

[a] Density based on a survey area of 1,021 km².
[b] Density based on a survey area of 1,100 km².

densities of Greater White-fronted Geese ranging from 0.7 birds/km² at Meade River near the coast to 2.7 birds/km² at Singiluk, 140 km inland (Derksen et al. 1981). Greater White-fronted Geese arrive on the breeding grounds by mid-late May, and will nest singly or in small loose colonies (Johnson and Herter 1989), usually initiating nests by early June. Hatching typically occurs by the last week of June or first week of July, and the young are taken almost immediately to water. Greater White-fronted Geese usually rear their broods in groups and are often found in or near larger lakes. These geese begin fall-staging and migration earlier than observed in other arctic-nesting geese, and will have gathered into flocks by mid-August, often staging on deltas or along rivers (Johnson and Herter 1989).

The Canada Goose is a regular breeding and molting bird along the Beaufort Sea coast, but does not occur in all suitable habitats. Prior to 1996, Canada Geese were not reported nesting either in NPRA (Derksen et al. 1981) or on the Colville River Delta (Simpson et al. 1982, North et al. 1984), although local residents have observed Canada Geese nesting in the NPRA since at least the 1980s (J. Helmericks, pers. comm.). Canada Geese arrive and nest at about the same time as the other geese discussed above. A major molting area for these geese is located near Teshekpuk Lake, northwest of the NPRA Study Area (Derksen et al. 1981).

Distribution and Abundance

During the nesting survey on 18 June 2002, 51 Brant and 26 nests were recorded at 9 locations within the NPRA Study Area during the aerial survey (Figure 21). The majority of the nesting locations were in the northeastern section of the study area in the vicinity of Iqalliqpik and Tiŋmiaqsiuġvik. In addition, 2 nesting locations were immediately outside of the northeast section of the study (Figure 21), one of which had an

Table 25. Habitat selection by Tundra Swans during nesting and brood-rearing in the NPRA Study Area, Alaska, 2001–2002.

SEASON Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	MonteCarlo Results[a]
NESTING					
Open Nearshore Water	0	-	-	0	-
Brackish Water	0.03	0	0	<0.1	ns
Tapped Lake with Low-water Connection	1.59	0	0	0.2	ns
Tapped Lake with High-water Connection	0.01	0	0	<0.1	ns
Salt Marsh	0.08	0	0	<0.1	ns
Tidal Flat	0	-	-	0	-
Salt-killed Tundra	0	-	-	0	-
Deep Open Water without islands	44.52	1	2.2	6.9	ns
Deep Open Water with Islands or Polygonized Margins	33.66	7	15.2	5.2	prefer
Shallow Open Water without islands	6.70	0	0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	10.61	2	4.3	1.7	ns
River or Stream	5.85	0	0	0.9	ns
Aquatic Sedge Marsh	11.22	1	2.2	1.7	ns
Aquatic Sedge with Deep Polygons	0.27	0	0	<0.1	ns
Aquatic Grass Marsh	1.79	2	4.3	0.3	prefer
Young Basin Wetland Complex	2.27	0	0	0.4	ns
Old Basin Wetland Complex	57.88	5	10.9	9.0	ns
Riverine Complex	2.75	0	0	0.4	ns
Dune Complex	7.59	1	2.2	1.2	ns
Nonpatterned Wet Meadow	19.43	2	4.3	3.0	ns
Patterned Wet Meadow	72.74	4	8.7	11.3	ns
Moist Sedge-Shrub Meadow	156.09	6	13.0	24.3	avoid
Moist Tussock Tundra	182.43	15	32.6	28.4	ns
Riverine Low and Tall Shrub	7.22	0	0	1.1	ns
Upland and Riverine Dwarf Shrub	8.94	0	0	1.4	ns
Upland Low and Tall Shrub	2.79	0	0	0.4	ns
Barrens	6.25	0	0	1.0	ns
TOTAL	642.72	46	100	100	
BROOD-REARING					
Open Nearshore Water	0	-	-	0	-
Brackish Water	0.03	0	0	<0.1	ns
Tapped Lake with Low-water Connection	1.59	0	0	0.2	ns
Tapped Lake with High-water Connection	0.01	0	0	<0.1	ns
Salt Marsh	0.08	0	0	<0.1	ns
Tidal Flat	0	-	-	0	-
Salt-killed Tundra	0	-	-	0	-
Deep Open Water without islands	44.52	10	30.3	6.9	prefer
Deep Open Water with Islands or Polygonized Margins	33.66	11	33.3	5.2	prefer
Shallow Open Water without islands	6.70	1	3.0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	10.61	1	3.0	1.7	ns
River or Stream	5.85	0	0	0.9	ns
Aquatic Sedge Marsh	11.22	0	0	1.7	ns
Aquatic Sedge with Deep Polygons	0.27	0	0	<0.1	ns
Aquatic Grass Marsh	1.79	0	0	0.3	ns
Young Basin Wetland Complex	2.27	0	0	0.4	ns
Old Basin Wetland Complex	57.88	1	3.0	9.0	ns
Riverine Complex	2.75	1	3.0	0.4	ns
Dune Complex	7.59	0	0	1.2	ns
Nonpatterned Wet Meadow	19.43	4	12.1	3.0	prefer
Patterned Wet Meadow	72.74	1	3.0	11.3	avoid
Moist Sedge-Shrub Meadow	156.09	2	6.1	24.3	avoid
Moist Tussock Tundra	182.43	1	3.0	28.4	avoid
Riverine Low and Tall Shrub	7.22	0	0	1.1	ns
Upland and Riverine Dwarf Shrub	8.94	0	0	1.4	ns
Upland Low and Tall Shrub	2.79	0	0	0.4	ns
Barrens	6.25	0	0	1.0	ns
TOTAL	642.72	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.

estimated 50 adults and 25 nests present. The number of Brant and nests observed in 2002 was more than twice as great as that recorded in 2001 (20 Brant and 9 nests at 8 locations). The difference was likely due to refinement of the helicopter survey method and more favorable weather conditions during the survey in 2002. The Brant colony in the Alpine West ground-search area had 6 Brant nests in 2002 (the most accurate count of nests in this colony was made by ground-searchers) (Figures 10 and 21). Although suitable habitats for nesting Brant exist in the vicinity of Uvlutuuq and Iqalliqpik, much of the remainder of the study area lacks suitable habitats and is farther inland than Brant typically are found nesting (Anderson et al. 1999, Johnson et al. 1999, Ritchie and Wildman 2000).

During the nesting aerial survey in 2002, 48 Canada Geese and 22 nests were recorded at 23 locations (Figure 21). In comparison, only 7 Canada Geese and 1 nest were recorded incidentally at 4 locations in 2001. Ground searchers found an additional 18 Canada Goose nests, the majority of which (16 nests) occurred in the Alpine West ground-search area (Figures 10 and 21).

The most abundant species of goose observed during the brood-rearing and fall-staging aerial surveys in the NPRA Study Area was the Greater White-fronted Goose (Figures 22 and 23). Greater White-fronted Geese were the only species observed during aerial surveys in 2001, but small numbers of Canada Geese also were observed during 2002 surveys. The low numbers of Canada Geese (19 during the brood-rearing survey and 9 during the staging survey) and absence of Brant on these later surveys are consistent with the tendency of these 2 species to move to coastal areas during July and August.

During the brood-rearing aerial survey in 2002, 910 Greater White-fronted Geese were observed in 31 groups (29.4 geese/group, range = 2–82) (Table 26, Figure 22). Juvenile geese comprised only 12% (110 young) of the total. Densities of White-fronted Geese were the same in both 2001 and 2002: (0.8 geese/km^2 and 0.1 young/km^2). In both years, brood-rearing groups were observed primarily in lakes and ponds associated with the creeks in the study area.

During the fall-staging survey in 2002, 1104 Greater White-fronted Geese were observed in 37 groups (mean = 29.8 geese/group, range = 2–250) (Table 26, Figure 23). Densities were the same in both 2001 and 2002 (1.0 geese/km^2). Fall-staging geese were more widely distributed throughout the study area compared to brood-rearing and molting groups.

Habitat Use

Both Brant and Canada Geese nested most commonly on islands in waterbodies (Table 27). Over 90% of Brant nests and 68% of Canada Goose nests were located in three habitats: Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Deep Open Water with Islands or Polygonized Margins. In addition, Brant also nested in Patterned Wet Meadow (8% of nests), in association with waterbodies. Aquatic Sedge with Deep Polygons was a preferred nesting habitat in the Colville River Delta (Johnson et al. 2003b), but in the NPRA this habitat represented <0.1% of the total mapped area. Another preferred nesting habitat for Brant on the Colville River Delta was Salt-killed Tundra, which did not occur in the NPRA Brant survey area. Additional habitats used by nesting Canada Geese included Old Basin Wetland Complex, and Patterned Wet Meadow. Most Brant and Canada Goose nests were situated less than 1 m from the edge of a waterbody.

During brood-rearing, both White-fronted and Canada geese occurred in or near lakes, rivers, streams, and marshes (Table 28, Figure 22). More than 76% of all Greater White-fronted Goose sightings and 100% of the Canada Goose sightings were in aquatic habitats, usually near creek or river drainages. The terrestrial habitats in which Greater White-fronted Geese were observed in both years were those associated with lakes or the 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 survey itself, and may not represent use of foraging habitat.

During fall-staging, the distribution of Greater White-fronted and Canada geese shifted somewhat from that observed during brood-rearing. While aquatic habitats were still important, comprising 58% of all sightings of Greater White-fronted

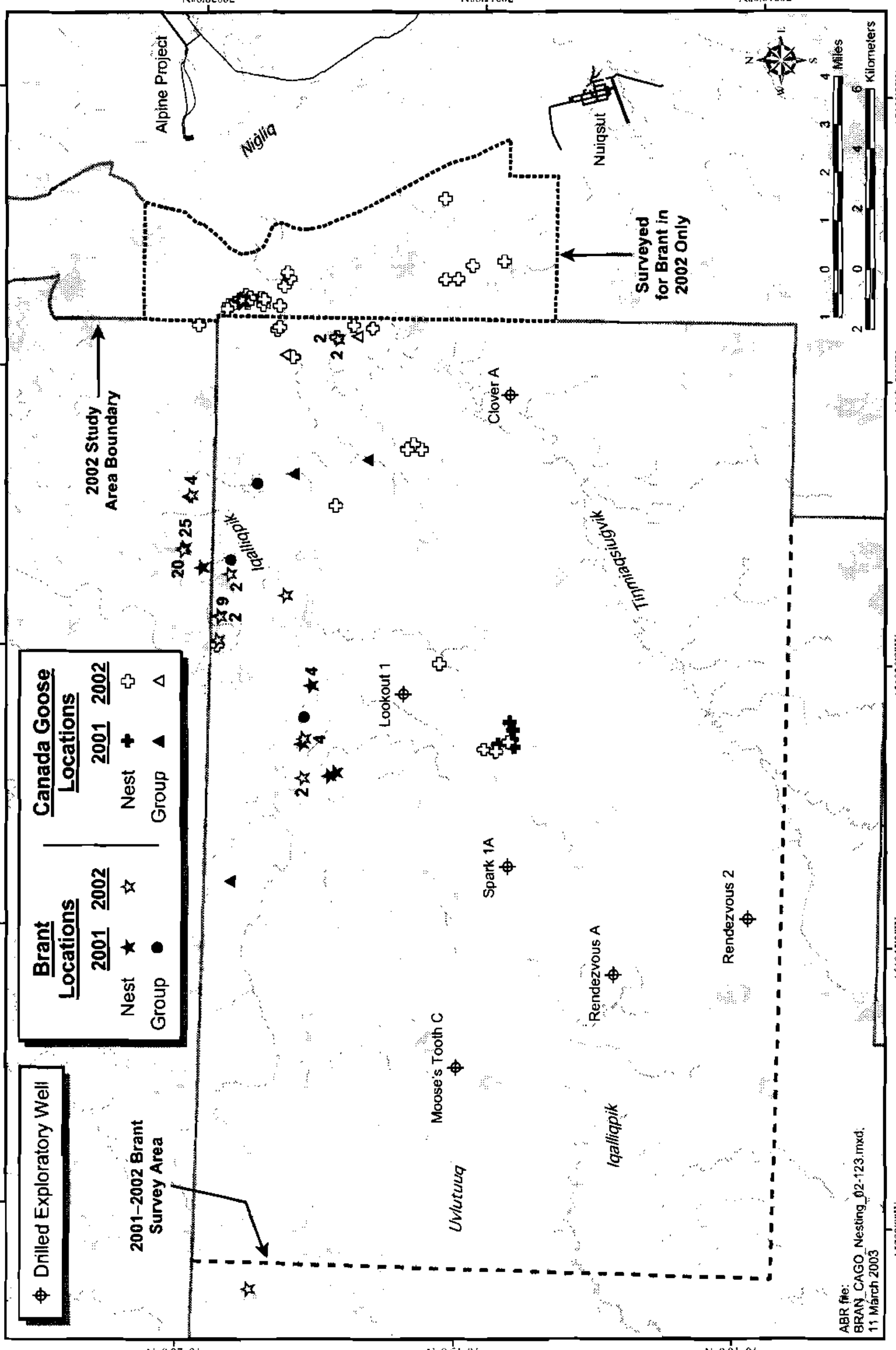

Figure 21. Brant and Canada Goose nest and group locations during aerial and ground surveys, NPRA Study Area, Alaska, June 2001–2002. Labels indicate the number of nests (and the year of observation) if >1 nest was present.

Geese, many of the lakes used were outside of river and stream drainages (Table 29, Figure 23). Another difference between the two seasons in 2002 was a shift in distribution of fall-staging groups of Greater White-fronted Geese toward the southwest portion of the study area (outside of the habitat-mapped area). During brood-rearing in 2002, only 16% of all groups occurred outside of the mapped area, whereas during fall-staging, >50% of all groups occurred outside this area. The only group of Canada Geese observed during fall-staging occurred in Patterned Wet Meadow near the northern reach of the Tiŋmiaqsiuġvik River.

GULL SURVEYS

Background

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

The Sabine's Gull is an uncommon migrant and breeder in the Beaufort Sea area (Johnson and Herter 1989). On the Arctic Coastal Plain, Sabine's Gulls arrive on their nesting grounds during the first week of June (Bergman et al. 1977, Rothe et al. 1983, North et al. 1984). Egg-laying begins in mid-June and continues until early July (Day et al. 2001, ABR, unpubl. data). Sabine's Gulls nest solitarily or in small colonies on the mossy edges of small ponds, on islands within ponds, or on low-lying marshy tundra near shore (Day et al. 2001).

Distribution and Abundance

In 2002, 89 Glaucous Gull nests were counted in the NPRA Study Area; 86 nests were found during aerial surveys and an additional 3 were found during ground searches (Table 30, Figure 24). Of the 89 nests found, 10 nests were in 2 small colonies—one colony in the Alpine West ground-search area had 4 nests (Table 5, Figure 10) and another south of the Lookout Well had 6 nests (Figure 24). The colony south of the Lookout Well was discovered during ground searches in 2001 and 4 nests were found in that year. Most other nest locations consisted of single nesting pairs.

Glaucous Gull nests were distributed throughout the NPRA Study Area in both 2001 and 2002 (Figure 24). Based on counts from aerial and ground surveys, nest density for Glaucous Gulls was 0.08 nests/km² in 2002 in the NPRA Study Area (1100 km²; Table 30). On similar aerial and ground surveys conducted on the Colville River Delta in 2002, nest density for Glaucous Gulls was 0.09 nests/km² (ABR, unpubl. data). Nest density in the 2001 NPRA Study Area (615 km²) was 0.05 nests/km², but nests were recorded only during the nesting survey for Yellow-billed Loons which focused on larger lakes and, therefore, the survey was not comprehensive for Glaucous Gulls (Burgess et al. 2002). All Glaucous Gull nest locations found in 2001 were checked in 2002 and 77% (23 of 30 nests) were occupied.

Nests of Glaucous Gulls were not revisited. On lakes that were included in the aerial loon survey, however, 2 Glaucous Gull broods were seen near a known nest locations (Figure 24). During ground searches in Alpine West, 2 broods were found in July, one with 1 young and the other with 2 young.

During the 2002 nesting survey for Yellow-billed Loons, 45 Sabine's Gull nests were found in the NPRA Study Area, either as single nests or in colonies (Table 30). Forty-three of the 45 Sabine's Gull nests in the study area were located in 5 nesting colonies (Figure 24). The number of nests in each colony, estimated by the number of adults present, ranged from 3–15. Two colonies, with 8 and 9 nests in 2002, also were present in 2001 with 5 nests each. An additional

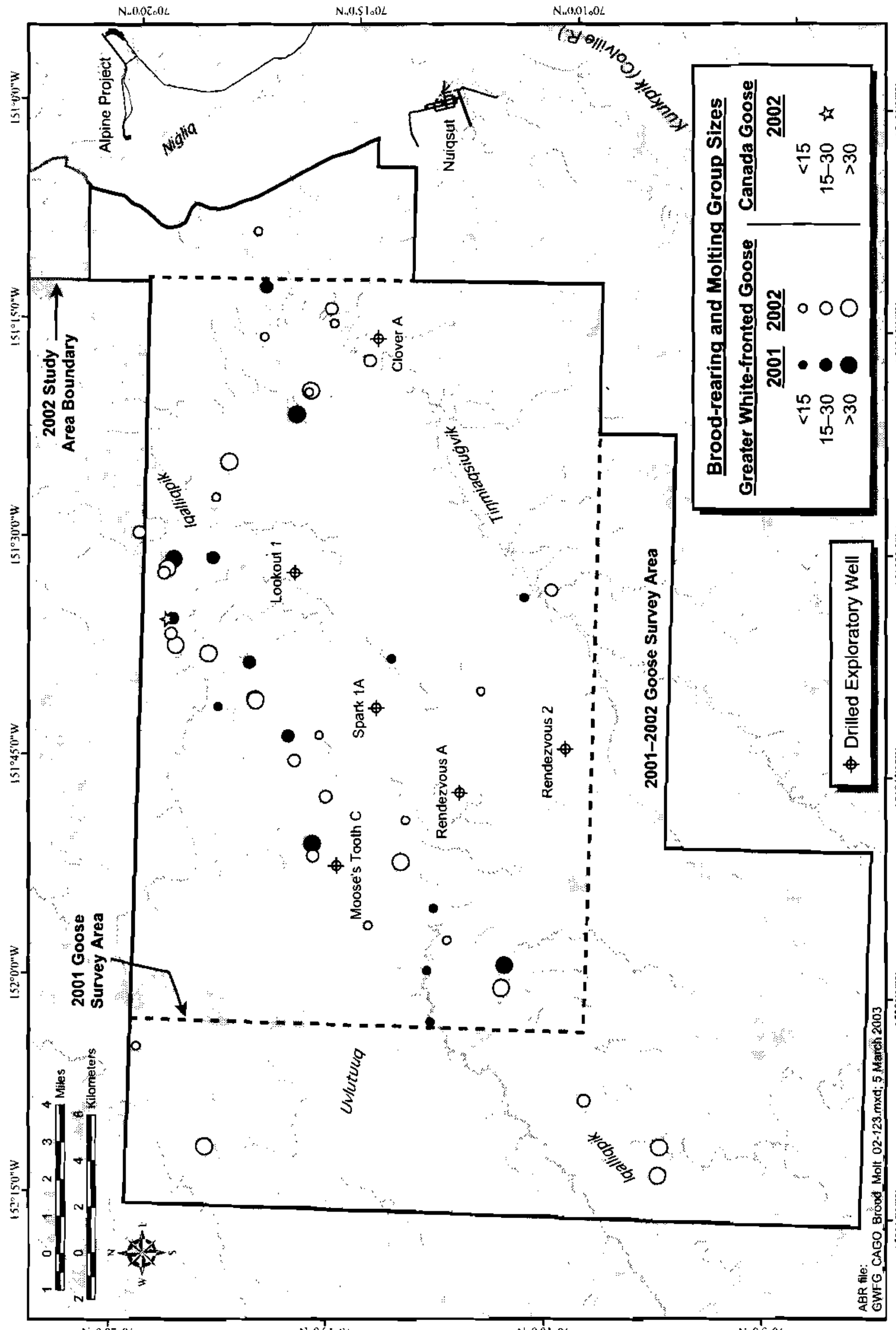

Figure 22. Greater White-fronted Goose and Canada Goose brood-rearing and molting groups during aerial surveys, NPRA Study Area, Alaska, 2001–2002.

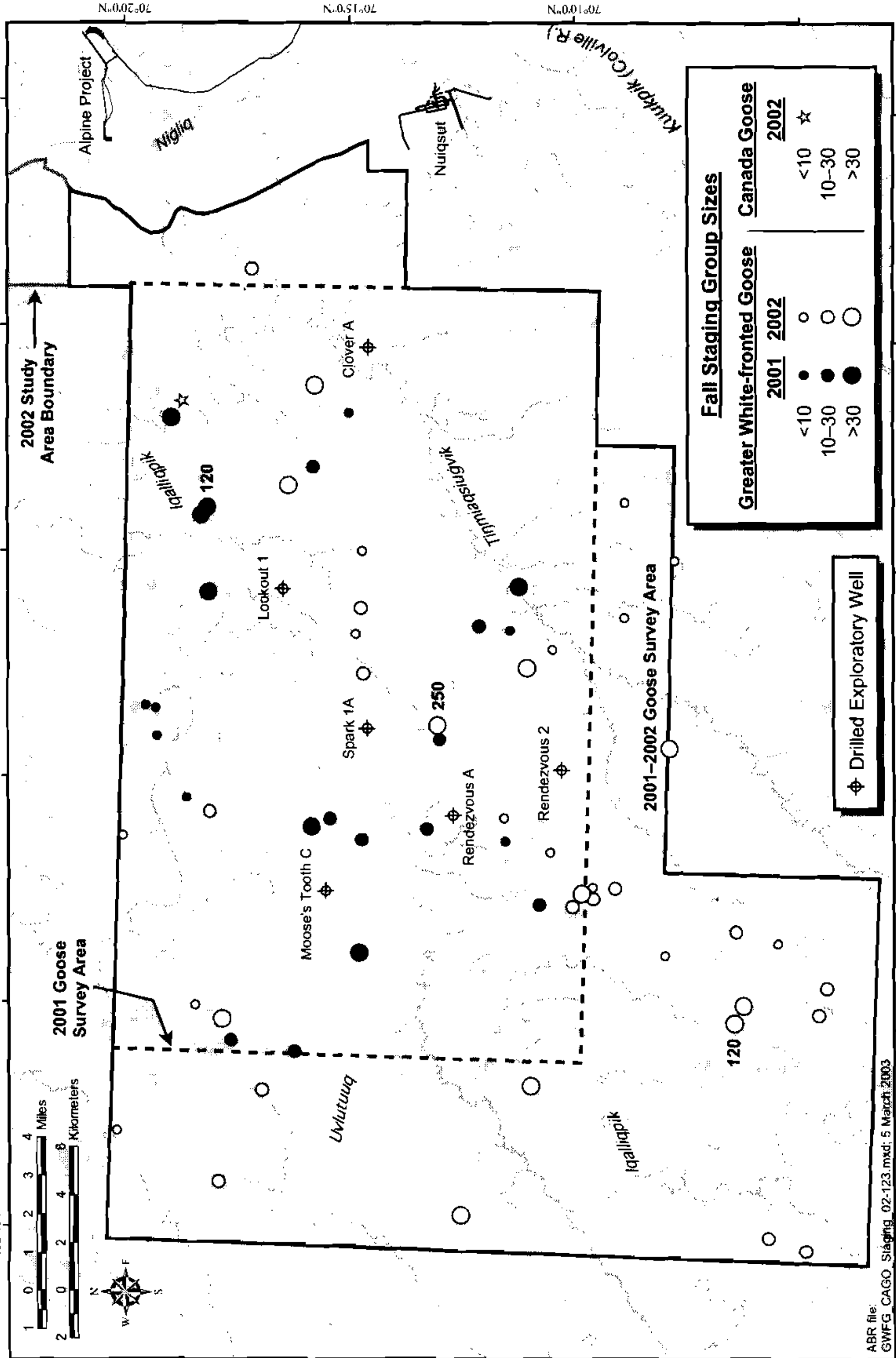

Figure 23. Greater White-fronted Goose and Canada Goose fall-staging groups during aerial surveys, NPRA Study Area, Alaska, 2001–2002. Labels indicate the number of birds for groups larger than 100 birds.

Table 26. Number and density of brood-rearing and fall-staging geese during aerial surveys of the NPRA Study Area, Alaska, 2001–2002.

SEASON Year	Greater White-fronted Goose Total Birds	 Density[a] (no/km²)	Canada Goose Total Birds	 Density (no/km²)
BROOD-REARING				
2001	508	0.8		
2002	910	0.8	19	0.02
FALL-STAGING				
2001	620	0.1		
2002	1.104	0.1	9	0.01

[a] Density based on a survey area of 615 km² in 2001 and 1,100 km² in 2002.

Table 27. Habitat use by nesting Brant and Canada Geese in the NPRA Study Area, Alaska, 2001–2002.

Habitat	Brant No. of Nests	 Use (%)	Canada Goose No. of Nests	 Use (%)
Deep Open Water with Islands or Polygonized Margins	4	16.7	1	4.0
Shallow Open Water with Islands or Polygonized Margins	8	33.3	15	60.0
Aquatic Sedge with Deep Polygons	10	41.2	1	4.0
Old Basin Wetland Complex			6	24.0
Patterned Wet Meadow	2	8.3	2	8.0
TOTAL	24	100	25	100

colony of 4 nests was located in 2001 <1 km north of the NPRA Study Area boundary (Figure 24). All Sabine's Gull colonies and nests were located in the western part of the study area. Sabine's Gulls are difficult to survey from the air and colonies are more obvious than single nesting pairs. Because our sightings are opportunistic and not comprehensive for Sabine's Gulls, densities and habitat use were not calculated.

Habitat Use

Habitat information is available for 104 Glaucous Gull nests in the NPRA Study Area in 2001 and 2002 (Table 31). Glaucous Gulls were found nesting in 8 of 27 available habitats. Most nests were located on islands in Shallow Open Water with Islands or Polygonized Margins (63 nests, 61%) and Deep Open Water with Islands or Polygonized Margins (18 nests, 17%). The remaining nests were found on islands or complex shorelines of 6 other habitats: Shallow Open Water without Islands (5 nests, 5%), Aquatic Grass Marsh (1 nest, 1%), Aquatic Sedge Marsh (3 nests, 3%), Old Basin Wetland Complex (7 nests, 7%), Nonpatterned Wet Meadow (2 nests, 2%), and Patterned Wet Meadow (5 nests, 5%).

Table 28. Habitat use by brood-rearing and molting groups of Greater White-fronted and Canada geese in the NPRA Study Area, Alaska, 2001–2002.

	Greater White-fronted Goose		Canada Goose	
Habitat	No. of Groups	Use (%)	No. of Groups	Use (%)
Deep Open Water without Islands	9	20.9	1	100
Deep Open Water with Islands or Polygonized Margins	16	37.2	-	-
Shallow Open Water without Islands	2	4.7	-	-
Shallow Open Water with Islands or Polygonized Margins	1	2.3	-	-
River or Stream	3	7.0	-	-
Aquatic Grass Marsh	2	4.7	-	-
Riverine Complex	1	2.3	-	-
Dune Complex	1	2.3	-	-
Nonpatterned Wet Meadow	1	2.3	-	-
Patterned Wet Meadow	2	4.7	-	-
Moist Sedge-Shrub Meadow	2	4.7	-	-
Riverine Low and Tall Shrub	3	7.0	-	-
TOTAL	43[a]	100	1	100

[a] 5 groups in 2002 occurred outside of the area mapped for habitats.

Table 29. Habitat use by fall-staging groups of Greater White-fronted and Canada geese in the NPRA Study Area, Alaska, 2001–2002.

	Greater White-fronted Goose		Canada Goose	
Habitat	No. of Groups	Use (%)	No. of Groups	Use (%)
Deep Open Water without Islands	14	34.1	-	-
Deep Open Water with Islands or Polygonized Margins	4	9.8	-	-
Shallow Open Water without Islands	2	4.9	-	-
Shallow Open Water with Islands or Polygonized Margins	3	7.3	-	-
River or Stream	1	2.4	-	-
Old Basin Wetland Complex	5	12.2	-	-
Nonpatterned Wet Meadow	1	2.4	-	-
Patterned Wet Meadow	4	9.8	1	100.0
Moist Sedge-Shrub Meadow	5	12.2	-	-
Moist Tussock Tundra	1	2.4	-	-
Riverine Low and Tall Shrub	1	2.4	-	-
TOTAL	41[a]	100	1	100

[a] 19 groups in 2002 occurred outside of the area mapped for habitats.

CARIBOU SURVEYS

Background

Caribou are the most important terrestrial species used for subsistence by local residents on the North Slope (Brower and Opie 1997, Fuller and George 1997, BLM 1998). The NPRA Study Area is within the annual hunting range of residents of Nuiqsut (Pedersen 1995, Prichard et al. 2001), the nearest community, and the continued availability of caribou for local subsistence harvest is a prominent issue in planning for oil and gas development (Lawhead et al. 2001).

The NPRA Study Area is used by caribou from 2 adjacent herds: the Teshekpuk Herd (TH) and the Central Arctic Herd (CAH) (BLM 1998). The 2 herds are similar in size, although the TH has been growing at a faster rate in recent years. The latest Alaska Department of Fish and Game (ADFG) photocensuses in July 2002 counted ~45,000 caribou in the TH (P. Valkenburg, pers. comm.) and 31,857 caribou in the CAH (E. Lenart, pers. comm.). The degree of use of the study area by each herd varies according to the season and year, but the available data demonstrate more consistent use of the northeastern NPRA area by TH caribou than by the CAH. The TH 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 NPRA Study Area is within the year-round range of the TH on the coastal plain (BLM 1998). Previous caribou studies in the NPRA have focused on the Teshekpuk Lake area to the west, the heart of the annual range of the TH (BLM 1998, Prichard et al. 2001) and relatively little data has been collected in our NPRA Study Area. Specific information reported recently for the study area comes from satellite tracking of a few collared caribou (Philo et al. 1993, Prichard et al. 2001), aerial transect surveys that covered the northern portion of the area in 1999, 2000, and 2001 (Noel 2000; Noel et al. 2001; L. Noel, pers. comm.), and anecdotal reports from the tracking of animals fitted with standard VHF radio-collars (G. Carroll, pers. comm.; E. Lenart, pers. comm.).

Caribou of the CAH also use the study area, but less frequently than do TH caribou. Telemetry studies since the 1970s (e.g., Lawhead and Curatolo 1984, Cameron et al. 1995) found little use of the area west of the Colville River by CAH caribou during the calving and insect seasons, the periods of greatest use of the coastal plain by that herd. In June 2001, however, several radio-collared females of the CAH were found in the northeastern part of the NPRA, providing the first record of CAH cows there during the calving season in >20 years of radio-tracking (E. Lenart, ADFG, pers. comm.). An unprecedented large movement of CAH caribou occurred in July 2001 during a period of warm temperatures and persistent westerly winds, when >6000 CAH animals moved westward across the Colville River Delta and into NPRA.

On the central North Slope, caribou movements during midsummer are influenced predominantly by harassment by mosquitoes (*Aedes* spp.) and oestrid flies (*Hypoderma tarandi* and *Cephenemyia trompe*) (White et al. 1975, Roby 1978, Lawhead and Curatolo 1984). Mosquito activity is lowest at the Beaufort Sea coast due to low ambient air temperature and elevated wind speeds there (White et al. 1975, Dau 1986), so caribou in this region normally move northward to the coast to escape mosquito harassment. Mosquito-harassed caribou move coastward and upwind as far as necessary to reach insect-free habitat (Lawhead and Curatolo 1984, Dau 1986).

Harassment of caribou by oestrid flies typically lasts from mid-July into August on the North Slope (Dau 1986). Fly-harassed caribou use unvegetated and elevated sites, such as pingos, mud flats, and river bars, as relief habitat. By August, insect harassment abates and coastal habitats become less important as caribou begin to disperse southward (Lawhead and Curatolo 1984, Prichard et al. 2001). This inland dispersal continues through fall migration in September and into the breeding season (rut) in October.

The majority of the CAH migrates south off the coastal plain to winter in the foothills and mountains of the Brooks Range (Cameron and Whitten 1979, Carruthers et al. 1987), whereas TH caribou winter on the coastal plain in most years (Prichard et al. 2001). The location and extent of winter range use on the coastal plain appears to be

Table 30. Number and density (nests/km²) of Glaucous Gull and Sabine's Gull nests located during aerial surveys and in ground-search areas of the NPRA Study Area, Alaska, 2001–2002.

SPECIES Year	Number of Nests by Survey Aerial Survey[b]	 Ground-search Areas[c]	 Total Nests	Nest Density[a] Aerial Survey
GLAUCOUS GULL				
2001	22	8	30	0.05
2002	86	3	89	0.08
SABINE'S GULL				
2001	10	3	13	–
2002	42	3	45	–

[a] Density based on survey area of 615 km² in 2001 and 1,100 km² in 2002.
[b] In 2002, data were collected during aerial nesting surveys for Yellow-billed Loons, Tundra Swans, and Brant. In 2001, data were collected during the aerial nesting survey for Yellow-billed Loons.
[c] In 2002, data were collected in large waterbird ground-search areas and lake drawdown study areas. In 2001, data were collected in large waterbird and Red-throated Loon ground-search areas.

a fundamental difference between the CAH and the TH.

Distribution and Abundance

Moderate numbers of caribou were distributed throughout the survey area on the 2 pre-calving surveys in May 2002. On 3 May, 190 caribou in 61 groups were seen on transects and, on 25–26 May, 215 caribou were observed in 65 groups (Table 32, Figure 25), yielding estimates of 380 and 430 caribou over the entire study area, respectively (density = 0.29 and 0.33 caribou/km²). No calves were seen in May 2002. These numbers were lower than in 2001, when 319 caribou (no calves) were observed in 55 groups (estimate ~640 caribou) in a smaller area on 20 May.

The NPRA Study Area was not an important calving area in 2001 or 2002. Results of other studies (BLM 1998; Philo et al. 1993; Noel 2000; Noel et al. 2001; Prichard et al. 2001; L. Noel, pers. comm.; G. Carroll, pers. comm.) show that it is located at the southeastern periphery of the TH calving grounds and is very rarely used for calving by CAH animals. The 2 calving surveys on 8 and 18 June (Figure 26) revealed little use of the study area by calving females in 2002, although the number of other caribou present was the highest seen until the peak in late October (Table 32). A total of 430 total caribou, including only 8 calves, were recorded during the first survey and 540 total caribou, including only 4 calves, were recorded during the second survey, for estimates of 860 and 1080 caribou, respectively, in the survey area. These results were consistent with our sex- and age-composition survey on 15 June 2001 (Appendix H), which found a very low proportion of calves (~7 calves: 100 cows) but a high proportion of yearlings (~72 yearlings: 100 cows).

Few caribou were seen in the caribou survey area during the 3 surveys conducted in the insect season from late June through late July (Figures 26 and 27, Table 32). The study area is located inland from the coastal relief habitats likely to be used by mosquito-harassed caribou in late June and early July, so caribou numbers generally are low there during warm, calm weather conditions that favor insect harassment. For instance, a total of only 26 caribou in 11 groups were observed on transects during the 3 surveys on 27 June, 18 July (none seen), and 26 July (Table 32). Insect harassment

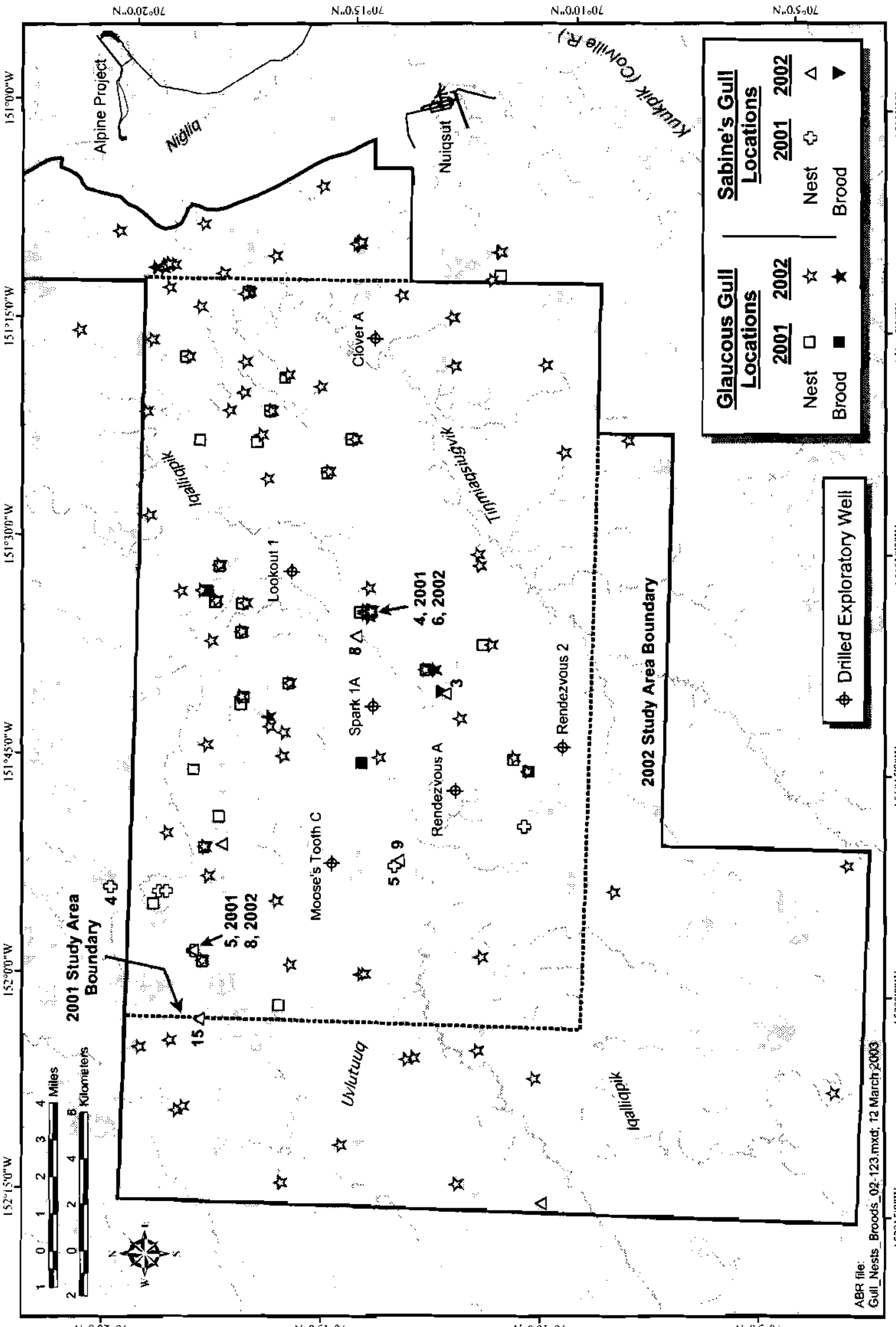

Figure 24. Glaucous Gull and Sabine's Gull nests and broods during aerial and ground surveys, NPRA Study Area, Alaska, 2001–2002. Labels indicate the number of nests (and the year of observation) if >1 nest was present.

Table 31. Habitat use by nesting Glaucous Gulls in the NPRA Study Area, Alaska, 2001–2002.

Habitat	Number of Nests	Habitat Use (%)
Deep Open Water with Islands or Polygonized Margins	18	17.3
Shallow Open Water without islands	5	4.8
Shallow Open Water with Islands or Polygonized Margins	63	60.6
Aquatic Sedge Marsh	3	2.9
Aquatic Grass Marsh	1	1.0
Old Basin Wetland Complex	7	6.7
Nonpatterned Wet Meadow	2	1.9
Patterned Wet Meadow	5	4.8
TOTAL	104	100

was mild on 27 June, moderate on 18 July, and absent on 26 July (Lawhead and Prichard 2003). Moderate mosquito harassment on 26 June had caused caribou to move to the coast just prior to the 27 June survey. Similarly, moderate-to-severe mosquito harassment daily beginning 14 July (through 19 July) apparently caused all caribou to move out of the survey area, probably to the coast, by the time of our 18 July survey. The survey on 26 July was preceded by several days of low mosquito harassment due to high winds or cool temperatures, but oestrid flies appeared to be active. It is likely that caribou moved inland into the study area when insect harassment subsided during cool, windy periods. For instance, at least 250 caribou were dispersed across the northwestern corner of the survey area during fox den observations on the evening of 12 July 2002.

In 2001, the numbers of caribou in the study area were relatively high prior to insect harassment, fairly high in July, and low in August (Figure 31, Appendix H). In addition, a large number CAH caribou (>6,000) traveled west across the Colville River and into NPRA along Uvlutuuq in the third week of July 2001 (Lawhead and Prichard 2002). Large fluctuations in the number of caribou using the study area during the insect season are consistent with the large aggregations and rapid movements of caribou that occur in response to changing levels of insect harassment.

The number of caribou seen in the study area increased from July to August 2002 (Figure 28, Table 32); 270 and 206 caribou were observed (540 and 412 estimated) on 3 and 14 August, respectively. During the period of potential oestrid fly harassment (late July to early September), caribou were strongly associated with stream courses, with many caribou standing on sand bars (Figures 27–29). Numbers were generally low from late August through early October, except for the 251 caribou seen (~500 estimated) on the early September survey. Only 29 caribou were observed in 11 groups on 6 October but the 2002 survey counts peaked on 25 October when 1001 caribou were observed in 130 groups (~2000 estimated) in the survey area (Figure 30, Table 32). The late October density of 1.53 caribou/km^2 was the highest density recorded in 2002 and was higher than all but one survey in 2001 (Figure 31). The number of caribou in the area was also high in mid- to late October 2001 (Appendix H). In contrast, the limited data from satellite collars of the TCH showed little use of the area during October from 1990–2001 (Prichard et al. 2001, Prichard and Murphy 2002). Based on satellite telemetry data, most TH caribou were south or southeast of Teshekpuk Lake in October 2002 during the rut (G. Carroll, ADFG, pers. comm.).

Subsistence hunting opportunities of caribou by local residents appeared to be more limited during most of the usual late summer and fall harvest period in 2002 than in 2001 due to the

Table 32. Number and density of caribou observed during 14 systematic aerial strip-transect surveys (50% coverage of 1,310-km² survey area), NPRA Study Area, Alaska, May–October 2002.

Date	No. of Large Caribou [a]	No. of Calves	Total No.	Density (caribou/km²)	Mean Group Size
3 May	190	0	190	0.29	3.1
25–26 May	215	0	215	0.33	3.3
8 June	422	8	430	0.66	3.7
18 June	536	4	540	0.83	6.6
27 June	17	0	17	0.03	3.4
18 July	0	0	0	–	–
26 July	9	0	9	0.01	1.5
3 August	239	31	270	0.41	15.0
14 August	170	36	206	0.31	2.3
26 August	63	1	64	0.10	1.3
9 September	231	20	251	0.38	4.0
24 September	48	2	50	0.08	6.3
6 October	29	0	29	0.04	2.6
25 October	959	42	1,001	1.53	7.8
TOTAL	3,128	144	3,272	0.38	4.7

[a] Adults + yearlings

lower abundance of caribou. No large movements of caribou onto the Colville River Delta were observed in 2002 (Lawhead and Prichard 2003). Many of the caribou seen in the NPRA study area during July–October were accessible in the drainages of Uvlutuuq and Iqalliqpik, requiring fairly long boat trips from Nuiqsut. Some caribou were harvested by Nuiqsut hunters along the Colville River in the fall (M. Ahmakak, pers. comm.).

FOX SURVEYS

Background

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are common on the coastal plain. Red foxes are common in the foothills and mountains of the Brooks Range, but on the coastal plain are found primarily along major rivers (such as the Colville and Sagavanirktok rivers), where they are much less common than the arctic fox (Eberhardt 1977). Arctic and red foxes have similar denning requirements and sometimes use the same den sites in different years, although arctic foxes appear to avoid sites that have been used by red foxes. For both arctic and red foxes, lemmings and voles are the most important year-round prey, supplemented by carcasses of caribou and marine mammals and, in summer, by ground squirrels and nesting birds and their eggs; garbage is eaten when available (Chesemore 1968, Eberhardt 1977, Garrott et al. 1983b).

Arctic Fox

Found throughout the coastal tundra of northern and western Alaska, the arctic fox is the most common predatory mammal on the Arctic Coastal Plain. The arctic fox is an important predator of nesting birds and small mammals, is a carrier of rabies, and is readily attracted to areas of human activity and artificial food sources (Eberhardt et al. 1982). Population estimates are difficult to derive for this species, but the population is known to undergo cycles in response to fluctuating populations of prey species (Follmann and Fay 1981, Burgess 2000). A prominent issue for oil and gas development in arctic areas is the well-documented attraction of foxes to artificial food sources, especially at areas

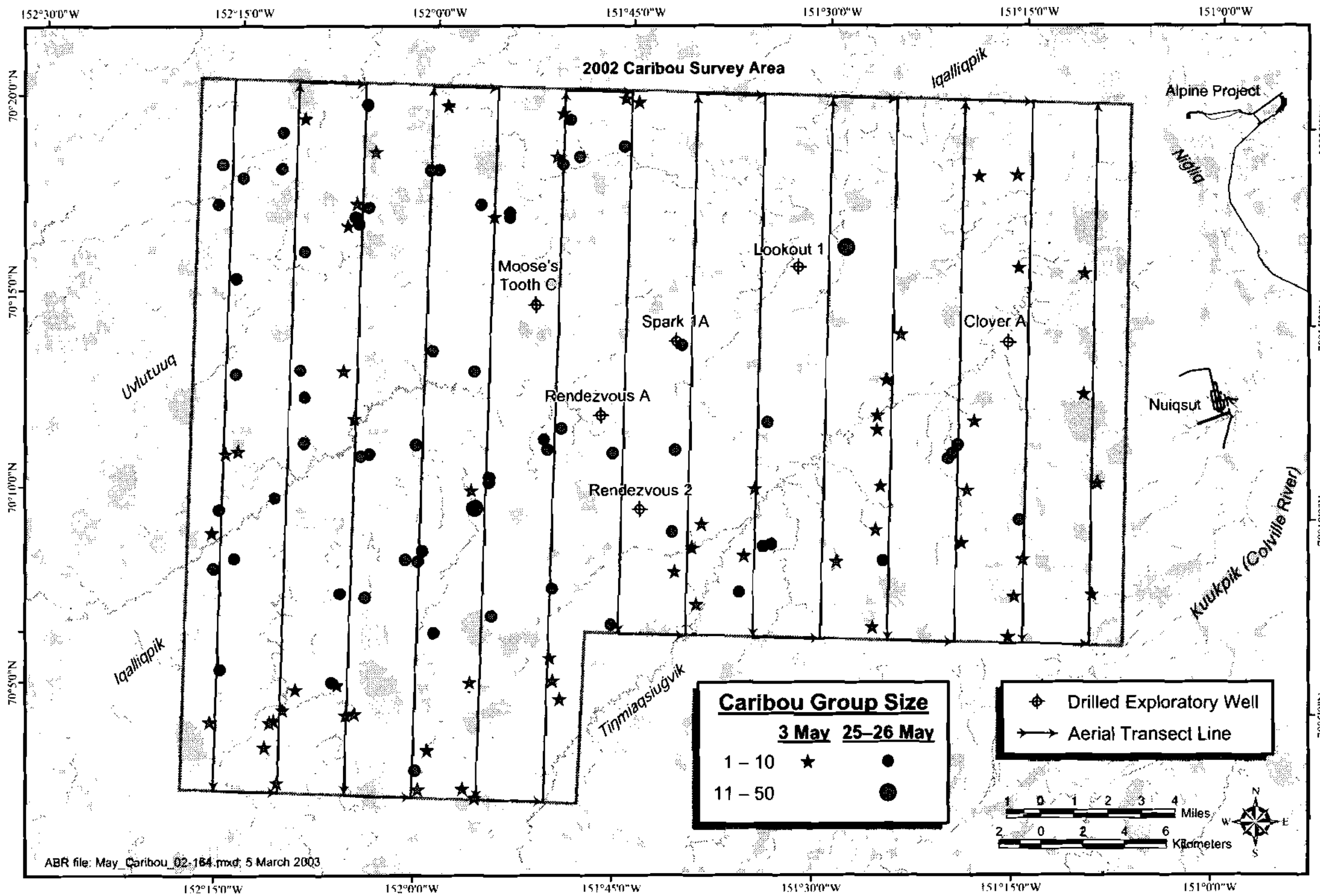

Figure 25. Distribution and group size of caribou observed during aerial surveys, NPRA Study Area, Alaska, May 2002.

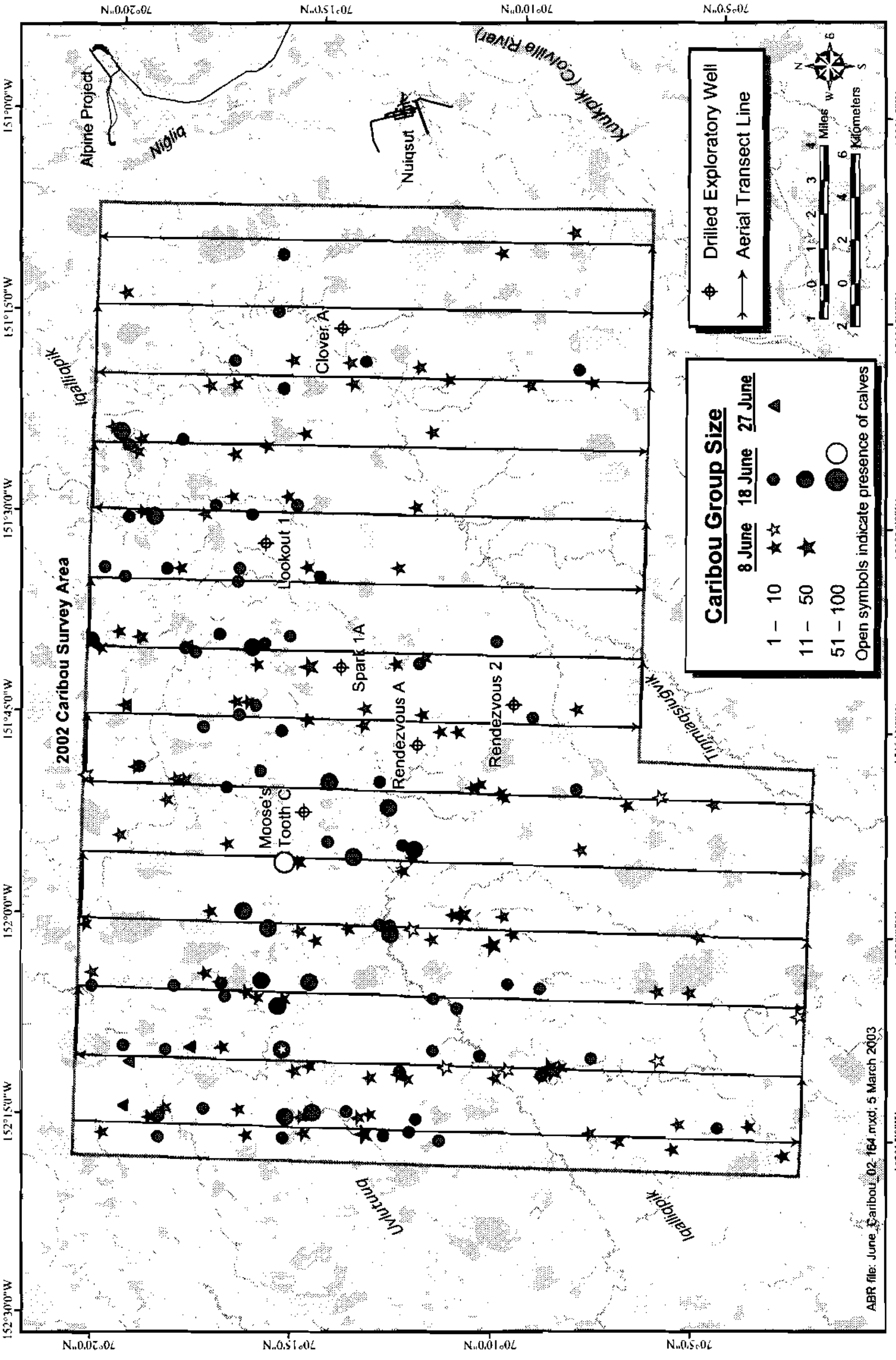

Figure 26. Distribution and group size of caribou observed during aerial surveys, NPRA Study Area, Alaska, June 2002.

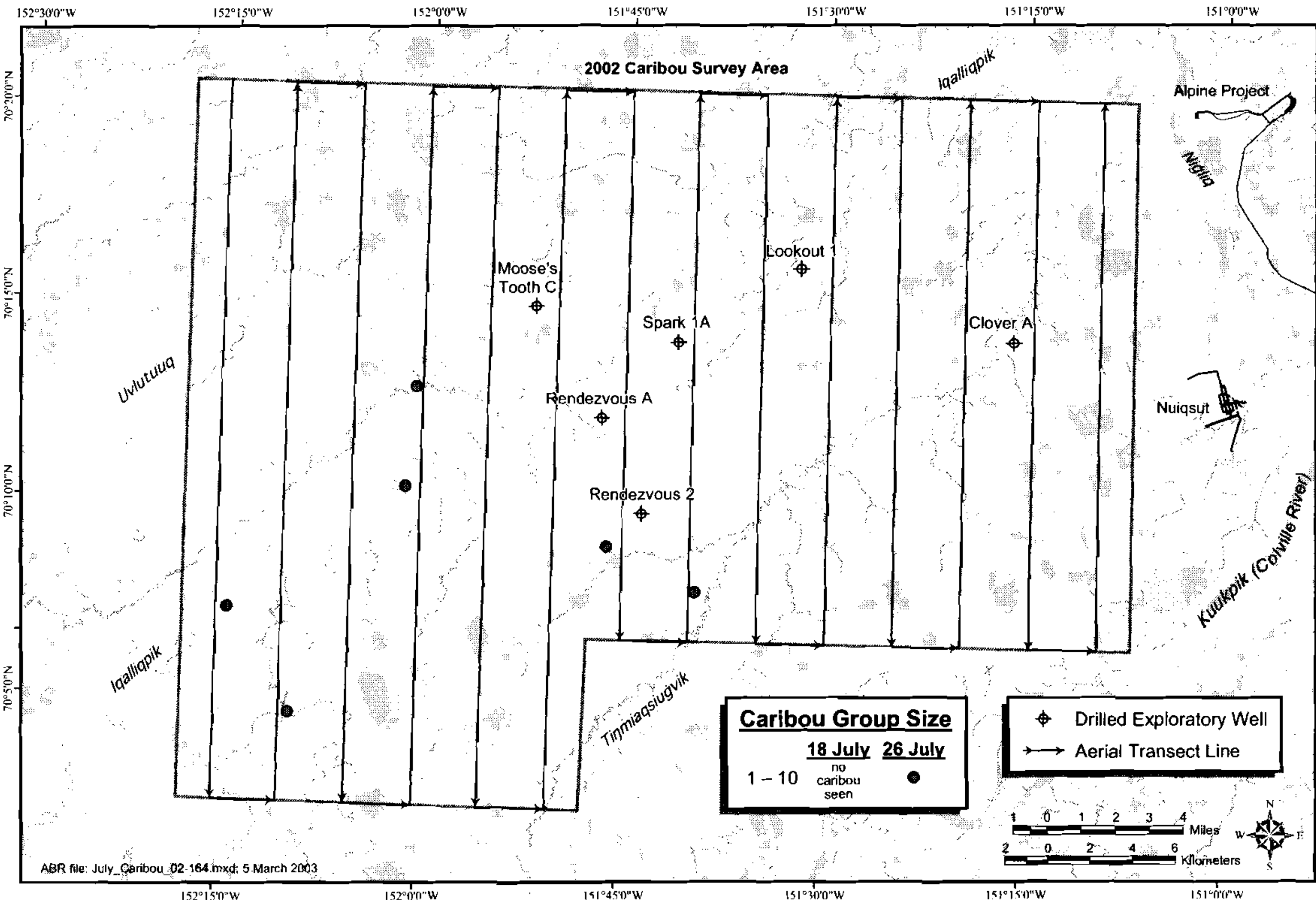

Figure 27. Distribution and group size of caribou observed during aerial surveys, NPRA Study Area, Alaska, July 2002.

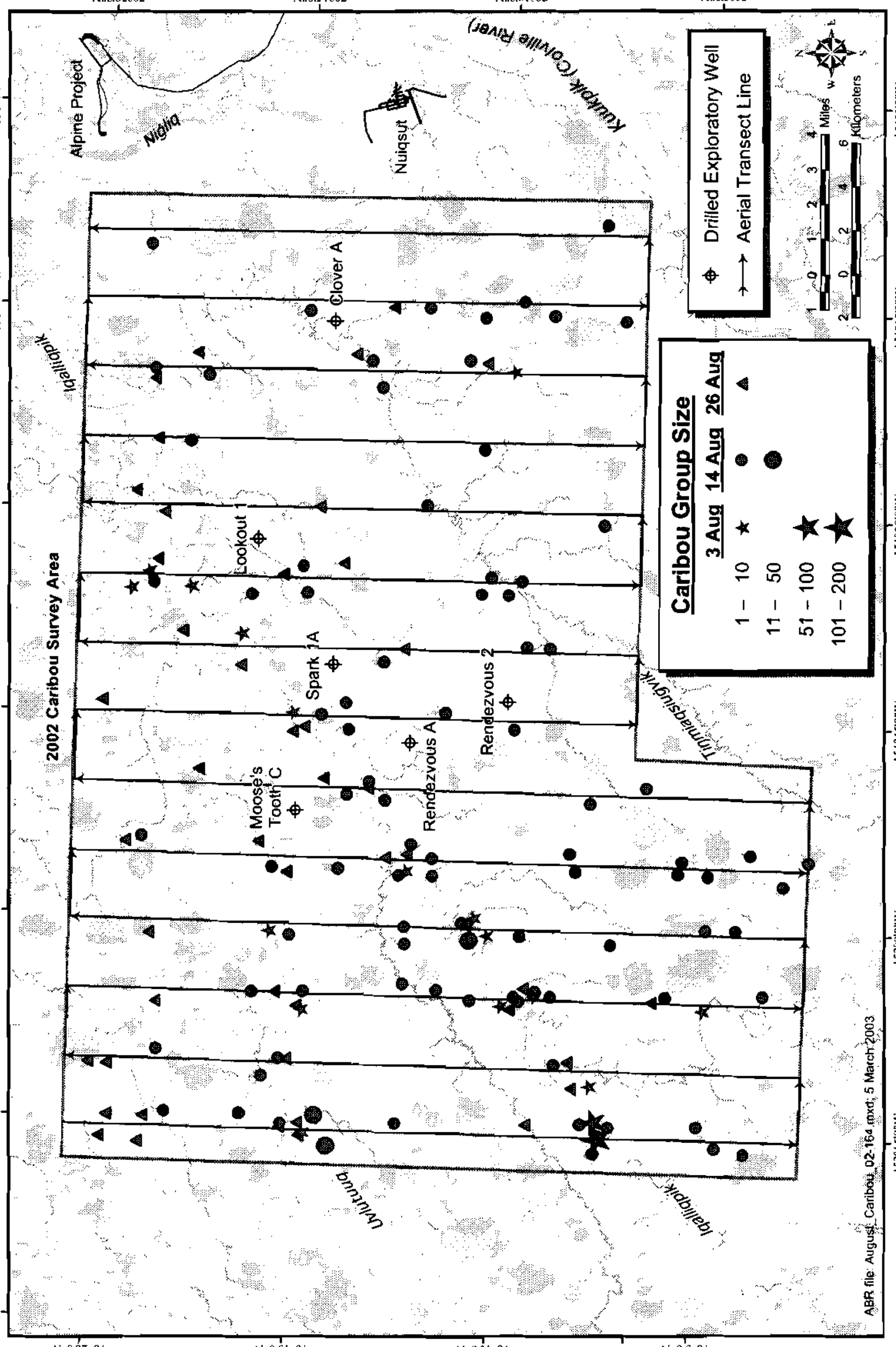

Figure 28. Distribution and group size of caribou observed during aerial surveys, NPRA Study Area, Alaska, August 2002.

of human activity, which creates the potential for fox population increases and associated negative effects on prey populations (Martin 1997, Day 1998, Burgess 2000).

In the winter, many foxes disperse widely from their summer territories (Chesemore 1975, Eberhardt and Hanson 1978), although recent satellite telemetry has demonstrated that some remain in the oilfield region throughout the winter (P. D. Martin, USFWS, pers. comm.). In late winter and spring, foxes move to summer territories to mate (March–April) and den.

Most pups are born in late May or June after a gestation period of ~52 days, and dens are occupied from late spring until pups disperse in August (Chesemore 1975). Pups first emerge from dens at 3–4 weeks of age (Garrott et al. 1984). Throughout northern Alaska, litters average 4–8 pups, but can range up to 15 pups in years when food is abundant (Chesemore 1975, Follmann and Fay 1981, Johnson et al. 1997). On the Colville River Delta and adjacent coastal plain toward the Kuparuk Oilfield, litters averaged 3–6 pups during 1993–2001 (Johnson et al. 2003a). Survival of arctic fox pups to weaning is highest in years when small mammals (primarily lemmings) are abundant (Macpherson 1969). Causes of pup mortality include predation (mostly by Golden Eagles and grizzly bears), starvation, and sibling aggression (Macpherson 1969, Garrott and Eberhardt 1982, Burgess et al. 1993).

Home ranges of adult arctic foxes in the Prudhoe Bay Oilfield averaged 21 km^2 (8 mi^2) (Eberhardt et al. 1982), but probably are larger outside the oilfields (away from artificial food sources). The density and occupancy rate of dens and the litter size and survival of pups is higher in oilfield areas than in undeveloped areas nearby (Burgess 2000). More den sites are available each year than are used (Macpherson 1969, Burgess 2000) and the rate of den occupancy is highest when food is abundant (Chesemore 1975, Eberhardt et al. 1983, Johnson et al. 2001). Foxes may return to the same den site in successive years.

Surveys conducted since 1992 have located 75 fox dens in the area east of the NPRA Study Area, extending from the western Colville River Delta east to the Kuparuk Oilfield (Johnson et al. 2003a). Foxes dig dens in raised landforms with relatively well-drained soil and greater depth to frozen ground, such as ridges, dunes, lake and stream shorelines, and pingos (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993, Johnson et al. 2003a). The habitats preferred by foxes for denning on the Colville River Delta and adjacent coastal plain are the Riverine or Upland Shrub and the Moist Sedge–Shrub Meadow types (Johnson et al. 2002; ABR, unpubl. data). Most dens are located on microsites with higher topographic relief than their immediate surroundings.

Red Fox

The red fox is much less abundant than the arctic fox on the Arctic Coastal Plain, where its distribution is restricted largely to major drainages such as the Colville and Sagavanirktok rivers (Eberhardt 1977, Johnson et al. 2003a). Four to 6 red fox dens have been used annually on the Colville River Delta in recent years (Johnson et al. 2003a); all were located in sand dunes in the Riverine or Upland Shrub habitat type.

Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Schamel and Tracy 1986, Hersteinsson and Macdonald 1992). Since 1992, red foxes have occupied at least 4 den sites formerly used by arctic foxes on the Colville River Delta and adjacent coastal plain tundra (Johnson et al. 2003a). Red foxes have been seen using culverts in the northwestern Kuparuk Oilfield (A. Stickney, pers. comm.), so use of development infrastructure in NPRA by this species is a possibility.

Distribution and Abundance

In 2001, the first year of fox surveys in the NPRA Study Area, we located 24 dens (4 of which were reported by avian nest search crews), including both active and inactive sites (Appendix H). Eleven more dens were found in 2002, including 8 found by avian nest search crews, for a 2-year total of 35 dens (Figure 32). Arctic foxes were much more abundant than red foxes. All but one of the 35 sites were arctic fox dens (97% of the total); the sole exception was an inactive red fox den on a sand dune bordering Uvlutuuq (Table 33). In comparison, 65 (87%) of 75 fox dens examined in 2001 between the western edge of the Colville River Delta and the Kuparuk Oilfield were classified as arctic fox dens and the remaining 10 dens (13%) were classified as red fox dens; 4 of the

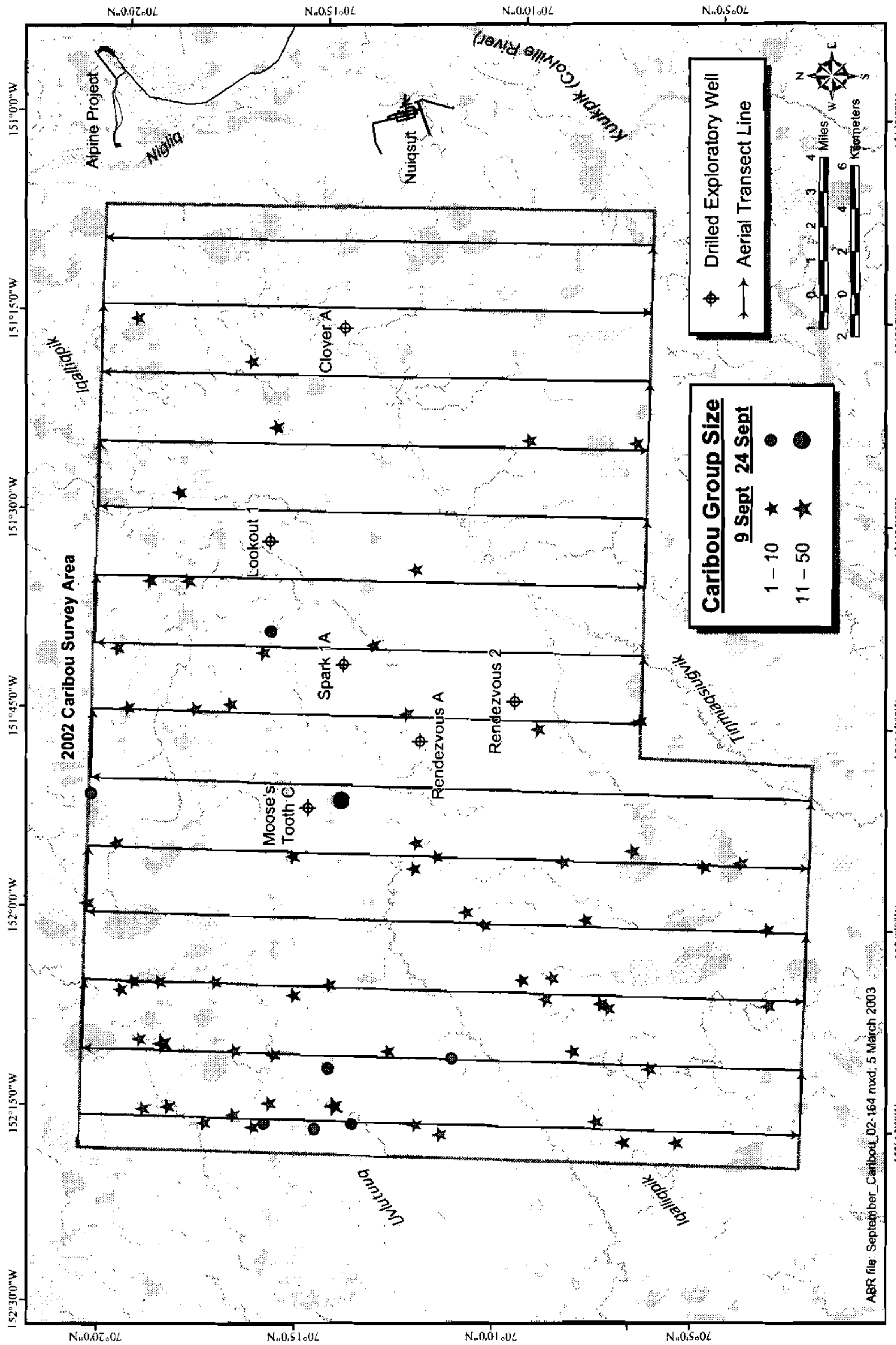

Figure 29. Distribution and group size of caribou observed during aerial surveys, NPRA Study Area, Alaska, September 2002.

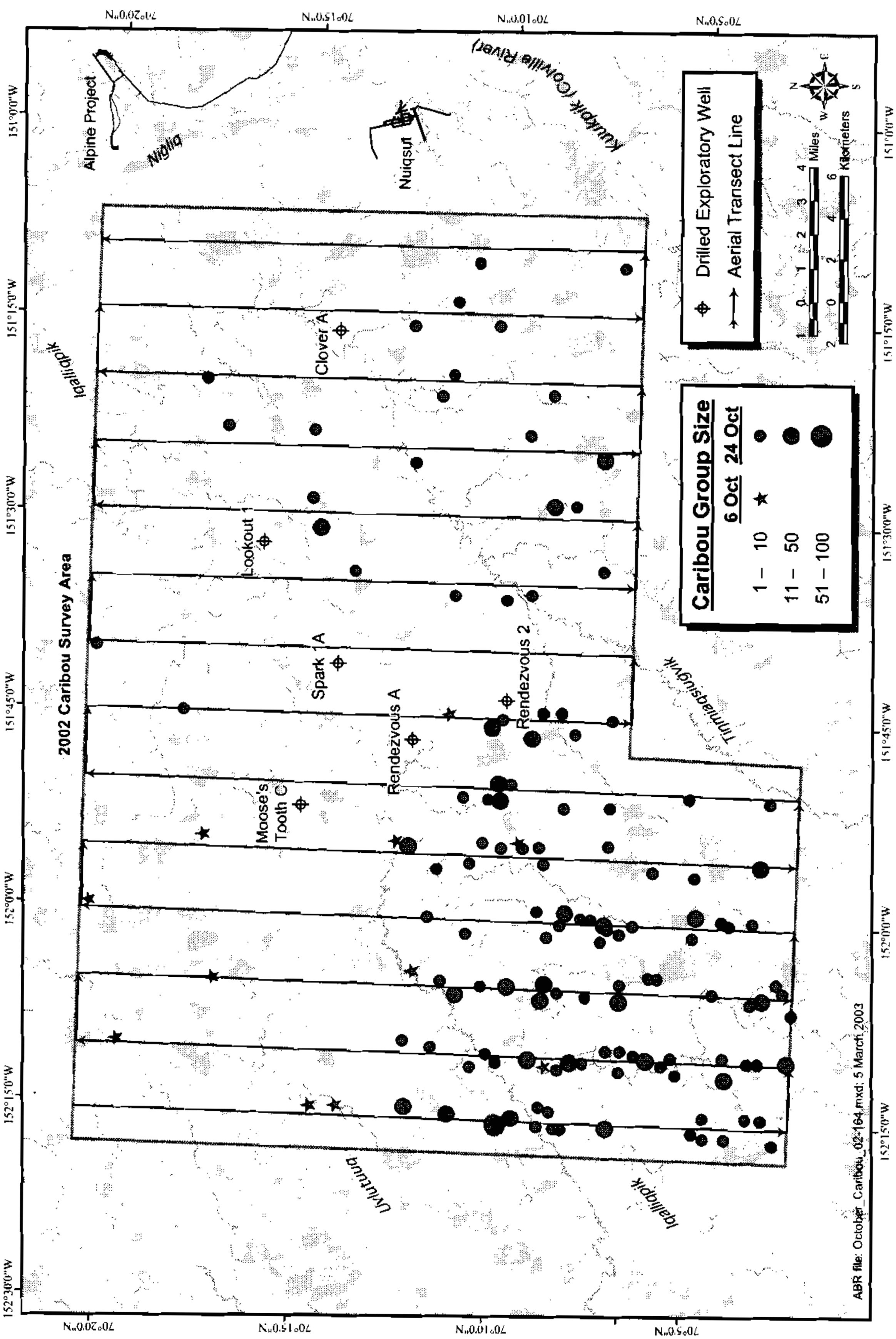

Figure 30. Distribution and group size of caribou observed during aerial surveys, NPRA Study Area, Alaska, October 2002.

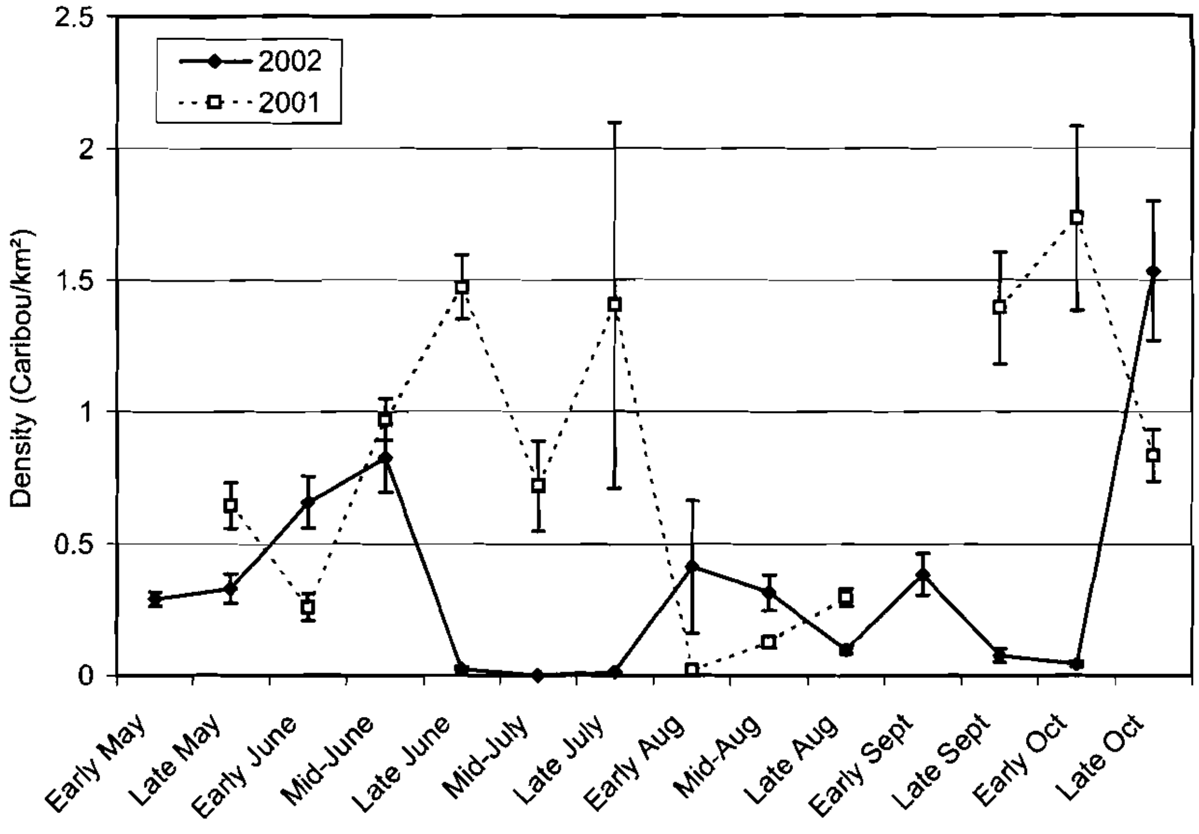

Figure 31. Caribou density (mean number/km^2 ± SE) observed during aerial surveys in the NPRA Study Area, Alaska, May–October 2001 and 2002.

latter sites were former arctic fox dens (Johnson et al. 2003a).

To date, we have confined our search effort to the 2001 NPRA Study Area, a small portion of which (<10%) remains to be searched for dens, consisting of the extensive complex of riparian habitats along Uvlutuuq and Iqalliqpik, containing abundant sand-dune habitat. Because this habitat is preferred by red foxes for denning on the Colville River Delta, we expect to find more red fox dens in future years. The small areas of tundra remaining to be searched (in the northeastern portion of the study area) are more likely to contain arctic fox dens.

The presence of 34 arctic fox dens in our 681-km^2 den survey area produces an unadjusted density (i.e., including the small areas not yet searched thoroughly) of 1 den/20 km^2. This density is higher than the 1 den/37 km^2 in the Colville River Delta survey area (551 km^2) but comparable to the 1 den/17 km^2 in the Alpine Transportation Corridor survey area (343 km^2) studied by Johnson et al. (2003a) east of NPRA. At 34 and 35 dens, respectively, the total number found to date is essentially identical between our NPRA Study Area and the areas to the east studied by Johnson et al. (2002). The density of arctic fox dens in NPRA is higher than the 1 den/34 km^2 reported by Eberhardt et al. (1983) for their 1700-km^2 Colville study area, which included parts of our NPRA Study Area and the adjacent Colville Delta/Alpine Transportation Corridor study areas of Johnson et al. (2003a). The density of arctic fox dens in NPRA is lower than was reported for the 805-km^2 developed area of the Prudhoe Bay Oilfield (1 den/12–15 km^2; Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues et al. 1994, Ballard et al. 2000).

A density was not calculated from the single red fox den found during surveys of the NPRA Study Area. The density of red fox dens in the Colville River Delta survey area in 2001 (Johnson et al. 2003a) was 1 den/61 km^2 (treating 2 adjacent dens used by one breeding pair of foxes as a single site). Comparative data on den density are unavailable for this species from other arctic tundra areas, but it appears that the density of red fox dens on the Colville River Delta is particularly high for the Arctic Coastal Plain. Although we expect to find more red fox dens in the NPRA Study Area, we do not expect the density to reach that on the Colville River Delta.

Based on brief visits at all 34 arctic fox dens during 30 June–2 July and 9 July 2002 and longer observations at 11 of those dens during 10–12 July, we concluded that pups were present at 1 natal den and classified another 8 dens as active (Table 33). Adults but no pups were seen at 8 of the 9 occupied dens; 2 adults were seen together at 2 of these dens. Thus, the maximum number of active dens (known or suspected to be occupied at some point by pups) was estimated to be 26% of the 34 arctic fox dens; the remaining 25 dens (74%) showed signs of occasional use by adults only or were completely inactive. In view of the number of dens at which only adults were seen (24%), it is likely that the occupancy rate in 2002 actually was lower than 26%. It is likely that the widespread rabies outbreak in arctic coastal Alaska in the winter of 2001–02 reduced the breeding population of foxes, and it is conceivable that this disease outbreak resulted in single adults occupying dens. A similar occurrence of adults being observed repeatedly at dens without pups occurred in 1997 on the Colville River Delta and Alpine Transportation Corridor, but was interpreted as an indicator of low rodent populations that may have decreased pup survival (Johnson et al. 1998).

The occupancy rate (natal and active categories combined) of dens in the NPRA Study Area in 2002 was below the 8-year mean and at the low end of the range reported for the area between the western Colville River Delta and the Kuparuk Oilfield (mean = 38%; SD = 15%; range = 24–67%) (Johnson et al. 2001). In comparison, Eberhardt et al. (1983) reported that the percentage of dens containing pups in their Colville study area ranged from 6% to 55% in a 5-year period, whereas 56–67% showed signs of activity by adults alone. Burgess et al. (1993) estimated that 45–58% of the dens in their study area in the Prudhoe Bay Oilfield produced litters in 1992, although only 21% still were occupied by families at the time of ground visits in late July–early August. In 1993, the occupancy rate by arctic foxes at 53 natural den sites (including adult resting dens) in the Prudhoe Bay Oilfield and surrounding area was 71%, and 49% of the sites were classified as natal dens (Ballard et al. 2000).

On 10–12 July 2002, we expended ~40 hr observing 11 arctic fox dens that were known or suspected to be active on the initial check at the beginning of July (Table 33); the red fox den was inactive in 2002, as in 2001. Despite our observation effort (which exceeded the 23 hr expended at 8 sites in 2001), the only den at which pups were confirmed in 2002 was Den 223. Evidence at that den included the remains of at least 1 pup with characteristic signs of Golden Eagle predation. In 2001, 9 pups were counted at 3 arctic fox dens, for a mean litter size of 3 pups (SD = 1.7, $n = 3$), and pups were strongly suspected to be present at 2 other dens. The 2001 litter size matched the mean for years when rodent prey are not numerous (see below).

Estimates of pup production are minimal figures because pups often remain underground for extended periods, making it difficult to reliably obtain complete counts. In general, our observations at dens were most successful in obtaining pup counts during early morning and evening, when foxes tend to be most active. Counts are most reliable when adults deliver food to the den site (Eberhardt 1977, Fine 1980). 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). Garrott (1980) noted that movements of arctic foxes from natal dens to secondary dens typically occurred after early to mid-July when the young were 5–7 weeks old, and that interchange of young between dens occurred after the initial move. We found no indications of moves in 2002, but it is possible that some dens were abandoned after our initial checks. In 2001, we found no evidence of moves by arctic foxes either, although several sites where adults were present on our first check were deemed inactive when observed on subsequent visits.

The variation in mean litter size documented for arctic foxes in the Colville River Delta region

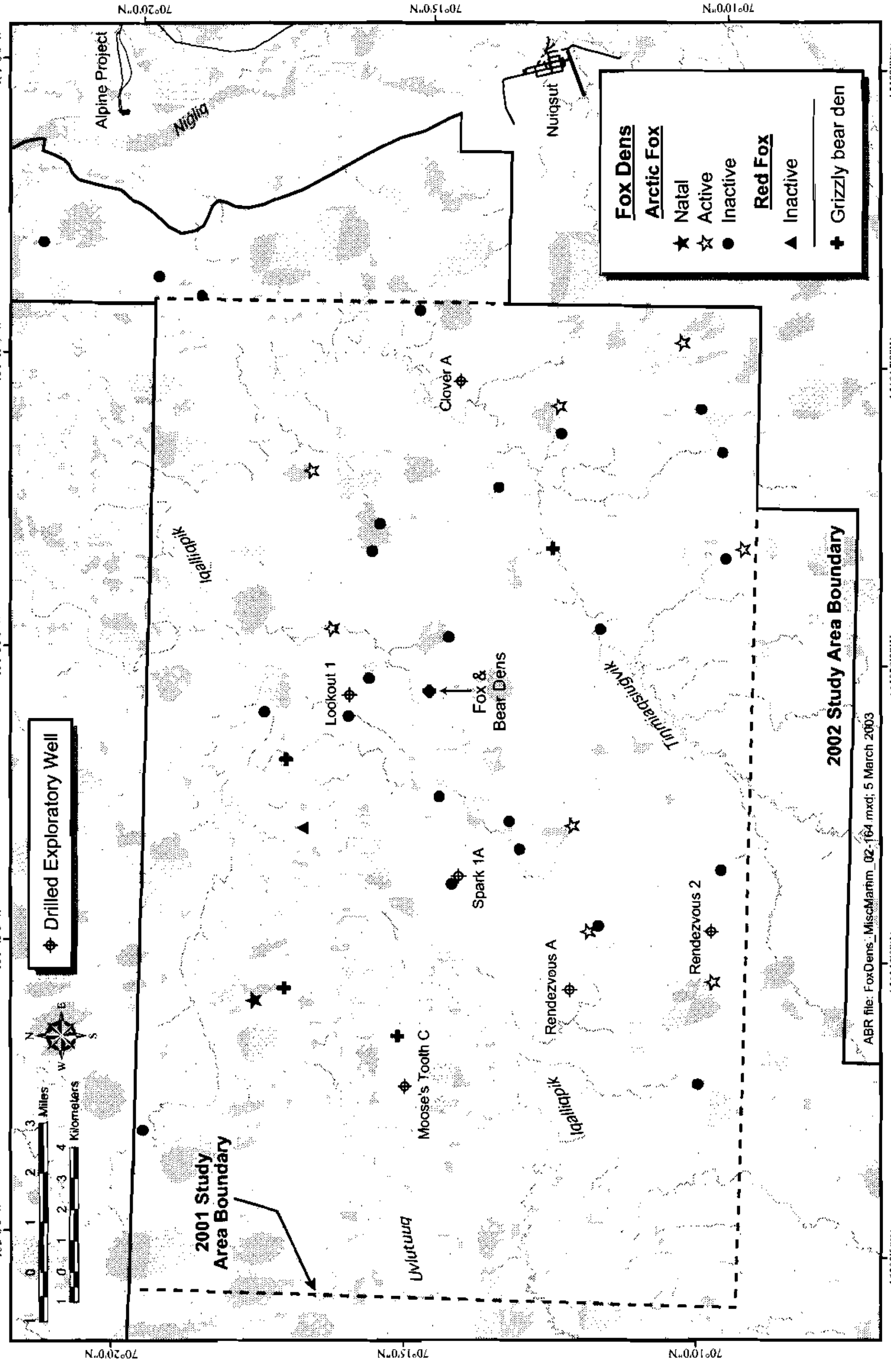

Figure 32. Distribution and status of fox dens and locations of grizzly bear dens, NPRA Study Area, Alaska, 2002.

Table 33. Landforms, activity status, and number of pups counted at arctic and red fox den sites in the NPRA Study Area, Alaska, 2001–2002.

Species	Site No.	Landform [a]	2002 Status	2002 Pup Count [b]	2001 Status	2001 Pup Count
Arctic Fox	200	DLB bank	Inactive	–	Inactive	–
	201	DLB bank	Inactive	–	Inactive	–
	202	Lake bank	Active	0	Natal	2
	203	Low ridge	Inactive	–	Inactive	–
	204	Lake bank	Active	0	Inactive	–
	205	River bank	Inactive	–	Inactive	–
	206	Stream bank	Active	0	Inactive	–
	207	DLB bank	Inactive	–	Inactive	–
	208	Lake bank	Active	0	Natal	≥2
	209	Low mound	Inactive	–	Inactive	0
	210	Pingo	Inactive	–	Inactive	–
	211	Lake bank	Active	0	Inactive	–
	212	Lake bank	Inactive	–	Inactive	–
	213	Lake bank	Inactive	–	Inactive	–
	214	DLB bank	Inactive	–	Inactive	–
	215	Lake bank	Inactive	0	Natal	5
	216	Stream bank	Active	0	Inactive	0
	218	Low ridge	Inactive	–	Inactive	0
	219	DLB bank	Inactive	–	Inactive	–
	220	Low ridge	Inactive	–	Active	0
	221	Low ridge	Active	0	Inactive	–
	222	DLB bank	Inactive	–	Active	0
	223	Lake bank	Natal	≥1 (dead)	Inactive	–
	225	DLB bank	Inactive	–	–	–
	226	Low mound	Inactive	–	–	–
	227	Low mound	Inactive	–	–	–
	228	DLB bank	Inactive	–	–	–
	229	Lake bank	Active	0	–	–
	230	Old beach ridge	Inactive	0	–	–
	231	Stream bank	Inactive	–	–	–
	232	Low ridge	Inactive	–	–	–
	233	Lake bank	Inactive	–	–	–
	234	Sand dune	Inactive	–	–	–
	235	Stream terrace	Inactive	–	–	–
Red Fox	217	Sand dune	Inactive	–	Inactive	–

[a] DLB = drained-lake basin.

[b] Zero indicates that den was observed but no pups were seen.

since 1993 (Johnson et al. 2003a) ranged from a low 3.2 pups in 1998 and 2001 (n = 6 and 11, respectively) to highs of 5.4 and 6.1 pups in the high-production years of 1999 and 1996 (n = 13 and 15, respectively). These figures were nearly identical to those reported by Garrott (1980) for years of low and high pup production in his Colville study area. In 1978, when small mammals (the principal prey of arctic foxes) were abundant, Garrott (1980) closely observed 7 litters from a total of 23 active dens, which averaged 6.1 pups (range = 2–8). In contrast, he observed only one litter the year before (from 2 active dens), when small mammals were scarce, and was unable to obtain a complete litter count. The low occupancy rates and litter sizes at arctic fox dens in 2001 and 2002 led us to infer that the density of small mammal prey in the NPRA Study Area was low, although we have no rodent population sampling data to support this inference directly.

Habitat Use

The habitat types used most often for denning by foxes in the den survey area (Figure 32) were the 2 most abundant types mapped: Moist Tussock Tundra and Moist Sedge–Shrub Meadow (11 dens each) (Table 34). Two other types—Patterned Wet Meadow and Upland and Riverine Dwarf Shrub—were used to a lesser extent (5 and 4 dens respectively), and single dens were located in each of 3 other habitat types (Table 34; 1 den occurred in the area not yet mapped). Foxes tend to den in bank habitats in the study area, including banks of lakes, streams, and drained-lake basins (Table 33).

Because arctic and red foxes both have similar denning requirements and may use the same den sites in different years, we included dens used by either species in the statistical analysis of habitat selection in the survey area (Table 34). The only habitat that was preferred for denning was Upland and Riverine Dwarf Shrub, which constituted only 1.7% of the area mapped but included 11.8% of the fox dens. The 3 most abundant habitats in the area (Moist Tussock Tundra, Moist Sedge–Shrub Meadow, Patterned Wet Meadow) and the 2 least abundant used by foxes (Upland Low and Tall Shrub, Salt Marsh) all were used in proportion to their availability by denning foxes, whereas the fourth most abundant (Old Basin Wetland Complex) only had 1 den and was avoided. Dens in wet habitats such as Patterned Wet Meadow and Salt Marsh were located in small patches of higher microrelief that were smaller than the minimum-sized habitat map unit.

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have relatively deep seasonal thaw layers. Foxes locate dens on raised landforms with well-drained soil; typical locations on the Arctic Coastal Plain include ridges, dunes, lake and stream shorelines, pingos, and low mounds (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993, Johnson et al. 2003a). In general, arctic foxes use a wider variety of denning habitats and substrates than do red foxes; on the Colville River Delta, the latter species dens almost exclusively in sand dunes. On the Colville River Delta and adjacent coastal plain to the east, foxes den in sand dunes (mostly those stabilized by vegetation), banks of streams and lakes (including banks of drained-lake basins), ridges, and pingos (Garrott 1980, Eberhardt et al. 1983, Johnson et al. 2003a). Those landforms are usually vegetated with upland shrubs and less commonly with riverine shrubs. Pingos are used commonly as den sites in the Prudhoe Bay area (Burgess et al. 1993), but account for only a small percentage of the known sites in the Colville area (Eberhardt et al. 1983). Chesemore (1969) reported that low mounds were used most often for den sites in the Teshekpuk Lake area west of our NPRA Study Area. These observations all confirm that the primary requirement for denning habitat is well-drained soil with a texture conducive to burrowing, conditions that occur on elevated microsites within a variety of larger habitat types.

OTHER MAMMALS

Background

Muskox

Muskoxen are native to Alaska but were extirpated by the late 1800s (Smith 1989). Historical records (e.g., Bee and Hall 1956) indicate a high level of use of the NPRA Study Area by muskoxen before extirpation. Muskoxen that inhabit the Colville–Kuparuk region originated from the Arctic National Wildlife Refuge (ANWR) population, which was reestablished through introductions in 1969 and 1970. By the mid-1980s, muskox sign had been found in the western

Kuparuk Oilfield (P. Kleinleder, pers. comm.) and lone bulls were seen near the Colville River (Reynolds et al. 1986). Golden (1990) reported that a small, mixed-sex group of muskoxen first overwintered in the area southeast of Nuiqsut in 1988–1989. A few muskoxen (mostly lone bulls) were seen on the Colville River Delta in summer during 1992–1993 and 1995–1998 (Johnson et al. 1999), and a group of 10–11 adults (mostly bulls) used the northeastern portion of the delta consistently in 2001 (Lawhead and Prichard 2002).

Most of the muskox population that resides in the Colville–Kuparuk region east of the study area appears to winter in the Itkillik Hills, then disperses seasonally into smaller groups during summer, some of which move northward along smaller drainages (notably the Kachemach River) to the vicinity of the Colville River Delta, while others move to the Kuparuk River floodplain (Johnson et al. 1998, Danks 2000, Lawhead and Prichard 2003). Lenart (2001) counted 277 muskoxen between the Colville River and ANWR (Game Management Unit [GMU] 26B) in April 2000, 53% of the total number of 523 animals observed in northeastern Alaska (GMU 26B and 26C combined). Slightly fewer than half of the animals in GMU 26B were found west of the Sagavanirktok River (GMU 26B West), where late-winter surveys by ADFG counted 92 muskoxen in 1997, 79 in 1998, 96 in 1999, 90 in 2000, and estimated 107 in 2001 (Lenart 2001). Thus, at least 100 muskoxen reside in the area between the Sagavanirktok and Colville rivers and occur consistently in winter across the Itkillik Hills and the upper Kuparuk River. Lawhead and Prichard (2002) estimated that at least 151 different muskoxen occurred in the general region stretching from the NPRA Study Area to the Sagavanirktok River in 2001, including animals as far east as Franklin Bluffs and as far west as the west side of the Colville River and NPRA. Muskox numbers in the northeastern portion of NPRA are not well-documented, but appear to be lower than in the area east of the Colville River. Suitable habitat exists in northeastern NPRA and it is expected that the population in the area will continue to increase (BLM 1998, Danks 2000).

Muskoxen home ranges are smaller and activity and movement rates are much lower during winter than summer. Long-distance movements from winter to summer ranges are common in mid- to late June following river break-up and leafing out of willows along drainages (Reynolds 1992b). Group size typically decreases from winter to summer as the breeding season (rut) approaches; most groups in ANWR ranged from 10 to 30 animals (Reynolds et al. 1986, Reynolds 1992a). The breeding season occurs in August and September, and calves are born between late April and late June, peaking around mid-May (Reynolds et al. 1986). Cows produce single calves at intervals of one to 3 years. Habitat use by muskoxen varies seasonally. In winter, muskoxen select upland habitats near ridges and bluffs with shallow, soft snow cover that permits easy access to food plants (Klein et al. 1993). In spring, muskoxen use moist tussock tundra and moist sedge–shrub tundra, apparently seeking high-quality flowering sedges (Jingfors 1980, Reynolds et al. 1986). By late spring and summer, muskoxen prefer river terraces, gravel bars, and shrub stands along rivers and tundra streams (Jingfors 1980, Robus 1981), where they eat willow leaves, forbs (especially legumes), and sedges (Robus 1984, O'Brien 1988). Thus, riparian shrub habitats and moist sedge–shrub meadows are the most important habitats for muskoxen.

Grizzly Bear

The grizzly bear (also called brown bear) is more likely to be encountered in the NPRA Study Area than is the polar bear (Bee and Hall 1956, BLM 1998); den records for the latter species (S. Schliebe, USFWS, unpubl. data) do not include any dens in the study area. Grizzly bears occur throughout northern Alaska from the Brooks Range to the Arctic Ocean. Population densities of grizzlies are considerably lower on the coastal plain than in the mountains and foothills (Shideler and Hechtel 2000). The number of bears using the northeastern NPRA is not well-documented, being confined mainly to a few incidental sightings (e.g., Noel 1999, 2000). The population to the east in the Prudhoe Bay and Kuparuk oilfields appears to have increased in the last 2 decades, however, and is likely to remain high because of the high survival of cubs born to females in the oilfields (Shideler and Hechtel 2000). ADFG biologists estimate that 60–70 grizzlies inhabit the "oilfield region"

Table 34. Habitat selection by arctic and red foxes denning in the NPRA Study Area, Alaska, 2001–2002.

Habitat	Area [a] (km^2)	No. of Dens	Use (%)	Availability [a] (%)	Monte Carlo Results [b]
Open Nearshore Water	0	–	–	0	–
Brackish Water	0	–	–	0	–
Tapped Lake with Low-water Connection	0	–	–	0	–
Tapped Lake with High-water Connection	0	–	–	0	–
Salt Marsh	0.15	1	2.9	<0.1	ns
Tidal Flat	0	–	–	0	–
Salt-killed Tundra[c]	0	–	–	0	–
Deep Open Water without Islands	0	–	–	0	–
Deep Open Water with Islands or Polygonized Margins	0	–	–	0	–
Shallow Open Water without Islands	0	–	–	0	–
Shallow Open Water with Islands or Polygonized Margins	0	–	–	0	–
River or Stream	0	–	–	0	–
Aquatic Sedge Marsh	0	–	–	0	–
Aquatic Sedge with Deep Polygons	0.27	0	0	<0.1	ns
Aquatic Grass Marsh	0	–	–	0	–
Young Basin Wetland Complex	2.52	0	0	0.5	ns
Old Basin Wetland Complex	60.94	1	2.9	11.2	avoid
Riverine Complex	2.78	0	0	0.5	ns
Dune Complex	7.59	0	0	1.4	ns
Nonpatterned Wet Meadow	20.40	0	0	3.7	ns
Patterned Wet Meadow	76.94	5	14.3	14.1	ns
Moist Sedge–Shrub Meadow	160.51	12	34.3	29.4	ns
Moist Tussock Tundra	188.39	11	31.4	34.5	ns
Riverine Low and Tall Shrub	7.22	0	0	1.3	ns
Upland and Riverine Dwarf Shrub	8.97	4	11.4	1.6	prefer
Upland Low and Tall Shrub	2.80	1	2.9	0.5	ns
Barrens	6.25	0	0	1.1	ns
TOTAL	545.72	35	100	100	

[a] Aquatic habitats 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.
[c] Salt-killed Tundra did not occur in the fox den survey area.

between the Colville and Canning rivers, extending inland 100 km to the White Hills, for a mean density of ~4 bears/100 km^2, about twice the density estimated for other areas of the coastal plain (Shideler and Hechtel 2000). Adult female bears have large home ranges (2,300–4,700 km^2) and are highly mobile, sometimes moving 50 km a day (Shideler and Hechtel 2000). Adult males cover even larger areas, especially during the breeding season in June when they typically move through the home ranges of several females.

Grizzly bears in northern Alaska occupy dens between late September and May. One to 3 cubs (mean of 2) are born per litter in December or January (Reynolds 1979, Garner and Reynolds 1986, Shideler and Hechtel 1995). Males and females remain separate for most of the year, coming together only briefly to court and mate between May and July (Garner et al. 1986). All bears occupy winter dens, with females and cubs entering dens earlier and emerging later than males and single females (Garner and Reynolds 1986, Shideler and Hechtel 2000). On the coastal plain, where permafrost limits the amount of denning habitat, grizzlies dig dens in pingos, banks of rivers and lakes, dunes, and steep gullies in uplands (Harding 1976, Shideler and Hechtel 2000). Most of the bears studied by ADFG denned within 50 km of the oilfields, although a few denned up to 90 km inland (Shideler and Hechtel 1995, 2000). Most grizzly dens in the Colville–Kuparuk region are clustered in the uplands southeast of the Colville River Delta, in the headwaters of the Miluveach and Kachemach rivers, although dens occur in low densities across the coastal plain tundra in suitable sites. Little information is available on the occurrence of dens in the NPRA Study Area, although we found several in our fox den surveys.

Grizzlies use river drainages on the coastal plain as primary travel routes, foraging areas, and denning areas (Johnson et al. 1999, Shideler and Hechtel 2000). In spring and summer, grizzly bears mainly eat plants, but also take ground squirrels, fox pups, caribou, and muskoxen (Quimby 1974, Garner and Reynolds 1986, Garner et al. 1986, Shideler and Hechtel 2000). Riparian habitats contain concentrations of preferred foods such as legumes (flowering plants in the pea family) and ground squirrels, and radio-tracking has confirmed they are preferred habitats (Shideler and Hechtel 2000). Artificial food sources also are powerful attractants, so human facilities located near rivers are especially likely to attract grizzly bears.

Wolverine

Wolverines are uncommon to rare on the coastal plain; they are more abundant in the foothills and mountains of the Brooks Range (Bee and Hall 1956, BLM 1998). In the mid-1980s, a rough population estimate of ~820 wolverines was calculated for the western North Slope (GMU 26A), assuming a density of 1 wolverine/140 km^2 (BLM 1998), but no other population estimates are available. Wolverines are harvested by subsistence hunters and trappers from Nuiqsut and other North Slope villages, primarily during the winter months when snowmachines provide wide-ranging access. In 1992, the estimated harvest by Nuiqsut residents was 14 wolverines (Fuller and George 1997) and 8 wolverines were reportedly taken in 1994–1995 (Brower and Opie 1997). Female wolverines give birth and rear young in winter dens excavated in snowdrifts and areas of deep snow cover. Wolverines have been observed rarely during caribou and waterfowl surveys in summer and fall on the Kuparuk River (ABR, unpubl. data) and on and near the Colville River Delta. Single adult wolverines were seen along the Tamayagiaq Channel of the Colville River Delta on 27 June 1993 (Smith et al. 1994) and near the mouth of the Kachemach River on 11 June 1998 (Johnson et al. 1999). Two wolverine sightings were reported in the vicinity of our NPRA Study Area in 1977–1978 (BLM 1998).

Distribution and Abundance

Muskox

No muskoxen were seen in the NPRA study area in 2002. In 2001, one small group of muskoxen was seen in the NPRA Study Area. The group, comprising 5 or 6 adults at various times, was seen on 5 occasions between 9 June and 27 June, with successive locations proceeding eastward through the southern portion of the study area. No calves were present in that group, but a small group of 3 adults and 2 calves was seen east of the study area in the Colville River floodplain on 20 August 2001.

Fewer muskoxen were seen in 2002 than in 2001 in the Colville–Kuparuk region as well (Lawhead and Prichard 2003). One large group (maximum 32 adults and 9 calves) of mixed age and sex was seen repeatedly near the mouth of the Kachemach River on the eastern edge of the Colville River Delta (Lawhead and Prichard 2003).

Grizzly Bear

Grizzly bears were seen only twice during our work in the NPRA Study Area in 2002. A sow with two cubs of the year was seen on 24 August in the northwest corner of the study area and a single unmarked adult was seen in the same area on 26 August. Grizzly bears were seen on 7 occasions in 2001. Four of the sightings occurred in the NPRA Study Area, one was just outside the northeast corner, and the other 2 were south and west of the area.

Three old winter dens were found in the 2002 Study Area during fox den and caribou surveys, in addition to the 3 found in 2001 (Figure 32), usually in well-drained landforms suitable for fox denning.

Several of the bears radio-collared by ADFG in the oilfield region to the east have denned near the Colville River or on the Colville River Delta in past years, but none of these bears have denned in the NPRA Study Area. Bears collared in northeastern NPRA by ADFG in summer 2002 will provide future data on den locations.

Wolverine

A large wolverine was seen off transect on 25 October 2002 at the southern edge of the study area near Tiŋmiaqsiuġvik. One adult wolverine was seen south of Uvlutuuq in the southwestern portion of the study area on 29 September 2001 during a caribou survey.

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Appendix A. Common and scientific names of birds and mammals observed in the NPRA Study Area, Alaska, 1999–2002.

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

[a] Unidentified scaup observed, probably Greater Scaup.
[b] Indicates species not observed during this investigation, but known to occur in the NPRA.

Appendix B. Coordinates (North American Datum 83 in decimal degrees)for the midlines of the 24 shorebird plots in the NPRA Study Area, Alaska, 2002.

	Start		End	
Plot No.	Latitude	Longitude	Latitude	Longitude
1	70.27807	-151.98065	70.28508	-151.99740
2	70.27635	-151.98452	70.27437	-151.95508
3	70.27805	-151.94412	70.27915	-151.91730
4	70.28369	-151.94296	70.28182	-151.91683
25	70.23495	-151.76157	70.24262	-151.77585
26	70.24585	-151.74068	70.25140	-151.76213
27	70.25087	-151.73165	70.24183	-151.73487
28	70.24185	-151.74382	70.23347	-151.75871
33	70.20074	-151.74321	70.20966	-151.73777
34	70.20154	-151.73203	70.19409	-151.71738
35	70.20267	-151.72727	70.19595	-151.70987
36	70.20160	-151.71855	70.21052	-151.72302
45	70.29173	-151.59087	70.29062	-151.61970
46	70.29528	-151.59748	70.29245	-151.57213
47	70.29302	-151.55849	70.29842	-151.57989
48	70.29486	-151.55057	70.30372	-151.55568
53	70.28950	-151.24070	70.29638	-151.25748
54	70.29119	-151.23918	70.28442	-151.21965
55	70.29785	-151.21815	70.30703	-151.21108
56	70.29295	-151.20960	70.30186	-151.20676
101	70.27405	-151.57338	70.27908	-151.55122
102	70.27397	-151.57343	70.26738	-151.59128
103	70.27464	-151.57789	70.27809	-151.60237
104	70.26745	-151.56388	70.27170	-151.54053

Appendix C. Classification and descriptions of wildlife habitat types found in the NPRA Study Area, Alaska, 2002.

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 mudflats 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, Halophytic Sedge Wet Meadow, Halophytic Willow Dwarf Shrub Tundra, and small barren patches. Dominant plant species usually include *Carex subspathacea, C. ursina, 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.
Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flats occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flats frequently are associated with lagoons and estuaries and may vary widely in actual salinity levels. Tidal Flats are considered separately from other barren habitats because of their importance to estuarine and marine invertebrates and shorebirds.

Appendix C. (Continued).

Habitat Class	Description
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 Upland Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant 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.
Aquatic 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.
Aquatic Sedge with Deep Polygons	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.*

Appendix C. (Continued).

Habitat Class	Description
Aquatic Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva*. Due to shallow water depths (<1 m), the water freezes to the bottom in the winter, and thaws by early June. *Arctophila 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 Aquatic 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, Aquatic 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 Aquatic 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. Aquatic Grass Marsh generally is absent. Soils have a moderately thick (0.2–0.5 m) organic layer overlying loam or sand.
Riverine Complex	Permanently flooded streams and floodplains characterized by a complex mosaic of water, Barrens, Riverine Dwarf Shrub, Riverine Low and Tall Shrub, Aquatic 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 Riverine Low Shrub, Nonpatterned Wet Meadow, or Fresh Sedge Marsh, while ridges commonly are Upland Dwarf Shrub or Upland Low Shrub.

Appendix C. (Continued).

Habitat Class	Description
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).
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.

Appendix C. (Continued).

Habitat Class	Description
Riverine Low and Tall Shrub	Both open and closed stands of low (≤1.5 m) and tall (>1.5 m) willows along riverbanks. Tall willows occur mainly on active riverine deposits along larger streams and rivers, where the vegetation is dominated by open (<75% cover) stands of *Salix alaxensis* with a sparse understory including *Equisetum arvense, Gentiana propinqua, Chrysanthemum bipinnatum, Festuca rubra,* and *Aster sibiricus.* Soils are well-drained riverine sands with a poorly developed organic horizon. Low willow stands, which can occur on active and inactive deposits, typically have an open to closed canopy of *S. lanata richardsonii* occasionally mixed with *S. planifolia pulchra.* Understory plants include *Equisetum arvense, Astragalus alpinus, Drepanocladus sp. Arctagrostis latifolia, Petasites frigidus,* and *Tomentypnum nitens.* Soils are interbedded layers of riverine sands, silts, and organics.
Upland Low and Tall Shrub	Open to closed stands of low (≤1.5 m) and tall (>1.5 m) willow often found on banks, dunes, and high-centered polygons. Upland Tall Shrub can be found on active sand dunes and is defined by the presence of *Salix alaxensis.* Low Shrub stands are found on short, steep banks of basins and on inactive sand dunes. Sites are dominated by *Salix glauca,* with *Dryas integrifolia, Salix lanata richardsonii, Arctostaphylos rubra.* and mosses in the understory. Included in this class are sites dominated by low shrub birch, *Betula nana.*
Upland and Riverine Dwarf Shrub	Dwarf scrub tundra on upland ridges, stabilized sand dunes and river terraces dominated by *Dryas integrifolia* or *Cassiope tetragona.* Upland *Dryas* sites typically are dry and sandy with deep thaw depths (>1.0 m), common associated species include *Salix glauca, S. reticulata, Arctostaphylos alpina, Arctagrostis latifolia, Thamnolia vermicularis,* and *Cetraria cuculata.* Riverine *Dryas* sites occur on well-drained, sandy river terraces. co-dominant species often include *Equisetum variegatum* and *Salix reticulata,* with *S. lanata richardsonii, Arctostaphylos rubra, Oxytropis deflexa, Tomentypnum nitens,* and *Thamnolia vermicularis* as associated species. *Cassiope tetragona* is found on slightly moister sites such as banks of thaw basins, riverbanks, and banks of older, well-stabilized dunes. On intermediate soils *Dryas integrifolia* may be co-dominant. Species found in association with *Cassiope* include *S. phlebophylla, Salix reticulata, Vaccinium vitis-idaea, Carex bigelowii, Hierochloe alpina,* and *Arctagrostis latifolia.* Cryptogams present include crustose lichens, *Hylocomium splendens, Dicranum* sp., *Tomentypnum nitens,* and *Rhytidium rugosum.* All sites have a wide variety of forbs.
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.

Appendix D. Number and density (number/km²) of nests found on 24 shorebird plots during nest-searching visits in the NPRA Study Area, Alaska, 2002. (Each plot was 10 hectares, see Figure 2).

	Plot Number											
Species	1	2	3	4	25	26	27	28	33	34	35	36
Red-throated Loon	0	0	0	0	0	0	0	0	0	0	0	0
Greater White-fronted Goose	0	0	0	0	0	1	2	0	0	0	0	0
Northern Pintail	0	0	0	0	0	0	0	1	0	0	0	0
Greater Scaup	0	0	0	0	0	1	0	0	0	0	0	0
Long-tailed Duck	0	0	0	0	0	0	0	0	0	0	0	0
Willow Ptarmigan	0	0	0	0	0	0	0	1	0	0	0	0
Black-bellied Plover	0	0	0	0	1	0	0	0	0	1	0	0
American Golden Plover	0	0	0	0	0	0	2	0	0	0	0	0
Bar-tailed Godwit	0	0	0	0	1	0	0	0	0	0	0	0
Semipalmated Sandpiper	1	0	0	1	0	1	0	1	2	0	0	0
Pectoral Sandpiper	1	0	0	0	0	2	0	1	2	2	1	4
Dunlin	0	0	0	0	0	0	0	0	0	0	0	0
Stilt Sandpiper	0	0	0	1	0	0	0	0	0	0	0	0
Buff-breasted Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0
Long-billed Dowitcher	0	0	1	0	0	2	1	0	0	0	1	0
Red-necked Phalarope	0	0	0	0	0	1	1	1	0	2	3	4
Red Phalarope	0	0	0	0	0	0	0	0	0	0	0	0
Arctic Tern	0	0	0	0	0	0	0	0	0	0	0	0
Savannah Sparrow	0	0	0	0	0	1	0	0	0	0	1	0
Lapland Longspur	1	4	5	4	0	2	1	2	6	2	2	0
Common Redpoll	0	0	0	0	1	0	0	0	0	0	0	0
Total Nests	3	4	6	6	3	11	7	7	10	7	8	8
Density (nests/km²)	30	40	60	60	30	110	70	70	100	70	80	80
Number of Species	3	1	2	3	3	8	5	6	3	4	5	2

Appendix D. (Continued).

Species	Plot Number 45	46	47	48	53	54	55	56	101	102	103	104	Total Nests	Mean Density (nests/km²)
Red-throated Loon	0	0	0	1	0	0	0	0	0	0	0	0	1	0.4
Greater White-fronted Goose	0	0	0	0	0	1	0	1	0	1	0	0	6	2.5
Northern Pintail	0	0	0	0	0	0	0	0	0	1	0	0	2	0.8
Greater Scaup	0	0	1	0	0	0	0	0	0	0	0	0	2	0.8
Long-tailed Duck	0	0	0	0	0	1	0	0	0	0	0	0	1	0.4
Willow Ptarmigan	0	0	0	0	0	0	0	0	0	0	1	1	3	1.3
Black-bellied Plover	1	1	1	0	0	0	0	0	0	0	0	0	5	2.1
American Golden Plover	0	0	0	0	1	0	0	0	0	0	2	0	5	2.1
Bar-tailed Godwit	0	0	0	0	0	0	0	0	0	0	1	0	2	0.8
Semipalmated Sandpiper	3	3	1	6	1	2	1	1	0	1	0	1	26	10.8
Pectoral Sandpiper	0	1	2	0	2	1	3	5	0	3	0	2	32	13.3
Dunlin	0	1	0	1	1	0	0	0	1	0	0	0	4	1.7
Stilt Sandpiper	0	1	0	0	0	0	2	1	0	0	0	0	5	2.1
Buff-breasted Sandpiper	2	2	1	1	0	0	0	0	0	0	0	0	6	2.5
Long-billed Dowitcher	0	0	0	0	1	0	1	1	1	1	0	0	10	4.2
Red-necked Phalarope	0	0	0	0	0	2	1	0	0	3	0	0	18	7.5
Red Phalarope	0	0	0	2	0	0	3	2	0	0	0	0	7	2.9
Arctic Tern	0	0	0	1	0	0	0	0	0	0	0	0	1	0.4
Savannah Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	2	0.8
Lapland Longspur	1	1	2	0	5	3	0	4	5	3	1	1	55	22.9
Common Redpoll	0	0	1	1	0	0	0	0	0	0	1	0	4	1.7
Total Nests	7	10	9	13	11	10	11	15	7	13	6	5	197	
Density (nests/km²)	70	100	90	130	110	100	110	150	70	130	60	50		82.1
Number of Species	4	7	7	7	6	6	6	7	3	7	5	4	21	

Appendix E. Number and mean density (number/km²) of nests found on clusters (4 plots each) of shorebird plots during nest-searching visits in the NPRA Study Area, Alaska, 2001–2002.

	Plots 1–4		Plots 25–28		Plots 33–36		Plots 45–48		Plots 53–56		Plots 65–68	Plots 101–104	Total Nests	Mean Density	Total Nests	Mean Density
Species	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	(nests/km²)	2002	(nests/km²)
Red-throated Loon	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.4
Greater White-fronted Goose	1	0	1	3	1	0	0	0	2	2	1	1	6	2.5	6	2.5
Northern Pintail	0	0	1	1	0	0	0	0	0	0	0	1	1	0.4	2	0.8
Greater Scaup	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	0.8
Long-tailed Duck	0	0	0	0	0	0	0	0	1	1	1	0	2	0.8	1	0.4
Willow Ptarmigan	1	0	3	1	0	0	0	0	2	0	0	2	6	2.5	3	1.3
Rock Ptarmigan	0	0	0	0	0	0	0	0	0	0	1	0	1	0.4	0	0
Black-bellied Plover	0	0	0	1	0	1	4	3	1	0	1	0	6	2.5	5	2.1
American Golden Plover	0	0	0	2	0	0	0	0	1	1	0	2	1	0.4	5	2.1
Bar-tailed Godwit	0	0	0	1	0	0	0	0	1	0	0	1	1	0.4	2	0.8
Semipalmated Sandpiper	5	2	6	2	3	2	7	13	4	5	3	2	28	11.7	26	10.8
Baird's Sandpiper	0	0	0	0	0	0	1	0	0	0	0	0	1	0.4	0	0
Pectoral Sandpiper	1	1	2	3	7	9	1	3	5	11	3	5	19	7.9	32	13.3
Dunlin	1	0	0	0	0	0	2	2	1	1	0	1	4	1.7	4	1.7
Stilt Sandpiper	0	1	0	0	0	0	0	1	4	3	0	0	4	1.7	5	2.1
Buff-breasted Sandpiper	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6	2.5
Long-billed Dowitcher	6	1	1	3	2	1	1	0	5	3	4	2	19	7.9	10	4.2
Red-necked Phalarope	0	0	4	3	4	9	0	0	5	3	1	3	14	5.8	18	7.5
Red Phalarope	0	0	0	0	2	0	1	2	0	5	1	0	4	1.7	7	2.9
Long-tailed Jaeger	1	0	0	0	0	0	0	0	0	0	0	0	1	0.4	0	0
Arctic Tern	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.4
Yellow Wagtail	0	0	1	0	0	0	0	0	0	0	0	0	1	0.4	0	0
Savannah Sparrow	0	0	1	1	2	1	0	0	0	0	1	0	4	1.7	2	0.8
Lapland Longspur	13	14	7	5	10	10	6	4	7	12	6	10	49	20.4	55	22.9
Common Redpoll	0	0	0	1	0	0	0	2	0	0	0	1	0	0	4	1.7
Total Nests	29	19	27	28	31	33	23	39	39	47	23	31	172		197	
Density	72.5	47.5	67.5	70.0	77.5	82.5	57.5	97.5	97.5	117.5	57.5	77.5	71.7		82.1	
Number of Species	8	5	10	14	8	7	8	12	13	11	11	12	20		21	

Appendix F. Nest evidence found near successful and failed nests of shorebirds in the NPRA Study Area, Alaska, 2002. Values represent percent of total nests for each type of evidence.

		Eggshell Fragments		Eggshell Parts		
Fate/Species	*n*	Present	Absent	None Found	Piece	Top or Bottom
SUCCESSFUL NESTS						
American Golden-Plover	1	100	0	100	0	0
Semipalmated Sandpiper	12	100	0	100	0	0
Pectoral Sandpiper	13	85	15	100	0	0
Stilt Sandpiper	2	100	0	100	0	0
Buff-breasted Sandpiper	1	100	0	100	0	0
Long-billed Dowitcher	1	100	0	0	100	0
Red-necked Phalarope	8	100	0	88	0	12
Red Phalarope	2	100	0	50	0	50
FAILED NESTS						
Black-bellied Plover	10	20	80	70	30	0
American Golden-Plover	1	0	100	0	100	0
Bar-tailed Godwit	1	100	0	0	100	0
Semipalmated Sandpiper	7	14	86	86	14	0
Pectoral Sandpiper	12	17	83	83	17	0
Dunlin	2	50	50	100	0	0
Buff-breasted Sandpiper	2	50	50	50	50	0
Long-billed Dowitcher	2	0	100	100	0	0
Red Phalarope	3	0	100	67	33	0

Appendix G. Daily survival rates (mean ± 1 SE) and 95% confidence intervals calculated using the Mayfield method for nests of shorebirds, waterfowl, and passerines in shorebird plots in the NPRA Study Area, Alaska, 2002. Blanks indicate no data for these species.

Species Group/Species	Mean Daily Survival Rate ± SE 95% Confidence Interval Sample Size of Nests						
	All Plots	Plots 1–4	Plots 21–24	Plots 31–34	Plots 41–44	Plots 51–54	Plots 101–104
Shorebirds[a]	0.981 ± 0.003 0.975 – 0.987 161	0.988 ± 0.009 0.970 – 1.005 12	0.985 ± 0.007 0.971 – 0.998 24	0.986 ± 0.006 0.974 – 0.998 27	0.972 ± 0.007 0.958 – 0.987 38	0.981 ± 0.006 0.970 – 0.993 39	0.984 ± 0.008 0.968 – 1.000 21
American Golden-Plover	0.993 ± 0.007 0.980 – 1.006 10	0.958 ± 0.041 0.877 – 1.040 2	1.000 ± 0.000 1.000 – 1.000 4	–	–	1.000 ± 0.000 1.000 – 1.000 1	1.000 ± 0.000 1.000 – 1.000 3
Black-bellied Plover	0.902 ± 0.029 0.843 – 0.961 12	–	0.818 ± 0.116 0.586 – 1.051 2	0.875 ± 0.083 0.710 – 1.040 2	0.902 ± 0.038 0.825 – 0.978 7	1.000 ± 0.000 1.000 – 1.000 1	–
Long-billed Dowitcher	0.988 ± 0.009 0.970 – 1.005 11	1.000 ± 0.000 1.000 – 1.000 2	1.000 ± 0.000 1.000 – 1.000 3	1.000 ± 0.000 1.000 – 1.000 1	–	0.980 ± 0.020 0.940 – 1.020 3	0.909 ± 0.087 0.736 – 1.082 2
Pectoral Sandpiper	0.979 ± 0.006 0.968 – 0.991 45	0.983 ± 0.017 0.950 – 1.016 5	0.979 ± 0.014 0.951 – 1.008 6	0.986 ± 0.010 0.966 – 1.006 11	1.000 ± 0.000 1.000 – 1.000 1	0.969 ± 0.011 0.946 – 0.992 16	0.986 ± 0.014 0.959 – 1.014 6
Red-necked Phalarope	1.000 ± 0.000 1.000 – 1.000 21	–	1.000 ± 0.000 1.000 – 1.000 4	1.000 ± 0.000 1.000 – 1.000 10	1.000 ± 0.000 1.000 – 1.000 1	1.000 ± 0.000 1.000 – 1.000 3	1.000 ± 0.000 1.000 – 1.000 3
Semipalmated Sandpiper	0.988 ± 0.005 0.978 – 0.998 36	1.000 ± 0.000 1.000 – 1.000 2	1.000 ± 0.000 1.000 – 1.000 4	0.957 ± 0.043 0.871 – 1.042 2	0.987 ± 0.007 0.973 – 1.002 17	0.988 ± 0.012 0.963 – 1.012 6	0.988 ± 0.012 0.964 – 1.012 5

Appendix G. (Continued).

Species Group/Species	All Plots	Plots 1–4	Plots 21–24	Plots 31–34	Plots 41–44	Plots 51–54	Plots 101–104
	Mean Daily Survival Rate ± SE 95% Confidence Interval Sample Size of Nests						
Waterfowl[b]	0.930 ± 0.019 0.891 – 0.969 17	–	0.911 ± 0.042 0.826 – 0.996 5	0.957 ± 0.043 0.871 – 1.042 2	0.833 ± 0.108 0.618 – 1.048 2	0.946 ± 0.030 0.886 – 1.007 4	0.944 ± 0.038 0.868 – 1.021 4
Passerines[c]	0.966 ± 0.012 0.942 – 0.989 37	0.900 ± 0.067 0.766 – 1.034 4	0.969 ± 0.021 0.926 – 1.012 8	1.000 ± 0.000 1.000 – 1.000 4	1.000 ± 0.000 1.000 – 1.000 4	0.935 ± 0.031 0.873 – 0.998 13	1.000 ± 0.000 1.000 –1.000 4
Passerines[d]	0.990 ± 0.010 0.984 ± 0.997 83	0.985 ± 0.010 0.965 – 1.006 18	0.987 ± 0.009 0.969 – 1.005 12	1.000 ± 0.000 1.000 – 1.000 13	1.000 ± 0.000 1.000 – 1.000 9	0.978 ± 0.011 0.955 – 1.000 18	1.000 ± 0.000 1.000 –1.000 13
Lapland Longspur[e]	0.956 ± 0.015 0.926 – 0.987 31	0.900 ± 0.067 0.766 – 1.034 4	0.962 ± 0.026 0.910 – 1.015 6	1.000 ± 0.000 1.000 – 1.000 3	1.000 ± 0.000 1.000 – 1.000 2	0.935 ± 0.031 0.871 – 0.998 13	1.000 ± 0.000 1.000 – 1.000 3
Lapland Longspur[f]	0.989 ± 0.004 0.981 – 0.997 77	0.985 ± 0.010 0.965 – 1.006 18	0.983 ± 0.012 0.960 – 1.007 10	1.000 ± 0.000 1.000 – 1.000 12	1.000 ± 0.000 1.000 – 1.000 7	0.978 ± 0.011 0.955 – 1.000 18	1.000 ± 0.000 1.000 – 1.000 12
All species[g]	0.976 ± 0.003 0.969 – 0.981 224	0.980 ± 0.010 0.947 – 0.992 17	0.976 ± 0.007 0.958 – 0.987 38	0.985 ± 0.006 0.967 – 0.993 33	0.973 ± 0.007 0.957 – 0.983 46	0.974 ± 0.006 0.958 – 0.983 58	0.972 ± 0.009 0.948 – 0.986 32

[a] Also includes Buff-breasted Sandpiper (n = 6), Bar-tailed Godwit (n = 2), Dunlin (n = 5), Red Phalarope (n = 8) and Stilt Sandpiper (n = 5).

[b] Includes Greater Scaup (n = 2), Greater White-fronted Goose (n = 8), Long-tailed Duck (n = 1) and Northern Pintail (n = 6).

[c] Incubation period; also includes Common Redpoll (n = 5) and Savannah Sparrow (n = 1).

[d] Incubation and nestling period; also includes Common Redpoll (n = 5) and Savannah Sparrow (n = 1).

[e] Incubation period.

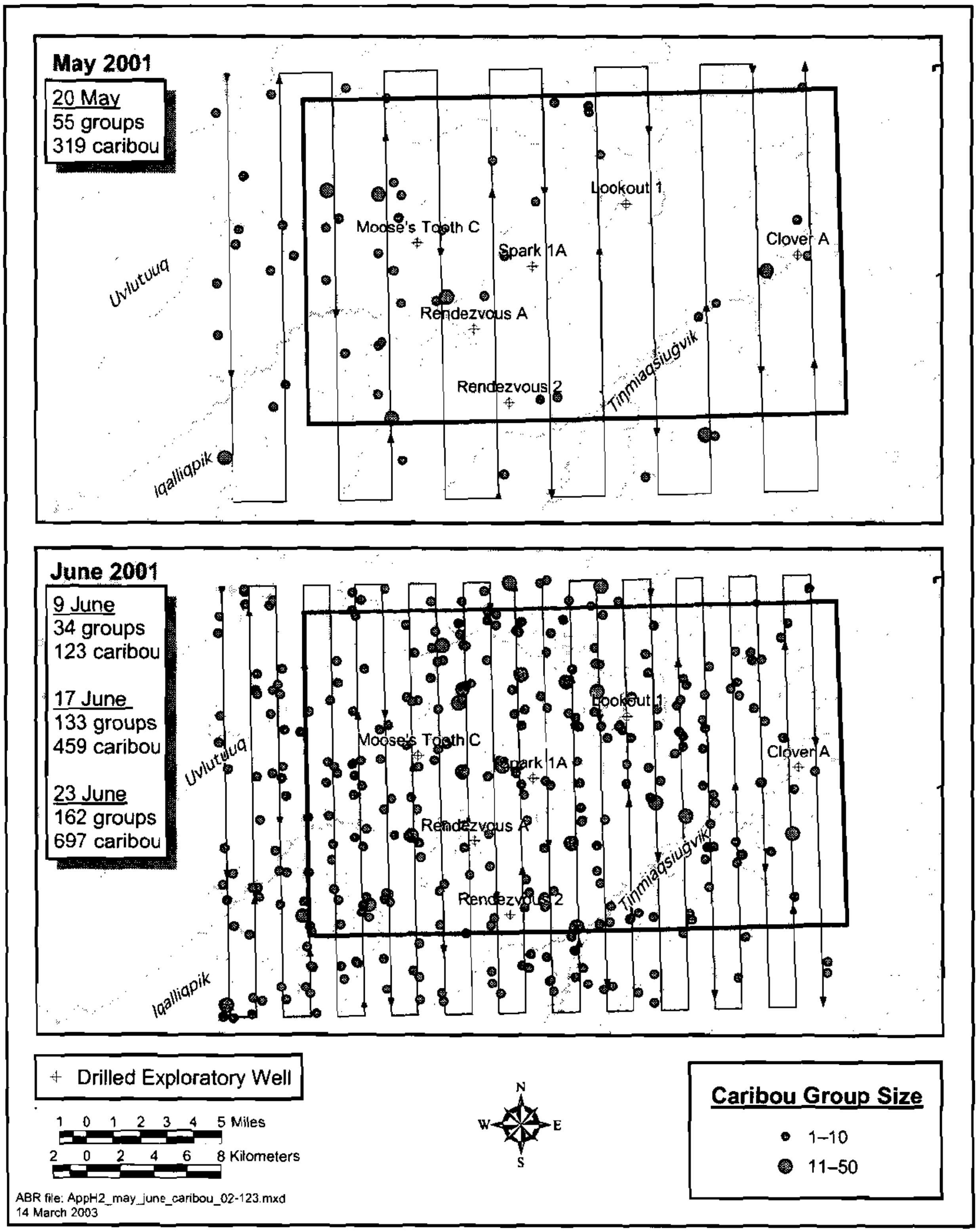
[f] Incubation and nestling period.

[g] Incubation period; also includes Arctic Tern (n = 2), Red-throated Loon (n = 1) and Willow Ptarmigan (n = 6).

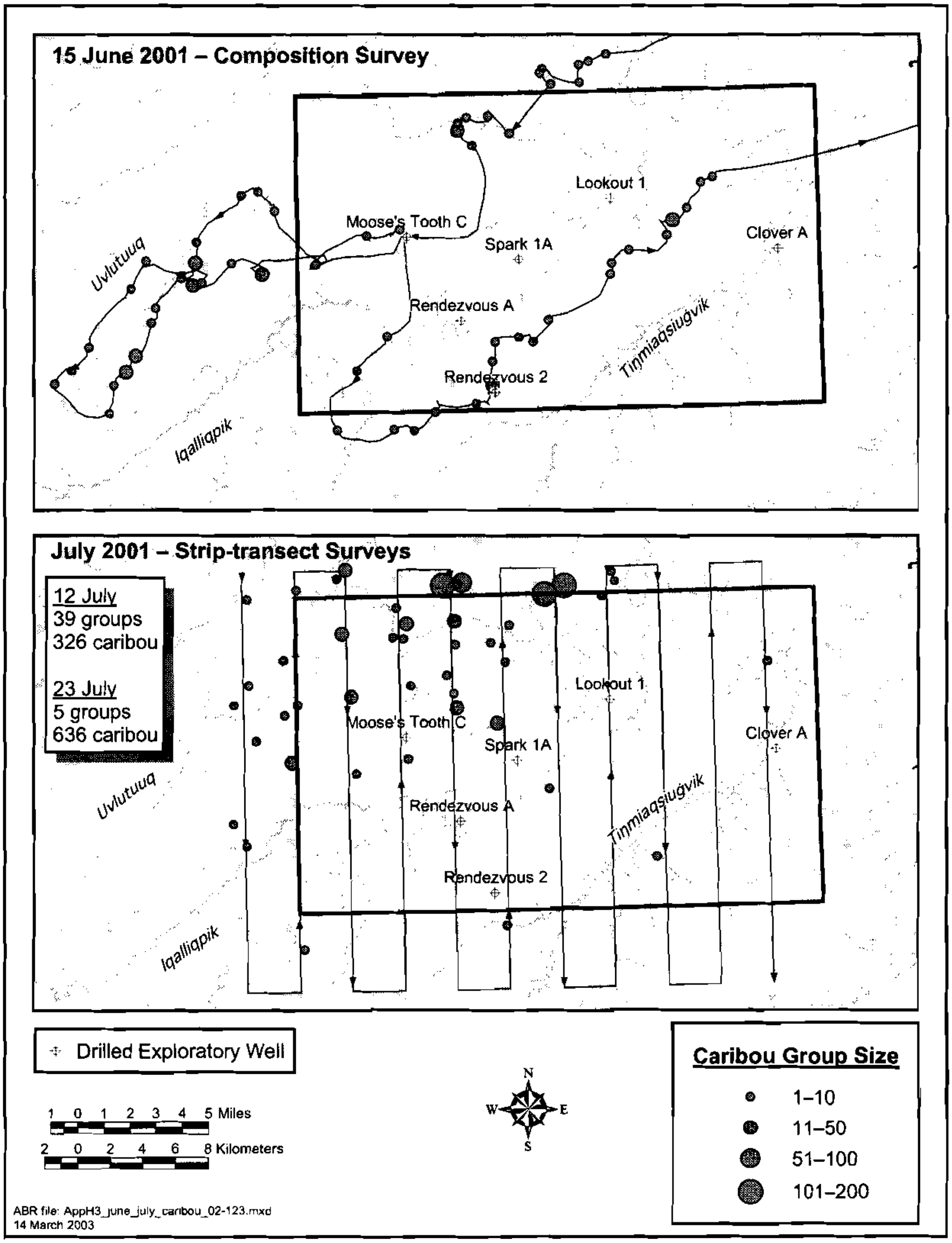
Appendix H1. Number and density of caribou observed during 12 systematic aerial strip-transect surveys (50% coverage of 953 km^2 survey area), NPRA Study Area, May–October 2001.

Date	No. of Large Caribou[a]	No. of Calves	Total No.	Density (caribou/km^2)	Mean Group Size
20 May	319	0	319	0.65	5.8
9 June	117	6	123	0.26	3.6
17 June	447	12	459	0.97	3.5
23 June	654	43	697	1.47	4.3
12 July	302	24	326	0.72	8.4
23 July	636	nr[b]	636	1.40	127.2
4 August	10	0	10	0.02	2.0
14 August	59	3	62	0.13	2.1
28 & 30 August	139	8	147	0.30	1.7
29 September	652	36	688	1.39	10.6
12 October	826	30	856	1.73	10.7
24 October	377	35	412	0.83	5.7
Total	4,538	197	4,735	0.82	6.2

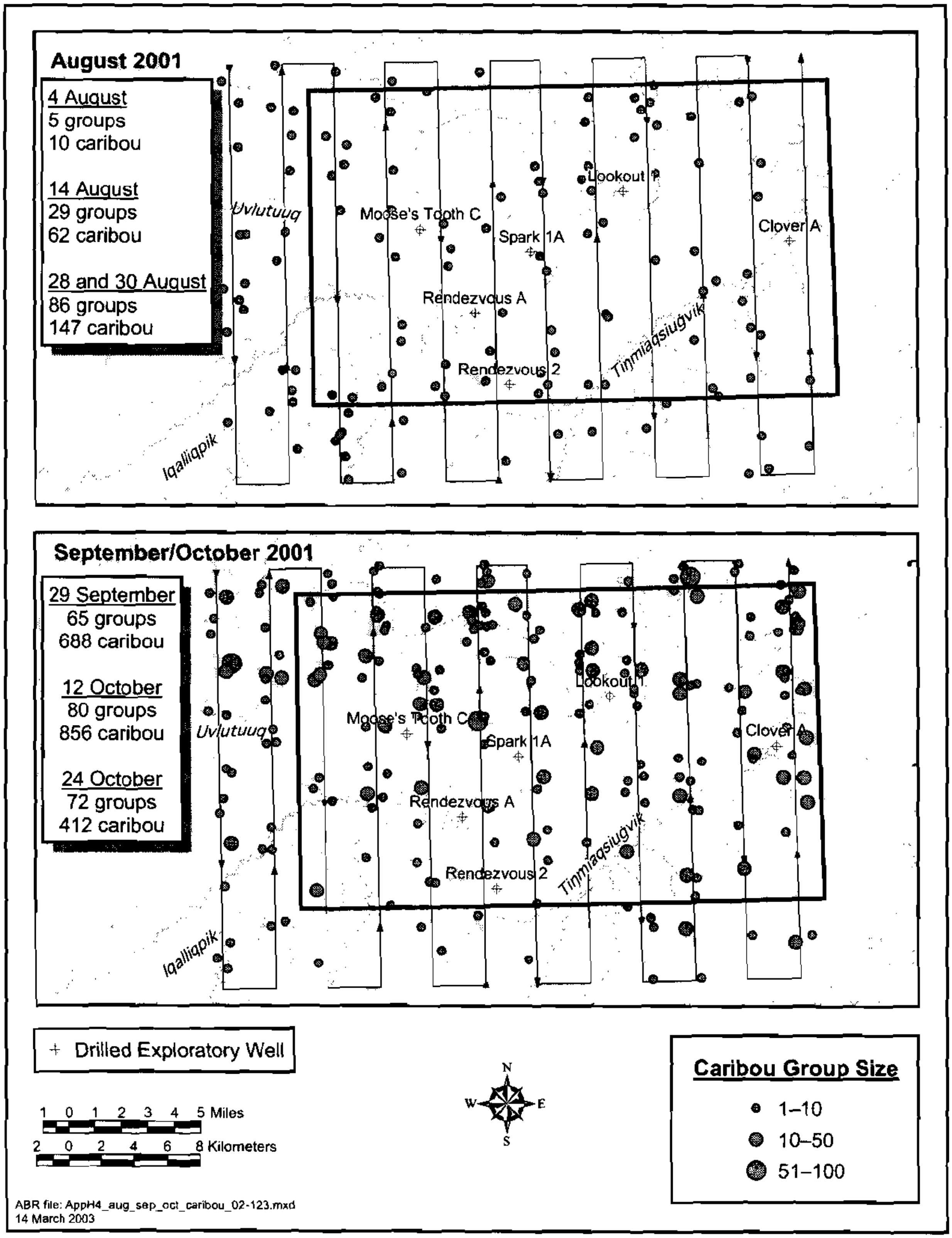
[a] Adults + yearlings.
[b] nr = calves present, but numbers not recorded.



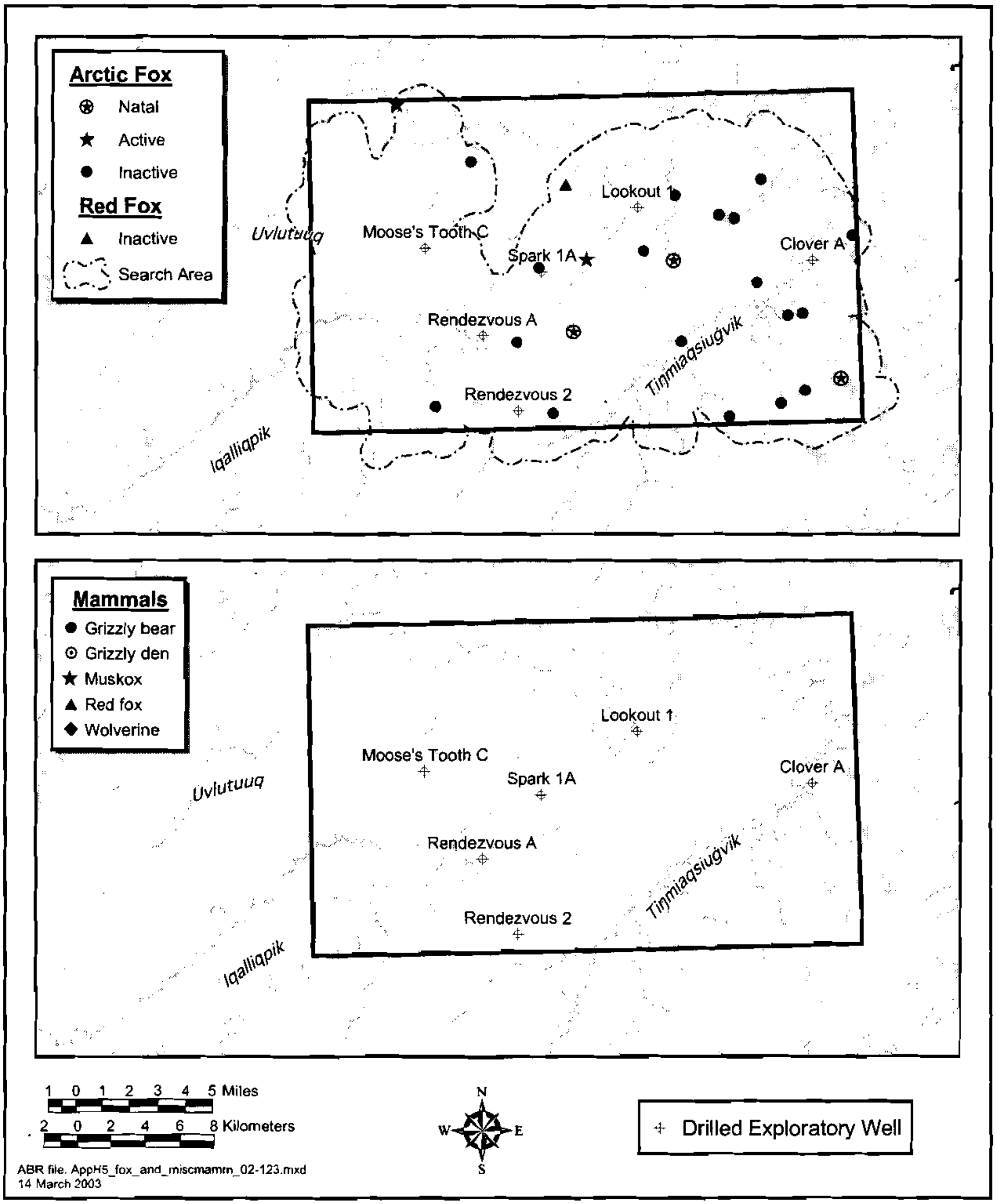
Appendix H2. Distribution and group size of caribou observed during aerial strip-transect surveys in the NPRA Study Area, May and June 2001.



Appendix H3. Survey route and caribou group locations during a sex- and age-composition survey on 15 June 2001 and distribution and group size of caribou observed during aerial strip-transect surveys in July, NPRA Study Area, 2001.



Appendix H4. Distribution and group size of caribou observed during aerial strip-transect surveys in the NPRA Study Area, August and September–October 2001.



Appendix H5. Distribution and activity status of fox dens observed in June–July and incidental sightings of other mammals during aerial strip-transect surveys in May–October, NPRA Study Area, 2001.