FINAL REPORT

MAMMAL SURVEYS IN THE GREATER KUPARUK AREA, NORTHERN ALASKA, 2012

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EXECUTIVE SUMMARY

- The focus of this study was the distribution, abundance, and calf production of Central Arctic Herd (CAH) caribou between the Colville and Kuparuk rivers in northern Alaska from spring to fall 2012. Surveys were conducted in spring (mid-May), the calving season (early June), postcalving (late June), late summer (mid-August), and fall (early October). Another survey planned for mid-September was cancelled due to poor weather. No surveys were scheduled during the insect season in July. Incidental sightings of other species of large mammals were recorded during aerial surveys for caribou and other species (mainly birds).
- A fixed-wing airplane was used to survey the distribution and abundance of caribou once during calving in 2012 (8–10 June). An earlier calving survey was not completed due to persistent fog and other inclement weather in early June. Summary maps of caribou density were prepared to compare calving distribution and density in 2012 with long-term averages from regional calving surveys conducted since 1993. A helicopter was used to sample the age and sex composition of caribou groups on 12 June.
- The timing of snow melt was slightly later than average in 2012. Snow depth at the Kuparuk airstrip in early May was greater than in any other year since at least 1983, but snow depth decreased rapidly during the third week of May. Due to colder-than-average temperatures in the last week of May and first week of June, however, snow did not melt completely until mid-June. Snow cover was patchy into the period when our calving surveys were conducted (8–10 June), requiring the use of a sightability correction factor in some parts of the study area.
- On the late calving survey (8–10 June), a total of 1,083 caribou were observed in the three calving survey areas, including 297 calves (37.8%), resulting in an expanded total estimate of 2,166 ± 206 caribou (adults and calves) and a mean density 0.67 ± 0.06 caribou/km². Adjusting the adult and yearling count for poor sightability due to patchy snow cover in the southern portion of the survey area produced an estimate of 1,949 ± 357 large caribou.
- The highest calving density in 2012 occurred southwest of the Kuparuk oilfield, in the Colville East survey area. Calving caribou were more concentrated in the western portion of the survey area, similar to 2010 and 2011, but farther west than has been observed in most years since 1996.
- On 8 June, 27 caribou (including one calf) were observed in the Kuparuk Field survey area, of which 11 caribou (including one calf) were north of the Spine Road and east of the Oliktok Point Road.
- Calf production by the western segment of the CAH was estimated at 80.1 calves:100 cows (n = 2,917 caribou) on 12 June, higher than the mean annual production estimated since 1978 (73.8 calves:100 cows). Calf production has exceeded the long-term mean in 15 of the last 17 years.
- Outside of the calving season, the densities of caribou in the Colville East survey area were fairly high in late June during postcalving, and were low in early May, mid-August, and early October.
- Between April and October 2012, 17 sightings of muskoxen were recorded in the study area and surrounding region. The maximum count was recorded on 8–9 June, when 43 individual muskoxen (33 adults and 10 calves) were observed in three groups.
- Thirty-two sightings of grizzly bears, totaling 33 adults and 18 cubs, were recorded within 75 km of the coast in the Kuparuk–Colville region and northeastern NPRA during wildlife surveys between April and October 2012.

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ACKNOWLEDGMENTS

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INTRODUCTION

Four herds of barren-ground caribou (*Rangifer tarandus granti*) inhabit Alaska north of the Brooks Range. The herds differ in their use of calving, insect-relief, and winter ranges (Murphy and Lawhead 2000). The Western Arctic Herd (WAH) is currently the largest herd in Alaska; the WAH peaked at ~490,000 animals in July 2003 (Dau 2011). Since then, the herd has declined by an estimated 4–6% per year, as indicated by Alaska Department of Fish and Game (ADFG) estimates of ~377,000 animals in July 2007, ~348,000 animals in July 2009, and ~325,000 animals in July 2011 (Dau 2011). WAH caribou calve in the Utukok uplands north of the western Brooks Range, move into the Brooks Range during the insect season, and most animals in the herd migrate south long distances in the fall to winter in western Alaska (Dau 2011).

The Teshekpuk Herd (TH) calves near Teshekpuk Lake, ~130 km (80 mi) west of Kuparuk, and uses coastal habitats and areas around Teshekpuk Lake for insect relief. The TH generally winters on the Arctic Coastal Plain (Person et al. 2007). However, since 2004–2005, portions of the herd have shown a tendency to winter with the Central Arctic Herd (CAH) and unusual wintering excursions by large portions of the herd were made to the ranges of the Porcupine Herd (PH) in 2003–2004 and the WAH in 2008–2009 (Carroll 2007, Parrett 2009, Lawhead et al. 2010).

The CAH typically calves in two areas on the coastal plain between the Colville and Canning rivers, uses coastal areas for insect relief, and winters in the Brooks Range (primarily in the southern foothills in recent years; Arthur and Del Vecchio 2009, Lenart 2011a). The PH typically calves in the northeastern corner of Alaska in the Arctic National Wildlife Refuge (ANWR) and in the Yukon Territory, Canada (Griffith et al. 2002), moves into the Brooks Range for insect relief (Walsh et al. 1992), and winters in the northern Yukon and the eastern Brooks Range in Alaska (Griffith et al. 2002).

The CAH is the primary herd that occurs in the oilfield region on the central Arctic Coastal Plain, whereas the ranges of the TH and PH are located west and east of the oilfields, respectively. From the early 1970s to 2002, the CAH grew at an overall rate of 7% per year (Lenart 2009). The herd grew rapidly from ~5,000 animals in the mid-1970s to the early 1990s, reaching a count of 23,444 caribou in July 1992 before declining 23% to 18,093 caribou in July 1995. By July 1997, the herd was estimated at 19,730 animals. The herd continued increasing, reaching 27,128 animals in July 2000 and 31,857 in July 2002; 66,772 caribou were counted in July 2009 (Lenart 2011a), representing a mean annual increase of 13% since 2002. The most recent photocensus of the CAH in July 2010 produced an estimate of 70,034 animals, indicating that herd growth had slowed (Lenart 2011a). Another photocensus was attempted in 2012 but was unsuccessful because of unsuitable weather conditions (E. Lenart, ADFG, personal communication).

Similar to the CAH, the TH increased substantially in size from the mid-1970s to the early 1990s (Murphy and Lawhead 2000, Parrett 2011). The TH experienced a dip in numbers in the early to mid-1990s similar to that seen in the CAH, but increased steadily from 1995 to its peak size (minimum population estimate) of 64,106 animals in July 2008 (Parrett 2011). A photocensus in July 2010 produced unsatisfactory results so another census was conducted in July 2011, producing an estimate of ~55,000 animals in the herd (L. Parrett, ADFG, personal communication), a decline of about 14% from the 2008 estimate. The 2010 and 2011 census efforts for both the CAH and the TH were confounded by some mixing of animals from the two herds, judging from the distribution of radio-collared animals (E. Lenart and L. Parrett, ADFG, personal communication), and not all radio-collared animals could be located for those censuses, suggesting that some animals may have been missed. The PH decreased steadily from a high of ~178,000 animals in 1989 to ~123,000 in 2001 (Griffith et al. 2002), but subsequently increased to ~169,000 animals by July 2010, the most recent population estimate (Caikoski 2011).

The Kuparuk oilfield and surrounding area (known as the Greater Kuparuk Area, or GKA) is located on the outer coastal plain in the western portion of the summer range of the CAH. Since 1978, shortly before development of the Kuparuk oilfield, considerable interest has focused on the use of the oilfield and surrounding area (particularly the Milne Point Unit) by the CAH during calving. The Kuparuk–Milne Point area is one of two locales (the other being the area between Bullen Point and the Staines River, east of the Prudhoe Bay oilfield) that consistently received concentrated use during the calving season from the late 1970s to the late 1980s, as determined by systematic aerial surveys beginning in 1978 (Whitten and Cameron 1985, Lawhead and Cameron 1988). Studies by ADFG reported local avoidance of oilfield facilities and human activities by cows with young calves in this general concentration area during the calving season (Dau and Cameron 1986, Cameron et al. 1992). From 1978 through 1992, ADFG conducted aerial transect surveys of caribou distribution annually during the latter portion of the calving season (usually 10–15 June). After 1992, however, that annual effort was cut back because of budget constraints and ADFG only conducted two more transect surveys, in June 1997 and June 2000. ABR has conducted similar transect surveys of the calving ground of the western segment of the CAH every year since 1993 (except 1994), and also conducted calving surveys in the region in 1983, 1984, and 1987.

The data from the surveys described in this report complement the data from telemetry studies by ADFG. Since 1992, ADFG survey efforts have focused primarily on tracking radio-collared female caribou, following a known-age sample of 60–80 cows annually (Arthur and Del Vecchio 2009, Lenart 2011a). A small sample of 10-month-old CAH females is outfitted annually with conventional VHF radio collars (Lenart 2011a) and some satellite collars have been deployed on bulls in recent years (E. Lenart, ADFG, personal communication).

In late July 2001, 10 female CAH caribou were outfitted with satellite collars by ADFG, in a cooperative study with the North Slope Borough (NSB) Department of Wildlife Management and the U.S. Bureau of Land Management (BLM), to study distribution and movements of the herd throughout the year (G. Carroll, ADFG, personal communication). In March 2003, 26 Global Positioning System (GPS) collars were placed on CAH caribou by ADFG to track the movements of specific caribou in relation to oilfield infrastructure (Arthur and Del Vecchio 2009). Another 27 GPS collars were deployed in March 2004, all but four of which were removed in March 2006 (Arthur and Del Vecchio 2009). The last four collars released automatically in June 2006, so no GPS or satellite collars were active on CAH caribou from then until June 2008 (Lenart 2009). In late June–early July 2008, 14 GPS collars were deployed by ADFG on CAH females, four of which were provided by ConocoPhillips Alaska (CPA). In late June 2009, four of the GPS collars were replaced and new GPS collars were placed on two other CAH females by ADFG, with funding from CPA (Lawhead et al. 2010). In 2010, 12 more CAH females were outfitted with GPS collars by ADFG, with funding by CPA. Three of those animals died during deployment, the remaining nine collars were retrieved 24 April 2012.

This study was conducted under contract to CPA to fulfill the mandate for ongoing caribou research in the Kuparuk River Unit Agreement by monitoring the distribution and abundance of caribou in and near the Kuparuk oilfield in 2012. Work was conducted primarily during the caribou calving season and secondarily during late winter and late summer in the area between the Kuparuk oilfield and the Colville River delta; the surveys in 2012 did not cover the insect season.

Although the impetus for this study was caribou research, the extensive aerial-survey coverage provided an opportunity to record data on the distribution and abundance of other large mammals as well, most notably muskoxen (*Ovibos moschatus*) and brown (hereafter, grizzly) bears (*Ursus arctos*).

The 2012 study had four objectives:

- Document the distribution and abundance of caribou in the region between the Kuparuk and Colville rivers during the calving season (early to mid-June);
- Sample the sex and age composition of caribou in the Kuparuk–Colville region at the end of the calving season (mid-June) to estimate initial calf production;
- Record the distribution and abundance of caribou between the Colville River delta and the Kuparuk oilfield during spring, late summer, and fall; and

- Record the distribution and abundance of other large mammals encountered incidentally during wildlife surveys in the Kuparuk–Colville region.

STUDY AREA

The study area extended east from the Colville River delta to the Kuparuk River and north from about latitude 70º N to the Beaufort Sea coast (Figure 1). This area encompassed the entire Kuparuk oilfield, the Alpine pipeline corridor between the Kuparuk oilfield and Colville River delta, the Milne Point oilfield, and the westernmost portion of the Prudhoe Bay oilfield (west of the Kuparuk River). Aerial surveys of calving caribou were conducted in three survey areas: (1) the Kuparuk Field survey area (1,035 km²), including the Kuparuk and Milne Point oilfields from Kalubik Creek east to the Kuparuk River; (2) the Kuparuk South survey area (788 km²), located south of the Kuparuk oilfield; and (3) the Colville East survey area (1,432 km²), located between the Colville River and the western Kuparuk oilfield and encompassing its westernmost pads, including the infrastructure constructed most recently for the Tarn (DS-2L and DS-2N), Meltwater (DS-2P), and Palm (DS-3S) projects.

These calving survey areas have been modified slightly over the years to optimize survey effort in areas used consistently by caribou. In 2002, the westernmost transect of the Colville East survey area and the two easternmost transects of the Kuparuk Field survey area were dropped and the Kuparuk South survey area was extended eastward to the Kuparuk River. The net result was an expansion of total coverage from 3,188 to 3,255 km². In mid-June 2009, we added two transects west of the Colville East survey area to assess caribou distribution along the Itkillik River for the Alpine Satellite Development Project (ASDP) caribou monitoring study (Lawhead et al. 2010). However, those transects were dropped in 2011 because of the small number of caribou in the area and concerns about the potential to disturb subsistence hunting activities along the Itkillik River.

Surveys during spring, postcalving, and late summer covered the expanded Colville East survey area, which was extended in the southwestern and southeastern corners for those surveys to form a rectangle on the southern end (thereby expanding the survey area to 1,700 km²).

The landscape in the Kuparuk–Colville region slopes gently downward from upland, moist tussock tundra in the upper reaches of the Sakonowyak, Ugnuravik, Kalubik, Miluveach, and Kachemach drainages to moist and wet tundra near the sea coast. The study area is characterized by permafrost-related features, such as oriented thaw-lakes, drained-lake basins, beaded streams, and pingos. The physiography, vegetation, and climate of the central Arctic Coastal Plain were described by Walker et al. (1980).

METHODS

CARIBOU CALVING SEASON

Surveys of the calving distribution of the western segment of the CAH in the GKA were conducted by ABR in 1993 and 1995–2012. In most years, we conducted two systematic aerial surveys of caribou distribution and numbers during calving. An early calving survey was conducted during June 1–8, around the typical peak of calving (2–4 June), and a late calving survey was conducted during 8–16 June, after most females had calved. In 2012, early calving surveys were not conducted due to persistent fog. Late calving surveys were conducted 8–10 June.

Caribou were counted by two observers, looking on opposite sides of a Cessna 206 survey airplane. In each survey area, the pilot navigated along north–south-oriented transect lines using route coordinates loaded into a GPS receiver. The pilot maintained the aircraft speed at ~150 km/h and the altitude at ~90 m (300 ft) above ground level (agl) using a radar altimeter. Transect lines were spaced at intervals of 1.6 km (1 mi), following section lines on U.S. Geological Survey topographic maps (Figure 1).

Observers counted caribou within a 400-m-wide strip on each side of the flight line, for a sampling intensity of 50% (0.8 km of each 1.6 km). The strip width was delimited visually using tape markers on the struts and windows of the aircraft, following the method of Pennycuick and Western (1972), and width was verified by comparison with maps loaded into the observers'

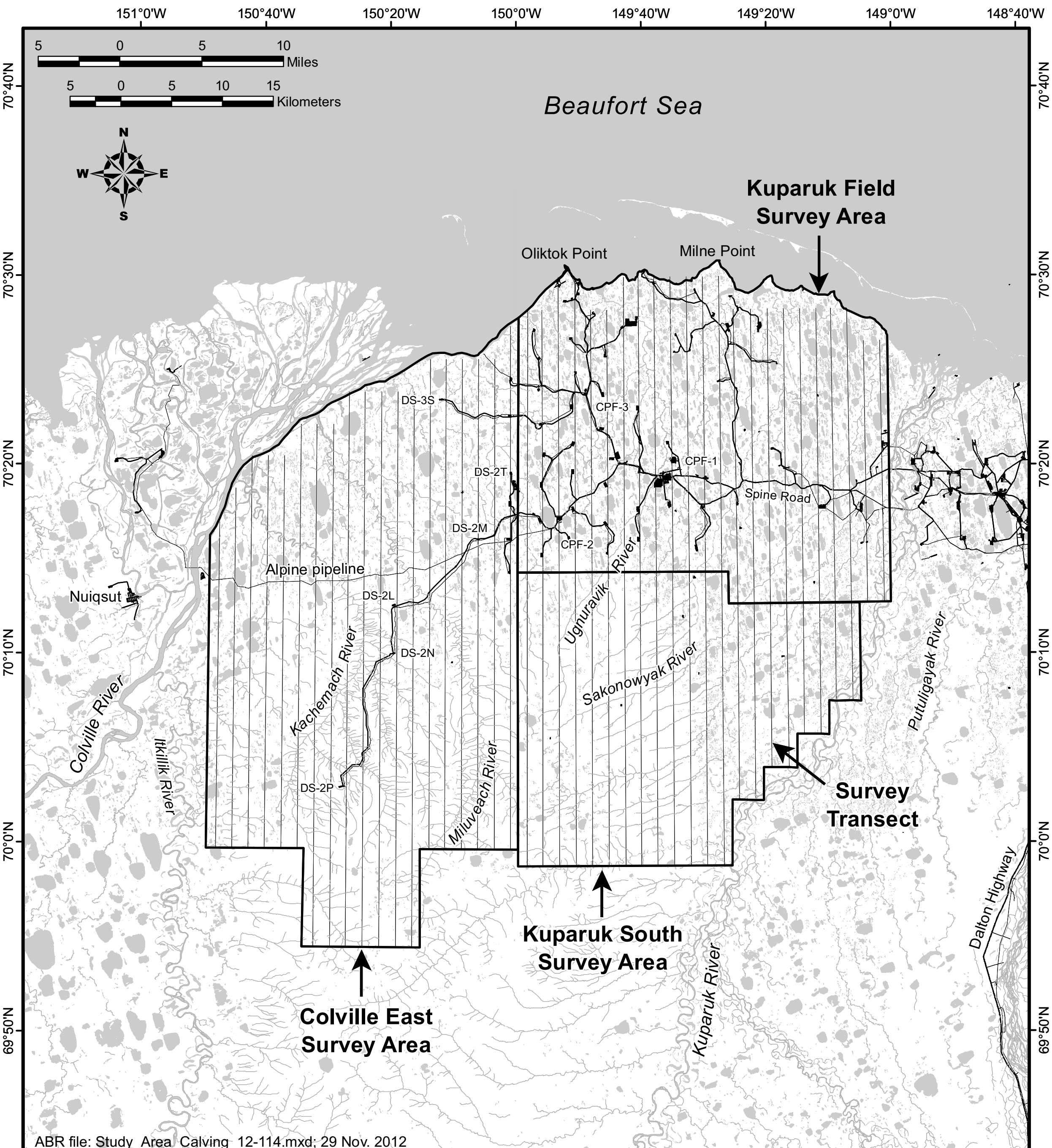

Figure 1. Survey areas and transect lines for systematic aerial surveys of caribou in the Kuparuk–Colville region, northern Alaska, during the 2012 calving season.

GPS receivers. Tape markers were positioned on the struts and airplane windows to indicate distances of 200 m and 400 m from the inner edge of the strip. For each caribou group observed within the strip, the airplane location was recorded using a GPS receiver, the numbers of adults and calves were recorded, and the group was assigned to a distance category (one of four 100-m-wide zones) east or west of the airplane. For production of map figures, caribou were assigned to the midpoint of the distance zone (50, 150, 250, 350 m) in which they were seen. For color maps of calving density (described below), caribou groups were pooled into the same 3.2-km-long (2-mi-long) transect segments used in previous years (Lawhead and Prichard 2011) for comparative purposes.

The percentage of ground surface covered by snow was estimated visually in the survey area as an index to survey conditions. The patchy background of snow and bare ground resulting from spring snowmelt is the most important factor diminishing sightability—defined as "the probability that an animal within the observer's field of search will be seen by that observer" (Caughley 1974: 923)—during the calving season (Lawhead and Cameron 1988). One way to adjust counts made during poor viewing conditions is to estimate sightability using a double-survey technique and then calculate a sightability correction factor (SCF) for post-survey adjustment of counts (Gasaway et al. 1986). In 1993, an SCF (1.88) for large caribou was calculated for patchy (20–70%) snow cover during calving surveys; no SCF could be computed for calf counts, however (Lawhead et al. 1994). During our late calving surveys in 2012, snow cover was patchy in Kuparuk Field and Kuparuk South on 8 June and was patchy in the SE portion of Colville East on 9–10 June; therefore, we applied the SCF to transects surveyed in these regions.

Population estimates for total caribou and for calves were extrapolated from their respective counts and standard errors using formulas modified from Gasaway et al. (1986). Because surveys covered 50% of the study area, the "observable population" (i.e., the estimated number of caribou in the entire survey area) was estimated by doubling the number of caribou observed. In this report, these estimates are followed by an 80% confidence interval (CI); for example, an observable population estimate of 70 ± 30 caribou means that the 80% CI ranges from 40 to 100 caribou.

Because the transect survey method using fixed-wing aircraft tends to undercount calves, a helicopter (Bell 206-LIII "Long Ranger") was used on 12 June to sample the sex and age composition (cows, calves, yearlings, and bulls) of caribou groups in portions of all three survey areas, as well as nearby areas south of the survey areas. Helicopter speed ranged from 40 to 125 km/h (slowing frequently to observe groups closely) and altitude ranged from 30 to 60 m (100–200 ft) agl to facilitate accurate identification of sex and age classes. We followed a nonsystematic survey path on this survey to maximize the number of groups encountered, using a GPS receiver to avoid duplicate counts and making an effort to include areas of both high-density (concentrated) calving and low-density peripheral areas, based on the distribution observed on 8–10 June.

To summarize calving distribution and abundance data from mid-June, we used the inverse distance-weighted (IDW) interpolation technique of the *Spatial Analyst* extension of *ArcMap* software (Environmental Systems Research Institute, Inc. [ESRI], Redlands, CA) on a geographical information system (GIS) platform to map caribou densities in 2012 and over all years (1993 and 1995–2012). This analysis used the total numbers of caribou and of calves pooled in each 3.2-km × 0.8-km segment of the transect strips; mean values were calculated for segments over all years and assigned to the centroid of the segment. The IDW interpolation technique calculated a density surface as the distance-weighted density of the 14 nearest centroids for each 200-m grid cell in the study area (power = 1). This analysis produced color maps showing surface models of the estimated density of all caribou (large caribou plus calves) and all calves observed over the entire survey area, to create an easily understood visual portrayal of the data.

SUMMER WEATHER CONDITIONS

The Kuparuk airstrip was closed during most of the summers of 2011 and 2012 while the runway was being upgraded and paved. Consequently, daily weather data at the airstrip were not recorded from 17 June through 9 December 2011 and during 4–14 August and 30–31 August 2012, so we were unable to obtain summer temperature data during those periods for comparison with the long-term weather record for this location. To estimate summer weather conditions in the GKA during those periods, we averaged data from the National Weather Service stations at Nuiqsut and Deadhorse. In comparisons of temperature data from previous years, Deadhorse temperatures tended to be lower than Kuparuk temperatures and Nuiqsut temperatures tended to be higher; therefore, we used the average of Nuiqsut and Deadhorse temperatures to estimate Kuparuk temperatures when data were not available. The differences from Kuparuk daily mean temperatures during July 2004–2010 averaged –0.48° C at Deadhorse, 1.13° C at Nuiqsut, and 0.26° C for the average of Deadhorse and Nuiqsut.

CARIBOU SURVEYS IN SPRING AND LATE SUMMER–FALL

Outside of the calving season in mid-June, aerial transect surveys were conducted in the expanded Colville East survey area in mid-May, late June, mid-August, and early October. The survey planned for mid-September was cancelled due to persistent inclement weather. The spring, late summer, and fall surveys used the same procedures as the calving surveys, but because visibility was better (either complete snow cover or none), surveys were flown at ~150 m (500 ft) agl and caribou were recorded within an 800-m-wide strip on each side of the airplane. Transects were spaced at intervals of 3.2 km to maintain 50% sampling coverage.

OTHER MAMMALS

Locations and numbers of large mammals other than caribou were noted and mapped as incidental observations during aerial surveys in the three calving survey areas and in the Colville East survey area during the late winter, postcalving, oestrid fly, and late summer surveys. Additional sightings were obtained from ABR observers conducting other wildlife surveys (mainly of birds) in the region.

RESULTS AND DISCUSSION

CARIBOU CALVING SEASON

HABITAT AND SURVEY CONDITIONS

Snow depth was the deepest on record at the Kuparuk airstrip in early May but melted rapidly after 16 May (Figure 2, Appendix A). Daily air temperatures from 1 May–15 June 2012 were variable compared to the 30 year mean: 1–10 May was 3.1 °C below average, 11–21 May was 2.9 °C above average, and 22 May–15 June was slightly below average (Figure 2, Appendix A).

DISTRIBUTION AND ABUNDANCE IN 2012

During 8–10 June, we counted 1,083 caribou, including 786 large caribou and 297 calves (37.8%), in all three survey areas combined. Doubling our 50% sample produced mid-June population estimates of 1,572 ± 144 large caribou and 594 ± 66 calves among all three areas, for a total estimate of 2,166 ± 206 animals (Table 1). After adjusting for low sightability, the estimate of large caribou increased to 1,949 ± 357 animals (Table 1).

The mean density (adjusted for sightability) estimated for the combined survey areas was 0.60 ± 0.11 large caribou/km² during 8–10 June (Table 2). Compared with previous years since 1993, the overall number and density of caribou in mid-June 2012 were only about a third of the long-term averages (Table 3, Appendix B). Caribou were concentrated in the Colville East survey area on both sides of the Meltwater Road in 2012 (Figures 3 and 4). Since 1993, most caribou have been found farther East, primarily in Kuparuk South. Given the lower-than-average densities in all three survey areas, it is likely that many CAH females still were south of the survey area, which was the distribution seen on the composition survey (described below). In years of late snow melt, such as 2012, calving tends to occur farther inland (Lawhead and Prichard 2001, 2002).

In 2012, the density of caribou in the Kuparuk Field survey area during calving was the second lowest recorded since late calving surveys began in 1993 (Table 3, Appendix B). On 8 June, 11 of the caribou (including the only calf in the area) counted in the Kuparuk Field survey area (40.7% of the total number) were located north of the

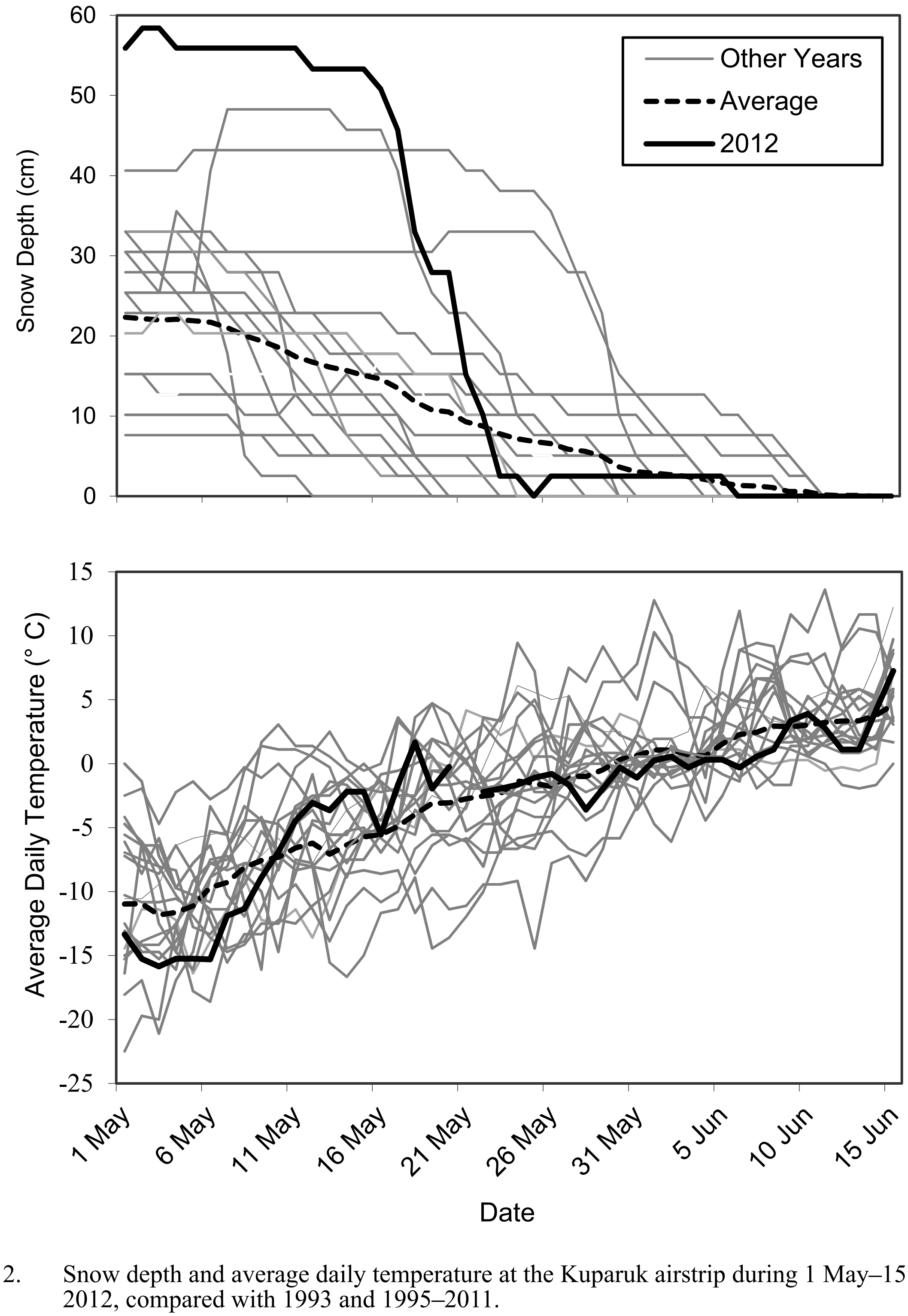

Figure 2. Snow depth and average daily temperature at the Kuparuk airstrip during 1 May–15 June 2012, compared with 1993 and 1995–2011.

Table 1. Estimated number of caribou (±80% CI) during the 2012 calving season in the Colville East, Kuparuk South, and Kuparuk Field survey areas.

Survey Area	Date	Total Area (km²)	Unadjusted Estimate [a]			SCF-Adjusted (Large Only) [c]
			Total	Large [b]	Calves	
Colville East	9–10 June	1,432	2,028 ± 190	1,450 ± 132	578 ± 62	1,720 ± 294
Kuparuk South	8 June	788	84 ± 16	70 ± 12	14 ± 5	131 ± 41
Kuparuk Field	8 June	1,035	54 ± 15	52 ± 15	2 ± 2	98 ± 37
Total	8–10 June	3,255	2,166 ± 206	1,572 ± 144	594 ± 66	1,949 ± 357

[a] Estimates are actual counts multiplied by 2 to account for 50% sampling intensity.
[b] Adults + yearlings.
[c] Applied Sightability Correction Factor (SCF) of 1.88 (Lawhead et al. 1994) to areas with patchy snow cover.

Table 2. Estimated density of caribou (number per km² ± 80% CI) during the 2012 calving season in the Colville East, Kuparuk South, and Kuparuk Field survey areas.

Survey Area	Date	Unadjusted Density			SCF-Adjusted (Large Only) [b]
		Total	Large [a]	Calves	
Colville East	9–10 June	1.42 ± 0.13	1.01 ± 0.09	0.404 ± 0.043	1.20 ± 0.21
Kuparuk South	8 June	0.11 ± 0.02	0.09 ± 0.02	0.018 ± 0.007	0.17 ± 0.05
Kuparuk Field	8 June	0.05 ± 0.01	0.05 ± 0.01	0.002 ± 0.002	0.09 ± 0.04
Total	8–10 June	0.67 ± 0.06	0.48 ± 0.04	0.182 ± 0.020	0.60 ± 0.11

[a] Adults + yearlings.
[b] Applied Sightability Correction Factor of 1.88 (Lawhead et al. 1994) to areas with patchy snow cover.

Table 3. Estimated density of caribou (number per km²) in the Colville East, Kuparuk Field, and Kuparuk South survey areas in mid-June 1993 and 1995–2012.

	Colville East		Kuparuk Field		Kuparuk South		Total		Timing of Snow Melt
Year	Total	Calves	Total	Calves	Total	Calves	Total	Calves	
1993	2.40	0.61	0.65	0.16	–	–	1.40	0.35	Intermediate
1995	1.52	0.23	–	–	5.05	0.97	2.54	0.44	Intermediate
1996	1.97	0.58	2.16	0.79	7.25	2.62	3.08	1.06	Early
1997[a]	3.05	0.92	0.28	0.07	2.40	0.69	1.91	0.56	Late
1998	1.39	0.23	0.62	0.18	10.22	3.68	2.84	0.89	Early
1999	1.47	0.37	1.17	0.41	3.26	1.03	1.70	0.51	Late
2000[a]	0.65	0.13	0.36	0.09	0.53	0.14	0.53	0.12	Late
2001	0.78	0.13	0.60	0.15	3.54	1.01	1.24	0.30	Late
2002	4.35	0.72	0.86	0.22	6.06	1.48	3.65	0.74	Early
2003	1.95	0.43	0.48	0.14	1.69	0.46	1.42	0.34	Intermediate
2004	5.28	1.73	0.56	0.17	3.63	1.06	3.29	1.05	Intermediate
2005	1.92	0.51	0.07	0.02	0.30	0.09	0.94	0.25	Intermediate
2006	2.83	0.71	0.88	0.24	10.61	3.14	4.09	1.15	Intermediate
2007	7.42	1.81	0.44	0.06	6.22	1.57	4.91	1.20	Intermediate
2008	7.09	1.28	1.43	0.27	14.74	3.07	7.14	1.39	Intermediate
2009	4.91	1.29	0.40	0.06	3.69	0.89	3.18	0.80	Early
2010[b]	4.61	1.52	0.12	0.03	0.57	0.12	2.21	0.71	Late
2011[a]	1.56	0.35	0.14	0.02	0.75	0.16	0.91	0.20	Late
2012[c]	1.68	0.48	0.10	<0.01	0.20	0.04	0.82	0.22	Late
Mean	2.99	0.74	0.63	0.18	4.48	1.23	2.52	0.64	

[a] Applied sightability correction factor (SCF) of 1.88 (Lawhead et al. 1994).
[b] Applied SCF only to counts in Kuparuk South survey area and southern portion of Colville East survey area.
[c] Applied SCF to counts in Kuparuk South, Kuparuk Field, and southern portions of Colville East survey areas.

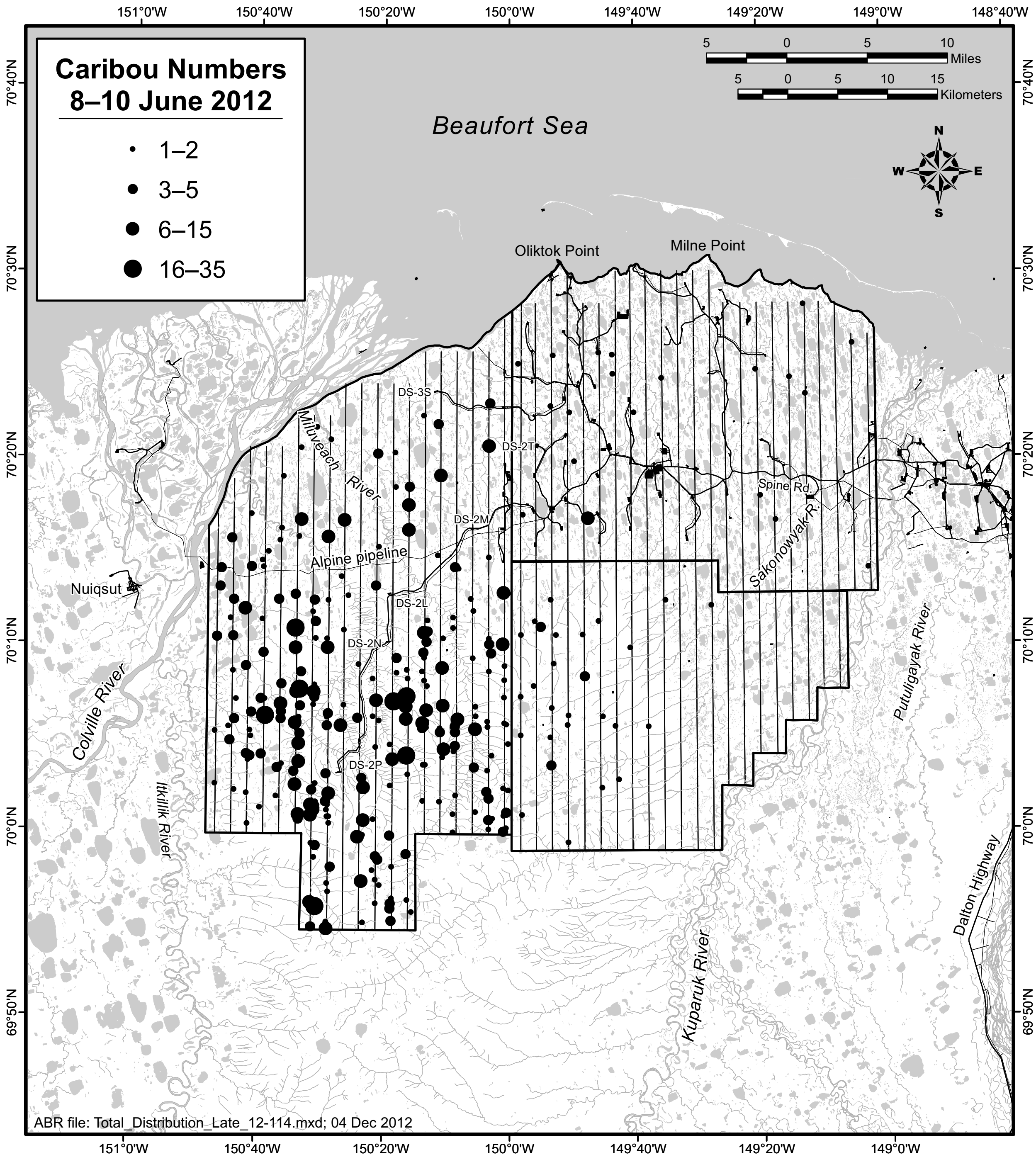

Figure 3. Distribution and number of all caribou (adults and calves) in the Kuparuk–Colville calving survey areas, 8–10 June 2012.

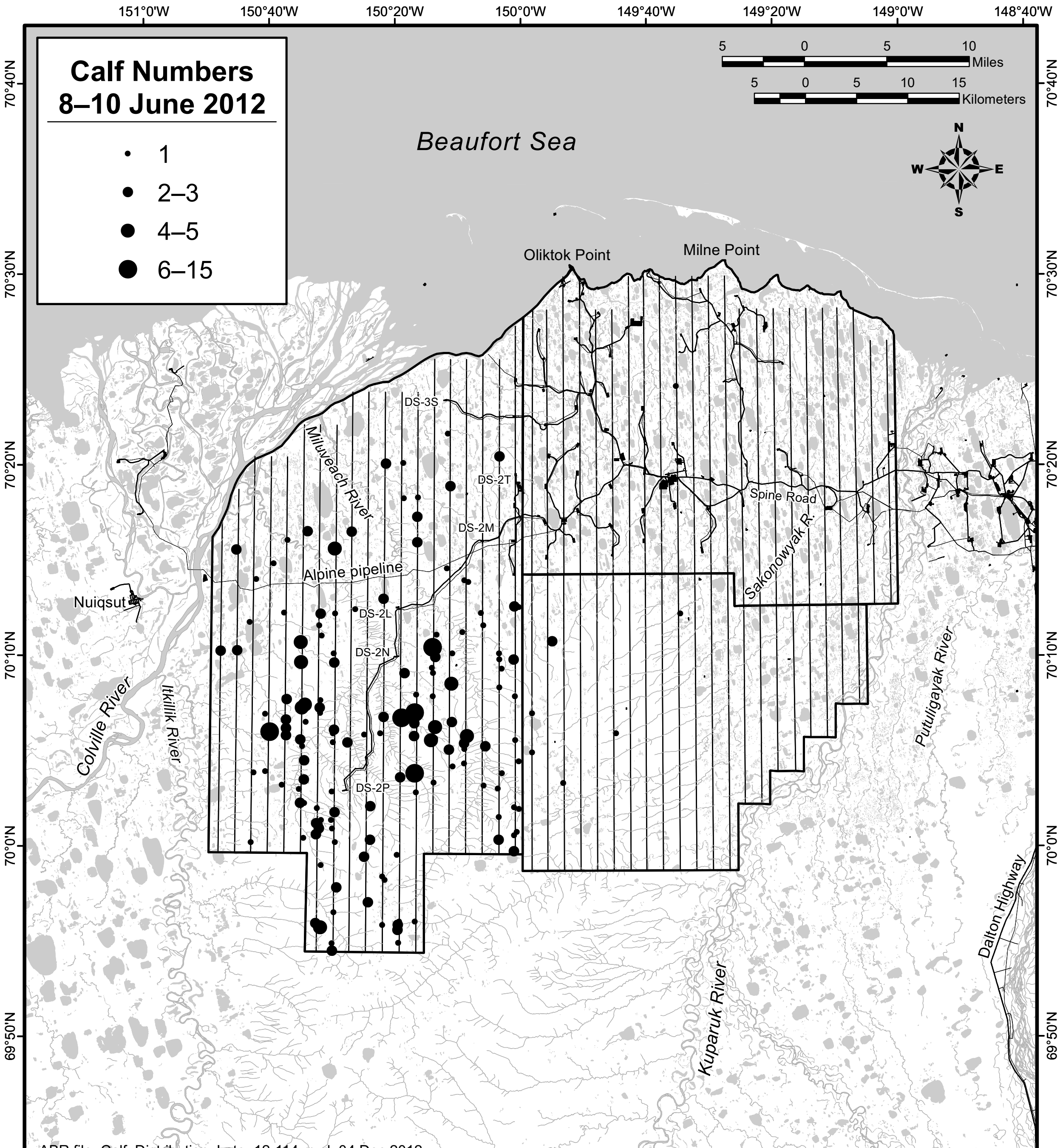

Figure 4. Distribution and number of calf caribou in the Kuparuk–Colville calving survey areas, 8–10 June 2012.

Spine Road and east of the Oliktok Point Road, an area encompassing ~50% of the Kuparuk Field survey area. Although the total numbers were quite low, these proportions are within the range observed in previous years. Over all years (1996–2012), the proportion north and east of those roads averaged 49% of total caribou and 50% of calves, within a wide range (22–77% for total caribou and 22–86% for calves) (Lawhead et al. 1997, 1998; Lawhead 1999; Lawhead and Johnson 2000; Lawhead and Prichard 2001, 2002, 2003a, 2003b, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012).

CALVING DISTRIBUTION AND DENSITY SINCE 1993

For comparative purposes, annual data were compiled from calving surveys in 1993 (Lawhead et al. 1994, Smith et al. 1994) and 1995–2012 (Johnson et al. 1996, 1997, 1998, 1999; Lawhead et al. 1997, 1998; Lawhead 1999; Lawhead and Johnson 2000; Lawhead and Prichard 2001, 2002, 2003a, 2003b, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, this study). The annual data were used to generate mean values over the entire 19-year period for each 3.2-km transect segment (Figure 5; note that some portions of the study area had fewer years of data). The corresponding estimates of observed population and density in each area reveal variability in numbers and densities among areas and years (Appendix B). The summary data since 1993 demonstrate that the areas of greatest calving activity (in terms of caribou distribution and density) consistently were located south or southwest of the Kuparuk oilfield (Figure 5).

The proportion of caribou in the Colville East survey area in 2012 was the second highest observed in that area since surveys began in 1993. The highest density of calving has occurred in Colville East in 10 of the 18 years since 1995, including 1997, 2000, 2003–2005, 2007, and 2009–2012 (Table 3). In the other years since 1995, the mean density of caribou during calving was highest in the Kuparuk South survey area (Table 3). In 2012 and other recent years, caribou densities in the Colville East survey area were lower near the Tarn (DS-2N) and Meltwater (DS-2P) roads than in adjacent areas away from roads and pads. This pattern of distribution is consistent with localized avoidance of the area within 2–4 km of active roads during calving by maternal caribou (Dau and Cameron 1986, Cameron et al. 1992, Lawhead et al. 2002, 2003, 2004; Lawhead and Prichard 2005, 2006, 2007, 2010, 2011, 2012).

An area of locally high density in the Colville East survey area in the 2012 calving season was located west of CPF-2 and southwest of DS-3S (Figure 5), the newest Kuparuk drill site, constructed during late winter 2002. Caribou density in that area during the calving season was low in 2000 and 2001, but increased during 2002–2012.

The variability among years is portrayed clearly by plotting the proportion of caribou in each survey area, divided by the proportion they represented over the total area surveyed (Figure 6). This plot provides a comparison of proportional use of the areas after correcting for differences in survey area sizes and variability in density among years. Since 1996, the proportion of total caribou found in the Kuparuk Field and Kuparuk South survey areas generally has declined and the proportion of the caribou in the Colville East survey area generally has increased, despite a great deal of annual variability (Figure 6). The number of caribou in the Kuparuk Field calving survey area in mid-June 2012 (late calving survey) was only 12% of the number expected (based on area) if caribou had been distributed uniformly throughout the three survey areas.

On 8 June 2012, 54 caribou were estimated in the Kuparuk Field survey area (unadjusted for sightability); caribou density was highest in areas away from roads (Figures 3–5). By comparison, the estimated numbers in the Kuparuk Field survey area during our late calving surveys in 1993 and 1995–2011 ranged from 54 to 2,458 caribou (Appendix B). The historically used Kuparuk–Milne concentration area was used at lower levels in 2012 than the range observed during 1979–1987 (~300–2,100 caribou north of the Spine Road; Figure 6 in Cameron 1994), although the numbers show a large amount of annual fluctuation (Appendix B). The density of calving caribou in the vicinity of the Milne Point Road (which passes through the center of the Kuparuk Field survey area) has declined since the 1980s (Figure 6; Noel et al. 2004, Joly et al. 2006).

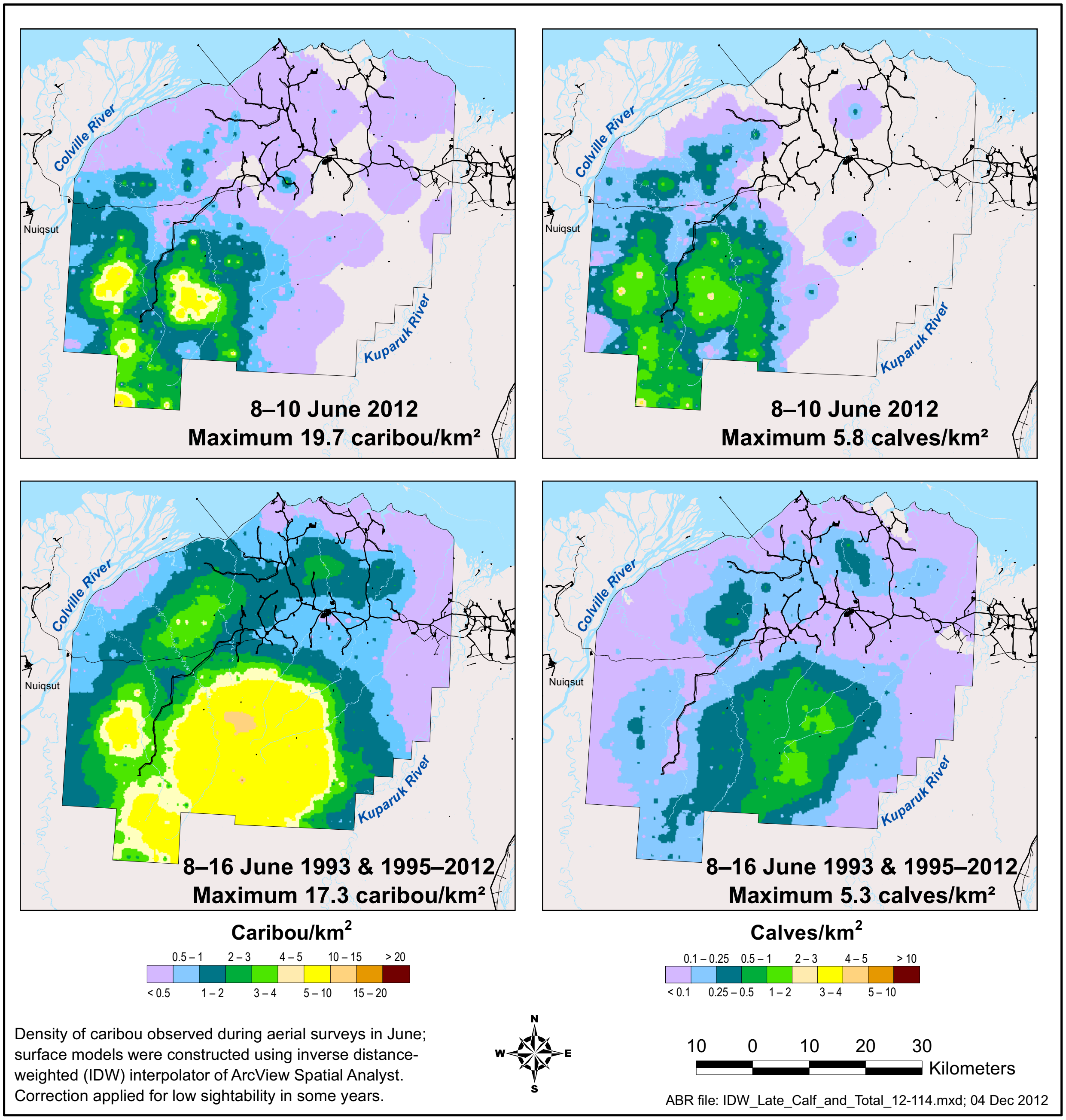

Figure 5. Distribution and density of all caribou and calf caribou in the Kuparuk–Colville calving survey areas during 8–10 June 2012 (top), and distribution and mean density of all caribou and calf caribou during mid-June in the Kuparuk–Colville calving survey areas, 1993 and 1995–2012 (bottom).

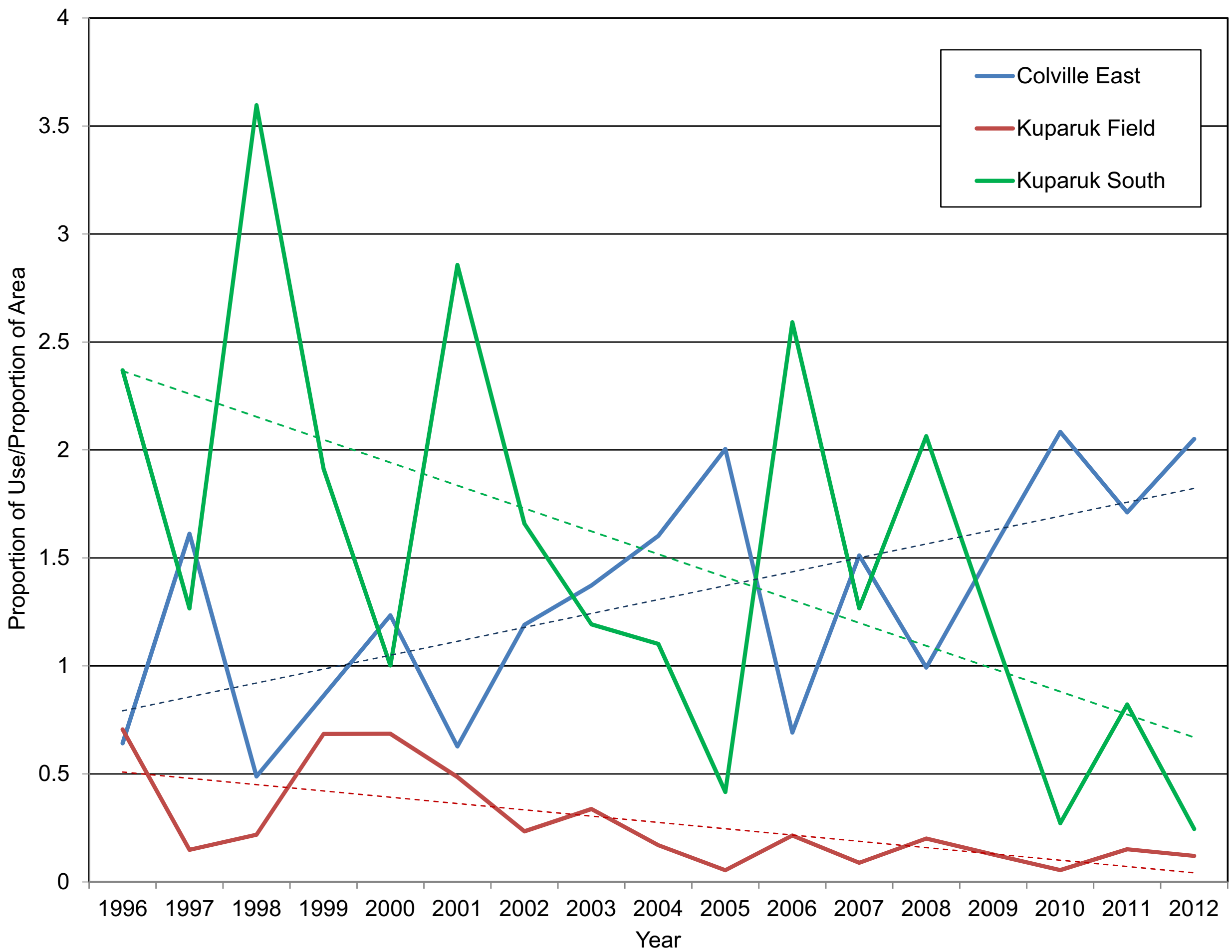

Figure 6. Proportion of caribou observed in each of three survey areas during calving surveys in mid-June 1996–2012, divided by the proportion of the total survey area represented by each area. Values greater than one indicate that caribou were more numerous in a survey area than expected (based on the area surveyed), and values less than one indicate that caribou were less numerous than expected. Dashed lines depict linear trends over all years.

SEX AND AGE COMPOSITION AT CALVING

During the age and sex composition survey on 12 June, we counted 2,917 caribou in the Kuparuk Field and Colville East survey areas (Figure 7). The sample comprised 1,580 cows, 1,266 calves, 66 yearlings, and 5 adult bulls (Table 4). Based on this sample, our estimate of calf production in 2012 was 80.1 calves:100 cows for the western segment of the CAH. Yearlings composed 2.3% of the total composition sample, for an overall ratio of 4.2 yearlings:100 cows (Table 4). Only 26 caribou in 6 groups were observed in the Kuparuk Field survey area, comprising 17 cows and 9 calves, for a calf:cow ratio of 52.9 (Table 4).

In 2012, our estimate of calf production by the western segment of the CAH was above the long-term average (73.8 calves:100 cows for 1978–2012; Figure 8). After declining between the mid-1980s and the mid-1990s, calf production increased in 1996 and has remained fairly high since then (Figure 8). The 2012 calf:cow ratio was similar to 2011 and slightly higher than in other recent years, exceeding 80 calves:100 cows for the second time since 2003. Our 2012 estimate is substantially lower, however, than ADFG's estimated parturition rate of 91.7 calves:100 cows for cows aged 4 years and older (*n* = 24 on 3–7 June 2012; E. Lenart, ADFG, personal

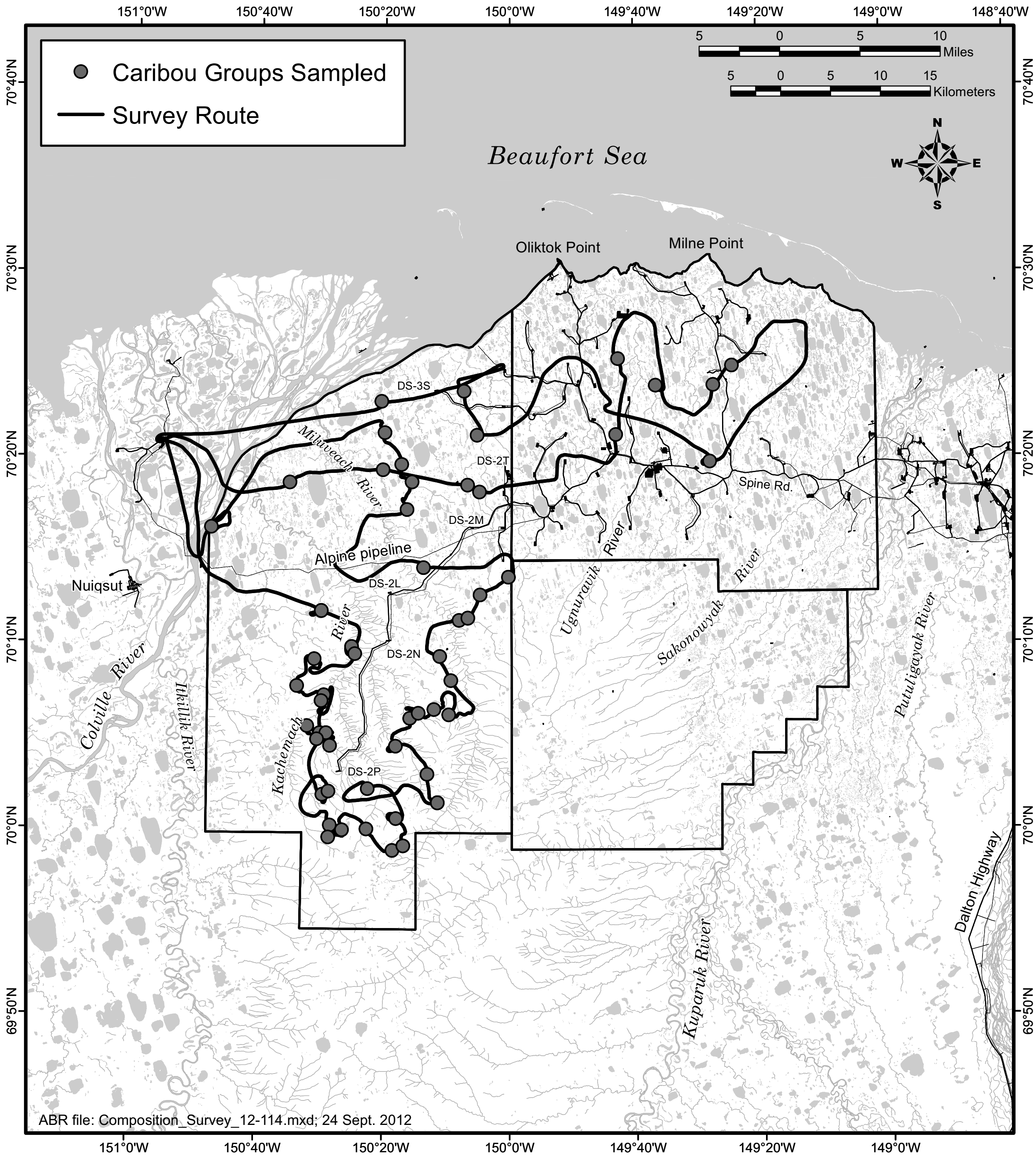

Figure 7. Route of aerial survey and location of groups sampled to quantify sex and age composition of caribou in the Kuparuk–Colville calving survey areas, 12 June 2012.

Table 4. Sex and age composition of caribou in the Kuparuk–Colville region, 12 June 2012.

Survey Area	No. of Groups	Total No.	Cows		Calves		Yearlings		Bulls		Calf Ratio [a]	Yrlg. Ratio [b]
			No.	%	No.	%	No.	%	No.	%		
Colville East	48	2,891	1,563	54.1	1,257	43.5	66	2.3	5	0.2	80.4	4.2
Kuparuk Field	6	26	17	63.4	9	34.6	0	0	0	0	52.9	0
Total	54	2,917	1,580	54.2	1,266	43.4	66	2.3	5	0.2	80.1	4.2

[a] Calves:100 cows.
[b] Yearlings:100 cows.

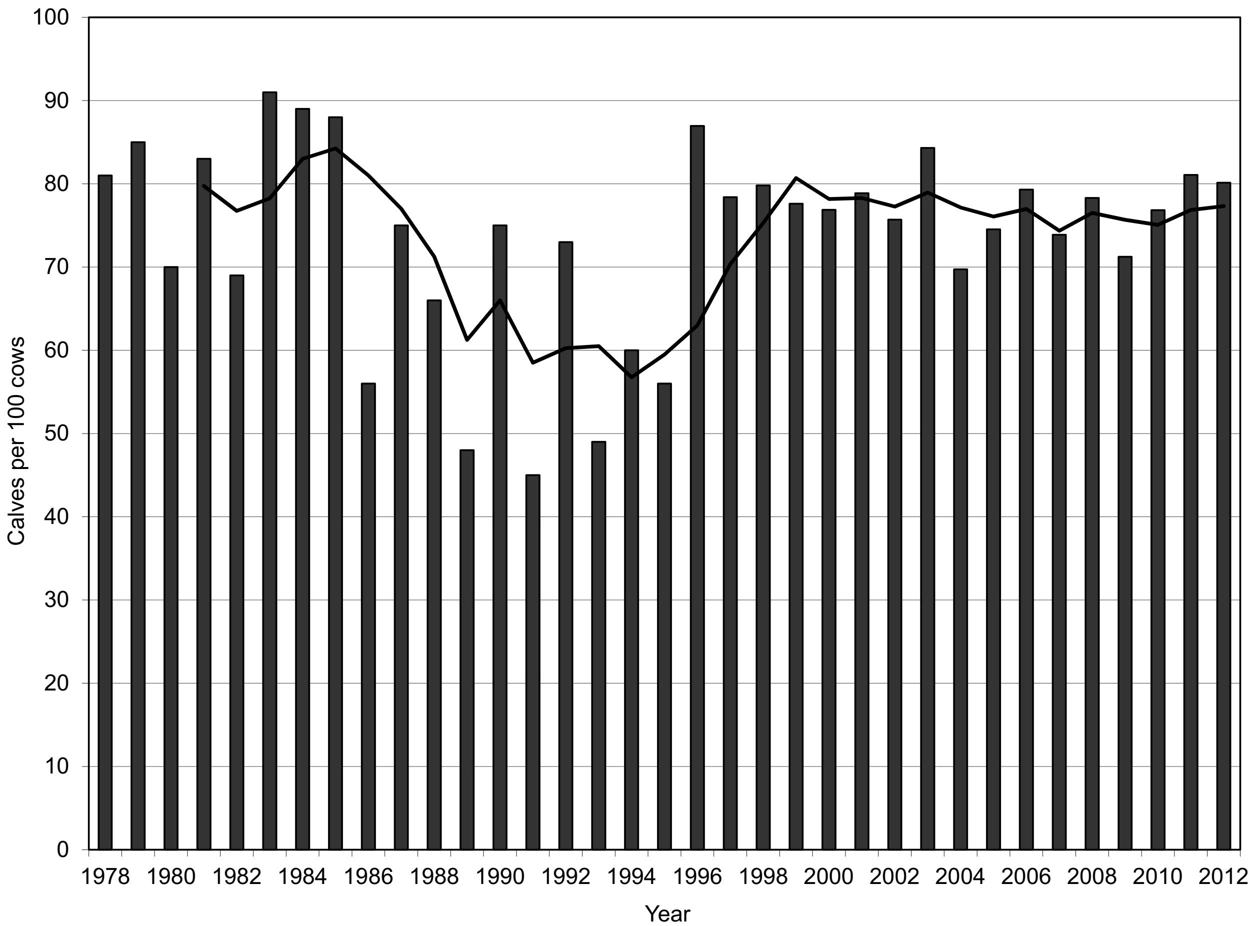

Figure 8. Estimated production of calf caribou (calf:cow ratio [bars] and 4-year moving average [line]) by the western segment of the Central Arctic Herd, based on aerial surveys in mid-June 1978–2012. Data sources: Fancy et al. (1992) for 1978–1990; Woolington (1995) for 1991–1992; Smith et al. (1994) for 1993; Cameron (1994) for 1994; Cameron (personal communication) for 1995; Johnson et al. (1997, 1998) for 1996–1997; Lawhead (1999) for 1998; Lawhead and Johnson (2000) for 1999; Lawhead and Prichard (2001, 2002, 2003a, 2003b, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, this study) for 2000–2012.

communication). The late June calf:cow ratio estimated by ADFG was 69.2 calves:100 cows (*n* = 26), based on radio-collared adult females aged four years and older (E. Lenart, ADFG, personal communication), producing an estimated calf mortality rate of 22.5% since early June.

Our estimated calf:cow ratios have consistently been lower than those of ADFG (Figure 9), probably because of methodological differences. Our estimates usually are obtained about a week after the typical peak of calving in the first week of June, so some mortality of neonatal calves occurs between the ADFG and ABR counts. In addition, our classification of cows includes 2- and 3-year-old females. Because those age classes exhibit lower rates of parturition than older cows, our calf estimate would be expected to be less than the ADFG estimate, which was based on collared adults at least 4 years old. ADFG found that an average of only 2.1% of 2-year-olds were parturient between 1994 and 2010 (*n* = 94) and the percentage of 3-year-olds that were parturient tended to be lower than for older cows (Lenart 2011a).

The ratio of 4.2 yearlings:100 cows in our composition sample in 2012 was lower than the ADFG estimates reported for the CAH during 1979–2000 (range = 8–48; mean = 25.3; *n* = 14) (Lenart 2009) and near the low end of our estimates during 1996–2011, which ranged between 2.4 and 39.6 yearlings:100 cows (mean = 11.0; *n* = 15). These low yearling ratios were not expected because calf production has consistently been high in recent years (Figure 9). Yearling:cow

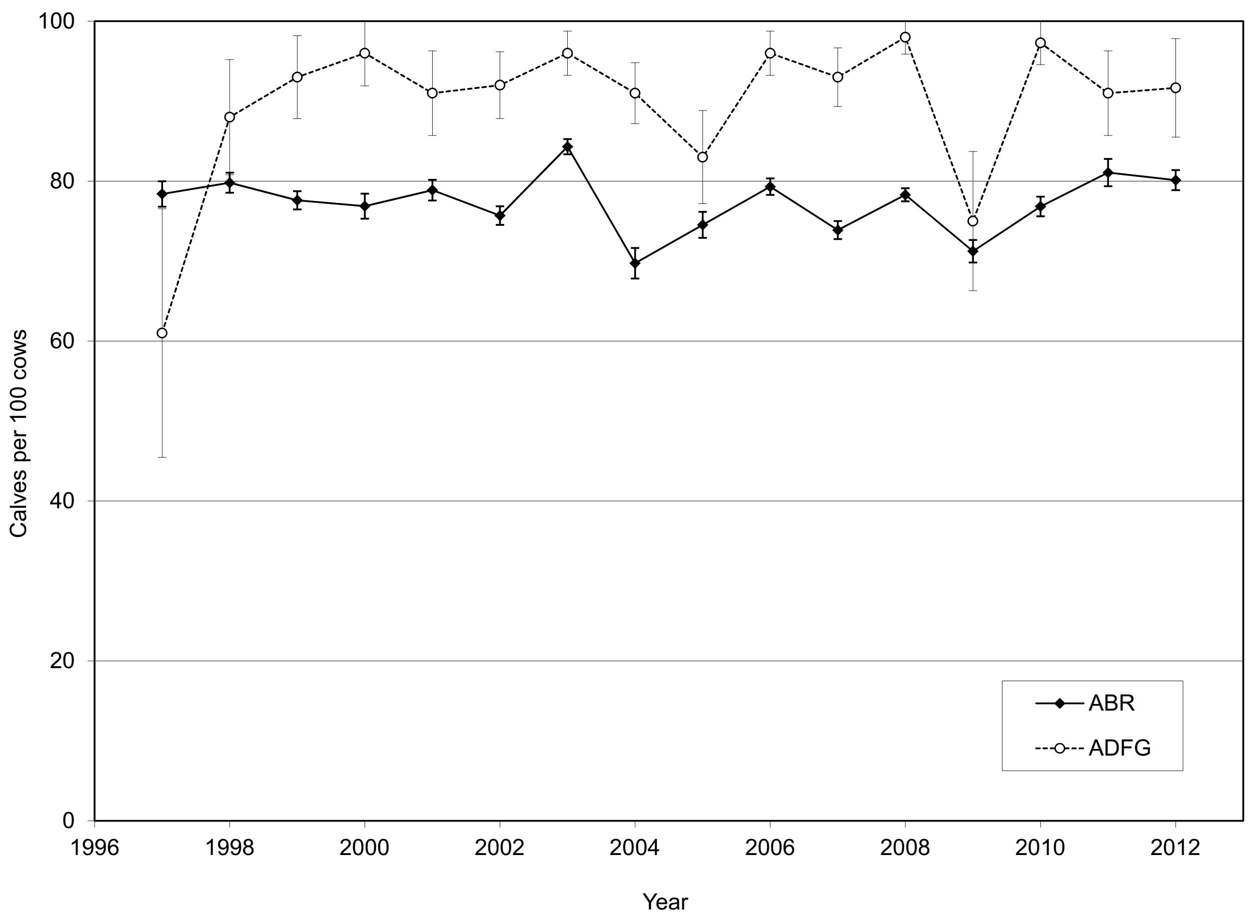

Figure 9. Estimated calf production (number [± SE] of calves:100 cows), based on estimates from radio-collared females by ADFG (aged ≥4 years old; Lenart 2012, personal communication) and from aerial surveys by ABR (females aged ≥2 years old), 1997–2012.

ratios are difficult to estimate because they rely on subjective classification of caribou into age groups by the observer, although we used the same observer on all composition surveys during 1997–2010 and 2012, with a different observer only in 2011). Low yearling:cow ratios also can result from annual differences in the migration and distribution patterns of yearlings, which often associate with barren adult females, and from changes in the proportion of nonreproductive 2-year-old cows in the population. Indeed, our composition surveys have tended to focus on the areas of the western calving grounds having the greatest density of calving females, so yearlings may be underrepresented.

SUMMER WEATHER CONDITIONS

During the midsummer insect season, variability in weather conditions typically results in fluctuating insect activity levels and corresponding changes in caribou density as caribou aggregate and move rapidly through the study area in response to insect harassment. Caribou move rapidly toward the coast in response to mosquito harassment and then disperse inland when mosquito activity abates in response to cooler temperatures or higher wind speeds. Information on summer weather conditions in 2012 was compiled to document insect-season conditions and to estimate the frequency of occurrence and severity of insect harassment by applying models of insect activity in relation to temperature and wind speed.

No field observations were conducted for this study during the insect season in 2012, but ABR biologists conducting ground activities near the coast for other studies in June 2012 reported that midges (which typically become active shortly before mosquitoes) emerged by 18 June and some mosquitoes emerged by 21 June. Cool and windy conditions prevailed after 22 June, however, and mosquito harassment was low for the rest of June 2012.

The occurrence of insect harassment in July and August was estimated from weather data. Because the Kuparuk airstrip was not active during portions of August 2012, we estimated the average daily temperatures for days with missing data by averaging Nuiqsut and Deadhorse temperature data, as described earlier. Comparing daily mean temperatures from the historical Kuparuk and the averaged Nuiqsut/Deadhorse data sets suggested that the latter temperature estimates tend to be approximately 0.25° C higher than the Kuparuk data. Hence, comparisons of estimated 2012 temperatures with those measured in previous years should be interpreted with some caution. The thawing degree-day (TDD) sums at Kuparuk in 2012 were above average in summer 2012 (late June–late August) and were more than twice the 30-year mean in late August, the highest values recorded for that period in the last three decades (Appendices C–D).

Weather conditions have been used to predict the occurrence of harassment by mosquitoes (*Aedes* spp.) and oestrid flies (*Hypoderma tarandi* and *Cephenemyia trompe*) (White et al. 1975, Fancy 1983, Dau 1986, Russell et al. 1993, Mörschel 1999). The estimated probabilities of insect activity based on daily maximum temperatures from the averaged Nuiqsut and Deadhorse data (but ignoring wind speed; Russell et al. 1993) were well above average in late June, late July, and late August (Appendices E and F). The estimated probability of oestrid-fly activity (Mörschel 1999), based on average hourly wind speeds and temperatures recorded at Nuiqsut, exceeded 50% on eight days during the summer (13 June–7 August). The peak fly-harassment probability reached 73% on the afternoon of 29 July, when the mean air temperature reached 22º C (69º F), with calm winds (Appendix G). High-probability estimates for fly activity corresponded to warm weather events on 13 July, 23–24 July, 27 July, and 29–30 July. High- probability estimates also occurred on 19–20 June, but those dates precede the normal onset of oestrid-fly activity. Although harassment by mosquitoes and oestrid flies typically ceases by mid-August in the study area, it is possible that oestrid fly harassment may have persisted into late August as a result of above-average temperatures.

CARIBOU SURVEYS IN SPRING AND LATE SUMMER–FALL

We conducted a spring survey on 11–12 May, a postcalving survey on 22 June, a late-summer survey on 18–19 August, and a fall survey on 4–5 October (Figure 10). A survey planned for

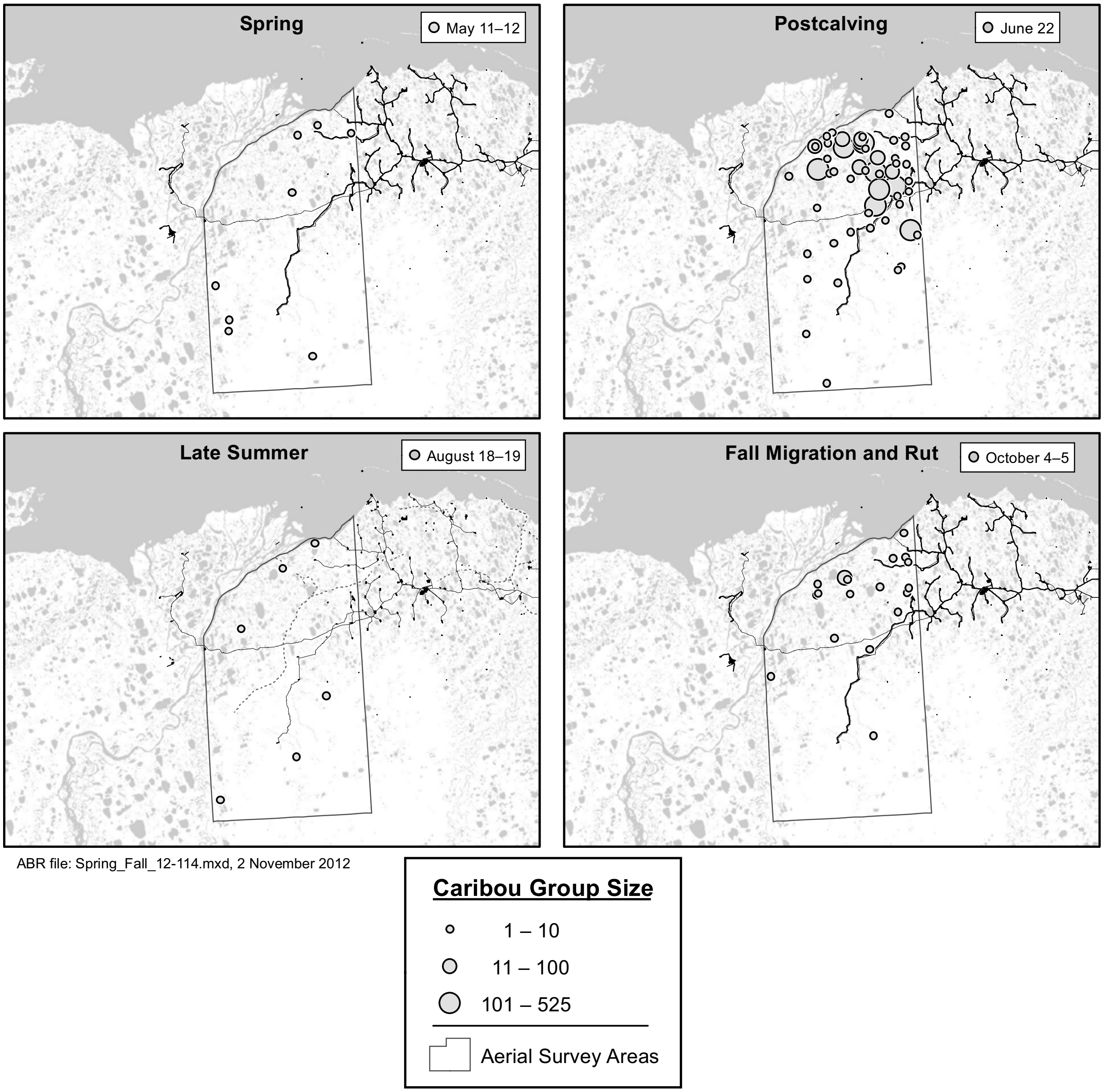

Figure 10. Distribution and size of caribou groups in the Colville East survey area, May–October 2012 (excluding calving surveys).

mid-September was canceled due to inclement weather.

Very few caribou (0.03 caribou/km²) were observed in the Colville East survey area on 11–12 May (Table 5). In contrast, caribou density in the survey area was high during the postcalving survey on 22 June (2.80 caribou/km²; Table 5), 66% greater than the density recorded on the late calving survey in mid-June (1.68 caribou/km² adjusted for low sightability; Table 3). Density was very low in mid-August (0.01 caribou/km²) and remained low in early October (0.07 caribou/km²; Table 5).

The overall mean density of caribou in the Colville East survey area during spring and late summer–fall 2012 (excluding calving and postcalving) was 0.03 caribou/km², lower than the range observed for those periods in other recent

Table 5. Number and density of caribou in the Colville East survey area, May–October 2012 (excluding calving surveys).

Date	Area Surveyed [a] (km^2)	Total Counted	Estimated Total	Density (caribou/km^2)	Number of Groups	Mean Group Size
11–12 May	850	25	50	0.03	8	3.1
22 June	850	2,373	4,746	2.80	53	44.8
18–19 August	850	8	16	0.01	6	1.3
4–5 October	850	56	112	0.07	27	3.1
Total	3,400	2,462	4,924	0.72	94	26.2

[a] 50% coverage of survey area.

years (0.05–0.62 caribou/km^2 in 2001–2011; Lawhead and Prichard 2002, 2003a, 2003b, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012), although densities are highly influenced by survey dates.

OTHER MAMMALS

GRIZZLY BEAR

Grizzly bears were recorded at widely scattered locations throughout the GKA and adjacent areas in 2012. Thirty-two grizzly bear sightings, totaling 33 adults and 18 cubs, were recorded within 75 km of the coast in the Kuparuk–Colville region during aerial and road surveys in 2012 (Table 6, Figure 11). Some of those observations were likely the same individuals observed multiple times, but individual identification is seldom possible from visual observations during our surveys, even for the ear-tagged, radio-collared bears being studied by ADFG (Shideler 2009, 2010).

Nine bear groups were observed in northeastern NPRA in 2012. On 10 May, three single adult bears and a sow with two cubs were observed in that area. We observed three bear dens in NPRA during spring surveys. Only one sighting of a bear was recorded on the Colville River delta, a sow with two cubs on 13 June. Four sightings of bears were recorded near the Alpine pipelines, including a sow with a single cub and two sightings of a sow with three cubs (Table 6). Nine bear groups, totaling 10 adults and three cubs, were recorded in the upper Miluveach River drainage. Seven sightings of a single bear were recorded near CPF-3 during 6–14 June; five of those sightings occurred during road surveys and it is likely that all involved the same individual bear, judging from its injured hind leg. One bear was observed along the Kuparuk River on 23 June and a single bear was observed west of the Deadhorse Airport on 22 June.

MUSKOX

Muskox sightings were recorded 17 times between 27 April and 4 October 2012 in four portions of the Kuparuk–Colville region: the Alpine pipelines area, the Colville River delta, the coastline near Beechey Point and Milne Point, and the Kuparuk River (Table 7, Figure 11). Because individual muskoxen could not be identified, we were unable to distinguish specific groups reliably on successive surveys. The numbers observed in various locations and different dates indicated the consistent presence of muskoxen present on both the Colville River delta and in the Kuparuk River/Beechey Point area for much of the summer. On 10–11 May, 34 individual muskoxen (32 adults and 2 calves) were observed in two groups in the western portion of the study area. On 8–9 June, 43 muskoxen (33 adults and 10 calves) were observed in three groups. On 22–24 June, 41 muskoxen (33 adults and 8 calves) were observed in three groups. On 16–18 August, 42 muskoxen (36 adults and 6 calves) were observed in five groups, although some groups may have been observed more than once (Table 7, Figure 11).

Based on these results, there were approximately 43 muskoxen in the area for much of the summer of 2012. In past years, two

Table 6. Locations and number of grizzly bears observed during aerial and road surveys in the Kuparuk–Colville region, April–October 2012.

General Location	Date	Adults	Young	Total	Specific Location
NPRA	26 April	1	2	3	West of Nuiqsut
	10 May	1	0	1	Southwest of Nuiqsut
	10 May	1	2	3	West of Nuiqsut
	10 May	1	0	1	Southwest of Nuiqsut
	10 May	1	0	1	Near Coast
	19 June	1	0	1	West of Nuiqsut
	19 June	1	2	3	Fish Creek Delta
	21 June	1	0	1	Near Coast
	4 October	1	0	1	Southwest of Nuiqsut
Colville River Delta	13 June	1	2	3	E of Alpine
Alpine Pipelines	11 May	1	1	2	North of Alpine Pipelines
	9 June	1	3	4	North of Alpine Pipelines
	16 June	1	0	1	Near DS-2N
	4 October	1	3	4	Near DS-2L
Upper Miluveach River	11 May	1	2	3	Southwest of DS-2P
	12 May	1	0	1	East of DS-2P
	16 June	1	0	1	East of DS-2P
	16 June	1	0	1	East of DS-2P
	22 June	2	0	2	East of DS-2P
	25 June	1	0	1	East of DS-2P
	25 June	1	0	1	East of DS-2P
	25 June	1	1	2	East of DS-2P
	4 October	1	0	1	East of DS-2P
CPF-3 Area	6 June	1	0	1	West of CPF-3
	7 June	1	0	1	West of CPF-3
	8 June	1	0	1	West of CPF-3
	9 June	1	0	1	West of CPF-3
	10 June	1	0	1	West of CPF-3
	12 June	1	0	1	West of CPF-3
	14 June	1	0	1	Near DS-3S
Kuparuk River	23 June	1	0	1	N. Spine Road
Prudhoe Bay	22 June	1	0	1	W of Deadhorse Airport

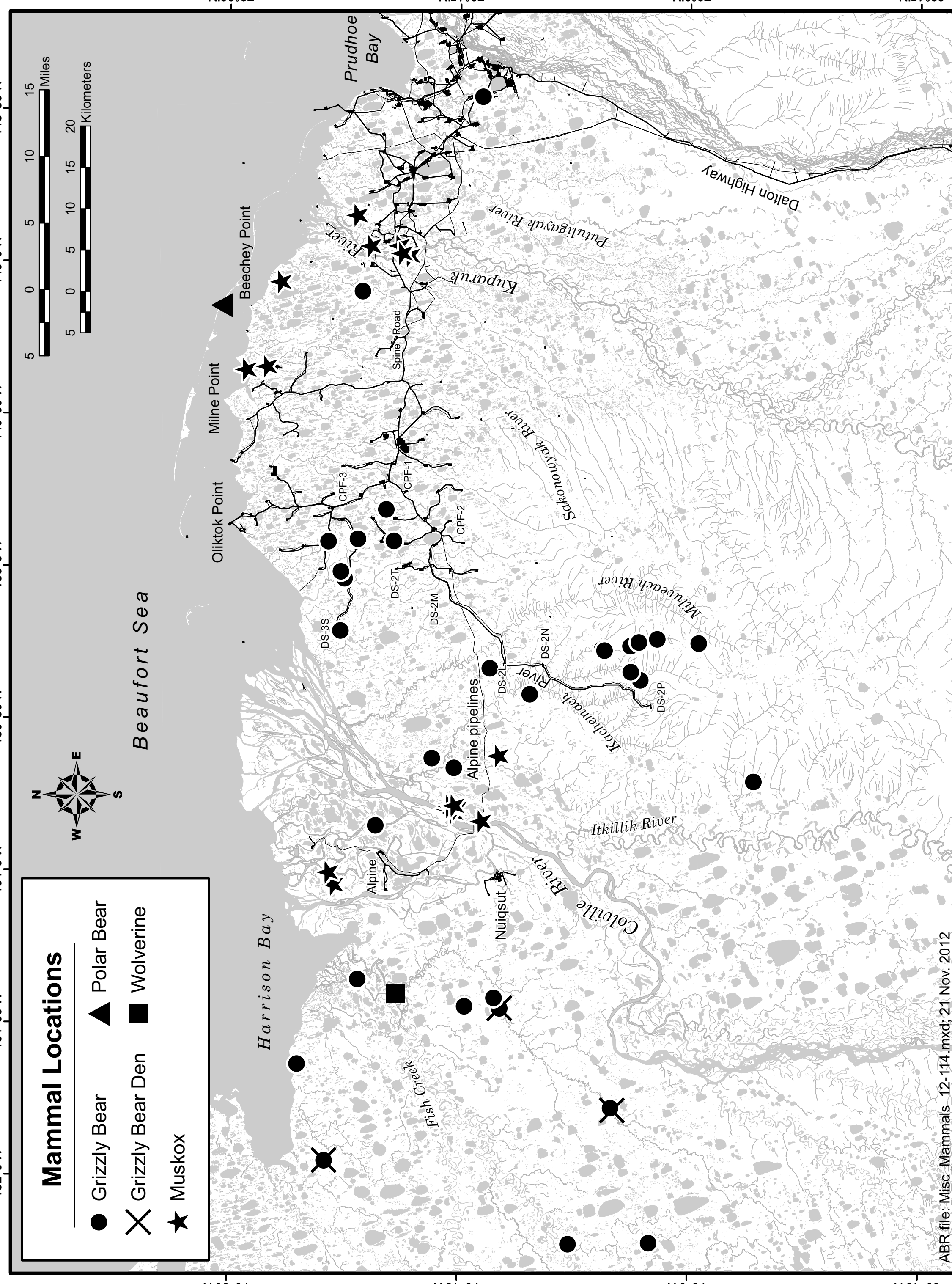

Figure 11. Distribution of other large mammals observed during aerial and road surveys in the Greater Kuparuk Area, the Colville River delta, and northeastern NPRA, April–October 2012.

Table 7. Locations and number of muskoxen, polar bears, and wolverines observed during aerial and road surveys in the Kuparuk–Colville region, April–October 2012.

Species	General Location	Date	Adults	Young	Total	Specific Location
Muskoxen	Alpine Pipelines	11 May	11	0	11	S of Alpine Pipelines
	Colville River delta	21 April	21	0	21	NW Colville delta
		10 May	21	2	23	NW Colville delta
		9 June	11	2	13	NE of Nuiqsut
		11 June	11	3	14	NE of Nuiqsut
		24 June	12	2	14	E of Nuiqsut
		17 August	14	0	14	NE of Nuiqsut
		18 August	11	2	13	NE of Nuiqsut
		4 October	12	1	13	NE of Nuiqsut
	Beechey Point	8 June	9	7	16	E of Milne Point
		8 June	13	1	14	E of Milne Point
		16 August	5	3	8	E of Beechey Point
	Kuparuk River	22 June	10	4	14	N of Spine Road
		22 June	11	2	13	S of Spine Road
		16 August	3	0	3	N of Spine Road
		17 August	3	1	4	S of Spine Road
		21 September	5	0	5	S of Spine Road
Polar Bear	Beechey Point	16 August	1	1	2	Barrier island
Wolverine	NPRA	16 June	1	0	1	Fish Creek delta

mixed-sex groups of muskoxen generally were seen in the study area, one near the Colville River delta and the other near the Kuparuk River delta. In 2011, we observed 68 muskoxen (55 adults and 13 calves) near the Kuparuk River and Milne and Beechey points in early June. This apparent decline in muskox observations in the Kuparuk–Colville region in 2012 may have been due to a group of muskoxen that reportedly moved west into NPRA (J. Hamilton, Arctic Air Alaska, personal communication).

The muskox population on the North Slope of Alaska has declined since 1999, evidently due to a combination of predation by grizzly bears, disease, and unusual mortality events such as drowning (Reynolds et al. 2002a, 2002b; Reynolds 2006; Shideler et al. 2007; Beckmen 2009; Arthur and Del Vecchio 2010; Lenart 2011b). The decline first was reported in ANWR but later was noted farther west on the central coastal plain. Since 2007, the North Slope population has stabilized at about 200 animals (Lenart 2011b). Population surveys by ADFG in late winter (April) found 216 muskoxen in 2006, 196 muskoxen in 2009, and 190 in 2011 (Arthur and Del Vecchio 2010, Lenart 2011b). Because of the population decline, ADFG increased monitoring of the North Slope population in 2006 and is conducting an intensive radio-telemetry study to investigate distribution, movements, and survival (Arthur and Del Vecchio

2010). Disease monitoring also has increased (Beckmen 2009).

WOLVERINE

One wolverine (*Gulo gulo*) was observed on 16 June 2012 along lower Fish Creek in NPRA (Table 7, Figure 11). Wolverines have been observed rarely during ABR aerial surveys in the region; this was the ninth sighting since 1993. Five of the sightings occurred in the month of June, one in September, and three in October. The frequency of wolverine observations is influenced heavily by survey timing and conditions. Our survey efforts were concentrated in June, but the detectability of wolverines is higher in late fall when snow covers the ground.

POLAR BEAR

A polar bear (*Ursus maritimus*) sow and cub were observed on a barrier island near Beechey Point during a swan survey on 16 August (Table 7, Figure 11). Although polar bears occur annually in and near the Kuparuk oilfield during fall and winter, their occurrence during summer is unusual. In 2007, however, nine polar bears were observed in five groups in the Kuparuk–Colville area on 21 August (Lawhead and Prichard 2008). Two other polar bears were recorded in the Kuparuk area during summer surveys by ABR in the past: a single bear was observed on 24–26 June 1998 near Mine Site D and a single bear was observed at Colville Village (Helmericks home site) on 8 August 2008. With declining sea ice in summer and fall, more polar bears are expected to occur on the mainland and barrier islands in the Beaufort Sea during the open-water season (Schliebe et al. 2008).

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Appendix A. Snow depth (cm) and sum of thawing degree-days (TDD; º C above freezing) at the Kuparuk airstrip, April–June 1983–2012.

	Snow Depth (cm)			Sum of TDD (º C)		
Year	1 April	15 May	31 May	1–15 May	16–31 May	1–15 June
1983	10	5	0	0	3.6	53.8
1984	18	15	0	0	0.0	55.6
1985	10	8	0	0	10.3	18.6
1986	33	20	10	0	0.0	5.0
1987	15	8	3	0	0.6	6.7
1988	10	5	5	0	0.0	16.7
1989	33	–	10 [a]	0	5.6	20.6
1990	8	3	0	0	16.1	39.7
1991	23	8	3	0	7.8	14.4
1992	13	8	0	0.3	20.3	55.0
1993	13	5	0	0	8.6	33.6
1994	20	18	8	0	4.4	49.2
1995	18	5	0	0	1.1	59.4
1996	23	5	0	8.1	41.7	86.1
1997	28	18	8	0	20.8	36.1
1998	25	8	0	3.6	45.8	74.2
1999	28	15	10	0	1.4	30.3
2000	30	23	13	0	0.0	36.7
2001	23	30	5	0	0.8	51.9
2002	30	trace	0	4.2	30.3	57.8
2003	28	13	trace	0	10.8	23.6
2004	36	10	5	0	8.9	26.4
2005	23	13	0	0	2.5	14.2
2006	23	5	0	0	23.3	93.3
2007	25	46	5	0	0.0	46.4
2008	20	18	0	0	32.8	71.7
2009	36	13	0	0	16.7	71.7
2010	41	43	13	0	1.4	53.3
2011	25	18	0	0	27.8	12.5
2012	48	53	2	0	1.7	26.8
Mean	23.9	15.1	3.3	0.5	11.5	41.4

[a] Value for 1 June.

Appendix B. Estimated number and density of caribou in the Kuparuk Field, Kuparuk South, Colville East, Colville Inland, and Colville Delta survey areas during calving, 1993–2012.

Survey Area	Date	Total Area (km²)	Estimated Total Caribou [a]	Total Density (per km²)	Estimated Total Calves [a]	Calf Density (per km²)	Snow Cover
Kuparuk Field [bc]	4 June 1993	850	155	0.18	23	0.03	Patchy; SCF used
	15 June 1993	1,202	786	0.65	188	0.16	None
	11 June 1996	1,137	2,458	2.16	897	0.79	None
	3 June 1997	1,137	421	0.37	33	0.03	High; SCF not used
	11 June 1997	1,137	320	0.28	81	0.07	Patchy; SCF used
	4–5 June 1998	1,097	862	0.76	300	0.27	None
	14 June 1998	1,107	688	0.62	202	0.18	None
	12–13 June 1999	1,102	1,284	1.17	456	0.41	Patchy; SCF not used
	14–15 June 2000	1,107	402	0.36	102	0.09	Patchy; SCF used
	12 June 2001	1,107	666	0.60	168	0.15	Patchy; SCF not used
	6, 8 June 2002	1,035	1,124	1.09	304	0.29	None
	12 June 2002	1,035	886	0.86	226	0.22	None
	3, 5 June 2003	1,035	692	0.67	79	0.08	Patchy; SCF used
	13 June 2003	1,035	496	0.48	140	0.14	Low; SCF not used
	4 June 2004	397	105	0.26	15	0.04	Patchy; SCF used
	12, 16 June 2004	1,035	580	0.56	174	0.17	None
	4–5 June 2005	1,035	68	0.07	15	0.01	Patchy; SCF used
	9 June 2005	1,035	54	0.05	18	0.02	Low; SCF not used
	2–3 June 2006	1,035	49	0.05	8	0.01	Patchy; SCF used
	10 June 2006	1,035	912	0.88	248	0.24	None
	3–4 June 2007	1,035	120	0.12	8	0.01	Patchy; SCF used
	10 June 2007	1,035	452	0.44	60	0.06	None
	2–3 June 2008	1,035	376	0.36	36	0.03	Low; SCF not used
	10 June 2008	1,035	1,484	1.43	284	0.27	None
	2 June 2009	1,035	361	0.35	41	0.04	Patchy; SCF used
	8–9 June 2009	1,035	418	0.40	62	0.06	None
	8 June 2010	1,035	126	0.12	30	0.03	Low; SCF not used
	3–4 June 2011	1,035	98	0.09	8	0.01	Patchy; SCF used
	9 June 2011	1,035	143	0.14	23	0.02	Patchy; SCF used
	8 June 2012	1,035	102	0.10	4	<0.00	Patchy; SCF used
Kuparuk South [defg]	2 June 1993	825	328	0.40	16	0.02	Patchy; SCF used
	13 June 1995	548	2,769	5.05	531	0.97	None
	4 June 1996	599	3,573	5.96	1,044	1.74	None
	9–10 June 1996	599	4,344	7.25	1,572	2.62	None
	2 June 1997	599	286	0.48	42	0.07	High; SCF not used
	12 June 1997	599	1,437	2.40	415	0.69	Patchy; SCF used

Appendix B. Continued.

Survey Area	Date	Total Area (km²)	Estimated Total Caribou [a]	Total Density (per km²)	Estimated Total Calves [a]	Calf Density (per km²)	Snow Cover
Kuparuk South [defg]	4 June 1998	603	3,160	5.24	812	1.35	None
	12–13 June 1998	603	6,162	10.22	2,222	3.68	None
	12 June 1999	603	1,964	3.26	622	1.03	Low; SCF not used
	12–13 June 2000	603	320	0.53	83	0.14	Patchy; SCF used
	7 June 2001	603	534	0.89	49	0.08	Patchy; SCF used
	11 June 2001	603	2,132	3.54	608	1.01	Patchy; SCF not used
	7 June 2002	788	4,256	5.40	1,002	1.27	None
	11 June 2002	788	4,778	6.06	1,164	1.48	None
	4–5 June 2003	788	1,530	1.94	180	0.23	Patchy; SCF used
	12–13 June 2003	788	1,334	1.69	366	0.46	Low; SCF not used
	4 June 2004	603	248	0.41	49	0.08	Patchy; SCF used
	16 June 2004	603	2,188	3.63	640	1.06	None
	5 June 2005	788	308	0.39	41	0.05	Patchy; SCF used
	9–10 June 2005	788	314	0.40	88	0.11	Low; SCF not used
	4 June 2006	788	414	0.52	53	0.07	Patchy; SCF used
	10–11 June 2006	788	8,360	10.61	2,476	3.14	None
	4–5 June 2007	788	564	0.72	68	0.09	Patchy; SCF used
	10–11 June 2007	788	4,900	6.22	1,240	1.57	None
	3–4 June 2008	788	3,044	3.86	678	0.86	Low; SCF not used
	10–11 June 2008	788	11,614	14.74	2,416	3.07	None
	3 June 2009	788	481	0.61	41	0.05	Patchy; SCF used
	9 June 2009	788	2,906	3.69	700	0.89	None
	8–9 June 2010	788	474	0.60	98	0.12	Patchy; SCF used
	3 June 2011	788	229	0.29	26	0.03	Patchy; SCF used
	9–10 June 2011	788	590	0.75	128	0.16	Patchy; SCF used
	9 June 2012	788	158	0.20	26	0.03	Patchy; SCF used
Colville Inland [h]	23 May 1993	1,107	8	0.01	0	0.00	High; SCF not used
	28 May 1993	1,107	224	0.20	15	0.01	Patchy; SCF used
	7 June 1993	1,107	1,186	1.07	64	0.06	Low; SCF not used
	10 June 1993	1,107	1,249	1.13	127	0.11	None
	5 June 1995	1,107	321	0.29	30	0.03	Patchy; SCF used
Colville East [ijklm]	26 May 1993	650	60	0.09	0	0	High; SCF not used
	27 May 1993	1,050	87	0.08	0	0	High; SCF not used
	3 June 1993	1,050	542	0.52	0	0	Patchy; SCF used
	8 June 1993	709	914	1.29	148	0.21	Low; SCF not used
	11 June 1993	910	2,181	2.40	558	0.61	None
	4–5 June 1995	1,057	315	0.30	41	0.04	Patchy; SCF used
	12–13 June 1995	1,349	2,057	1.52	305	0.23	None
	3–4 June 1996	1,362	800	0.59	159	0.12	None

Appendix B. Continued.

Survey Area	Date	Total Area (km²)	Estimated Total Caribou [a]	Total Density (per km²)	Estimated Total Calves [a]	Calf Density (per km²)	Snow Cover
Colville East [ijklm]	12–13 June 1996	1,358	2,670	1.97	786	0.58	None
	1–2 June 1997	1,362	555	0.41	60	0.04	Patchy; SCF not used
	10–12 June 1997	1,321	4,035	3.05	1,214	0.92	Patchy; SCF used
	3 June 1998	1,370	1,840	1.34	284	0.21	None
	11–12 June 1998	1,370	1,902	1.39	310	0.23	None
	11 June 1999	1,478	2,166	1.47	544	0.37	Low; SCF not used
	11–12 June 2000	1,478	966	0.65	192	0.13	Patchy; SCF used
	5–6 June 2001	1,478	169	0.11	0	0	Patchy; SCF used
	10–11 June 2001	1,478	1,148	0.78	192	0.13	Patchy; SCF not used
	6–7 June 2002	1,432	5,584	3.90	830	0.58	None
	10–11 June 2002	1,432	6,232	4.35	1,034	0.72	None
	3–4 June 2003	1,432	1,162	0.81	120	0.08	Patchy; SCF used
	10, 12 June 2003	1,432	2,790	1.95	614	0.43	Low; SCF not used
	5 June 2004	1,262	1,444	1.14	350	0.28	Patchy; SCF used
	16 June 2004	1,323	6,982	5.28	2,286	1.73	None
	5–6 June 2005	1,432	1,387	0.97	297	0.21	Patchy; SCF used
	10–11 June 2005	1,432	2,746	1.92	726	0.51	Low; SCF not used
	3–5 June 2006	1,432	395	0.28	53	0.04	Patchy; SCF used
	11–12 June 2006	1,432	4,056	2.83	1,022	0.71	None
	2, 4–5 June 2007	1,432	2,290	1.60	192	0.13	Patchy; SCF used
	11–12 June 2007	1,432	10,624	7.42	2,596	1.81	None
	3–4 June 2008	1,432	3,810	2.66	422	0.29	Low; SCF not used
	11 June 2008	1,432	10,148	7.09	1,838	1.28	None
	3–4 June 2009	1,432	3,816	2.66	736	0.51	Patchy; SCF used
	9–10 June 2009	1,432	7,038	4.91	1,842	1.29	None
	9 June 2010	1,432	6,606	4.61	2,173	1.52	SCF used southern half
	2–3 June 2011	1,432	1,587	1.11	150	0.11	Patchy; SCF used
	10 June 2011	1,432	2,233	1.56	496	0.35	Patchy; SCF used
	9–10 June 2012	1432	2,403	1.68	683	0.48	SCF used SE portion
Colville Delta	28 May 1993	637	27	0.04	0	0	High; SCF not used
	10 June 1993	637	0	0	0	0	Low; SCF not used
	3 June 1995	637	18	0.03	0	0	Low; SCF not used
	2 June 1996	637	58	0.09	0	0	None
	13 June 1996	637	10	0.02	1	<0.01	None
	1 June 1997	637	0	0	0	0	High; SCF not used
	12, 20 June 1997	637	0	0	0	0	Patchy; SCF used
	11 June 2005	494	2	<0.01	0	0	None
	9 June 2006	494	6	0.01	1	<0.01	None
	12 June 2008	494	30	0.06	2	<0.01	None

Appendix B. Continued.

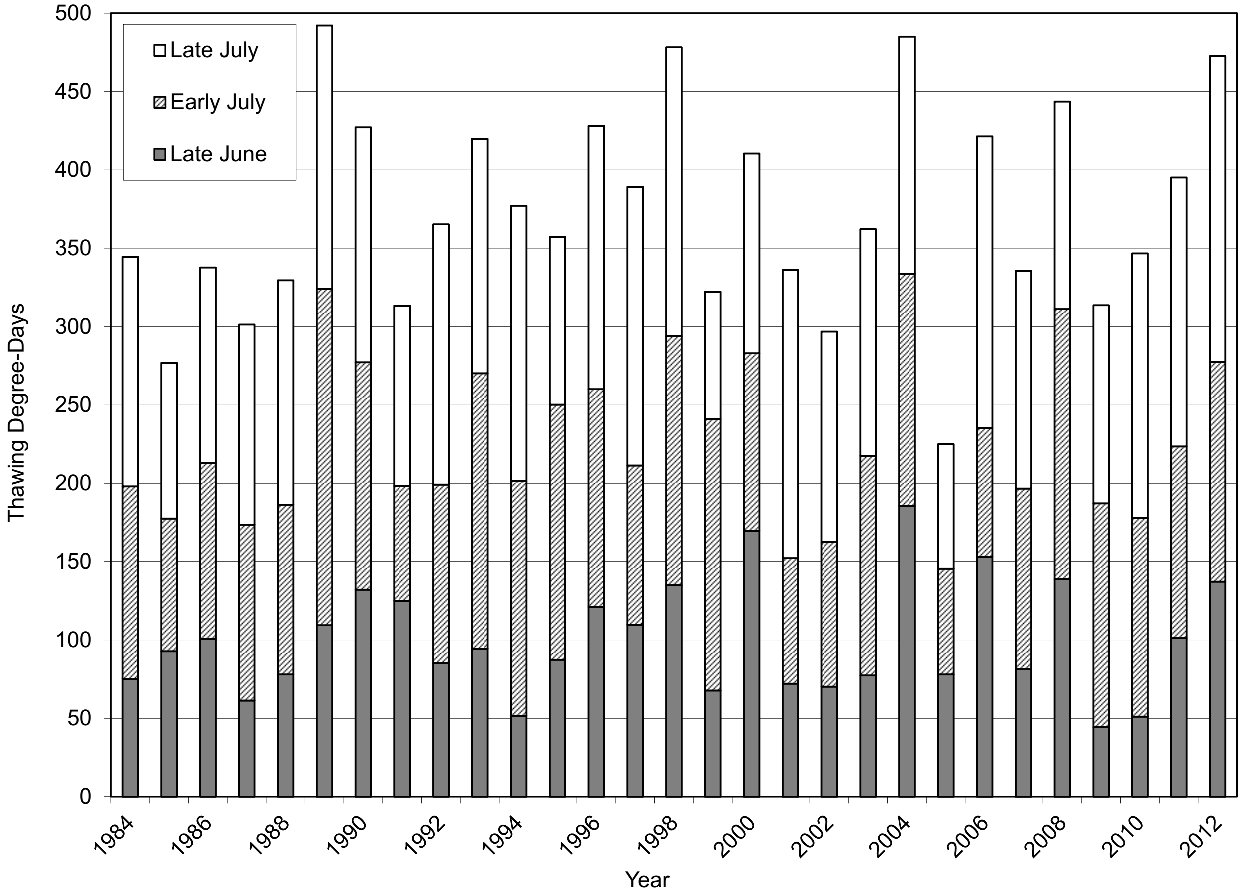
Survey Area	Date	Total Area (km²)	Estimated Total Caribou [a]	Total Density (per km²)	Estimated Total Calves [a]	Calf Density (per km²)	Snow Cover
Colville Delta	8 June 2009	494	14	0.03	2	<0.01	None
	7 June 2010	494	0	0	0	0	Low; SCF not used
	8 June 2011	494	0	0	0	0	Patchy; SCF used
	11 June 2012	494	10	0.02	4	0.01	Low; SCF not used

[a] Incorporates sightability correction factor (SCF) of 1.88 (Lawhead et al. 1994) where indicated.
[b] Dropped 2 easternmost transects in 2002.
[c] Unable to survey easternmost 14 transects on 4 June 2004.
[d] Kuparuk Inland survey area of 1993 and 1995.
[e] Shifted south 1.6 km in 1996 to eliminate overlap with Kuparuk Field survey area.
[f] Enlarged and extended east to Kuparuk River in 2002.
[g] Unable to survey easternmost 8 transects in 2004.
[h] Surveyed only in 1993 and early June 1995; northern quarter incorporated in Colville East survey area thereafter.
[i] Extended south to 70º N latitude in 1995, thus incorporating northern quarter of Colville Inland survey area.
[j] Extended south in 1999 to incorporate Meltwater South study area.
[k] Dropped westernmost transect in 2002.
[l] Unable to survey westernmost 3 transects on 5 June 2004.
[m] Unable to survey westernmost 2 transects on 16 June 2004.

Appendix C. Sum of thawing degree-days (º C above freezing) at the Kuparuk airstrip during five periods of the insect season, mid-June through August 1983–2012.

Year	16–30 June	1–15 July	16–31 July	1–15 August	16–31 August	Total
1983 [a]	66.2	74.7	103.8	100.3	50.7	402.9
1984	75.3	122.8	146.4	99.5	59.9	503.9
1985	92.8	84.7	99.4	100.0	70.8	447.8
1986	100.8	112.2	124.7	109.4	54.4	501.7
1987	61.4	112.2	127.8	93.1	109.4	503.9
1988	78.1	108.3	143.1	137.5	52.2	519.2
1989	109.4	214.7	168.1	215.8	133.9	841.9
1990	132.2	145.0	150.0	82.5	72.8	582.5
1991	127.6	73.3	115.0	70.6	54.4	438.3
1992	85.3	113.9	166.1	104.2	96.1	565.6
1993	94.4	175.8	149.7	96.1	78.1	594.2
1994	51.7	149.7	175.8	222.2	92.2	691.7
1995	87.5	162.8	106.9	83.3	83.6	524.2
1996	121.1	138.9	168.1	95.8	34.7	558.6
1997	109.7	101.7	177.8	194.2	97.8	681.1
1998	135.0	158.9	184.4	174.4	123.1	775.8
1999	67.8	173.3	81.1	177.5	69.7	569.4
2000	169.7	113.3	127.5	118.6	53.6	582.8
2001	72.2	80.0	183.9	131.7	32.5	500.3
2002	70.3	92.2	134.4	106.1	90.6	493.6
2003	77.5	140.0	144.7	91.9	55.0	509.2
2004	185.6	148.1	151.4	153.3	123.1	761.4
2005	78.1	67.5	79.4	176.7	44.4	446.1
2006	153.1	82.2	186.1	109.7	36.9	568.1
2007	81.7	115.0	138.9	134.4	103.6	573.6
2008	138.9	172.2	132.5	86.1	73.9	603.6
2009	44.4	142.8	126.4	133.6	95.0	542.2
2010	51.1	126.7	168.9	149.2	115.2	611.1
2011 [b]	101.2	122.4	171.6	142.8	83.7	621.7
2012 [b]	137.3	140.2	195.2	143.5	166.3	782.5
Mean	98.6	125.5	144.3	127.8	80.3	576.6

[a] Some missing values estimated by interpolation.
[b] Estimated by averaging values from Nuiqsut and Deadhorse (see text).



Appendix D. Index of annual insect-season conditions (expressed as cumulative thawing degree-days in º C above freezing at the Kuparuk airstrip; see Appendix C) from mid-June through July 1984–2012.

Appendix E. Average index values of mosquito activity[a] (adapted from Russell et al. 1993) during June–August 1983–2012, based on daily maximum temperatures at the Kuparuk airstrip.

Year	June			July			August		
	Early	Late	Total	Early	Late	Total	Early	Late	Total
1983	0.28	0.31	0.30	0.28	0.40	0.34	0.43	0.15	0.29
1984	0.26	0.37	0.31	0.60	0.68	0.64	0.46	0.21	0.33
1985	0.09	0.48	0.28	0.42	0.45	0.44	0.52	0.31	0.41
1986	0.01	0.46	0.24	0.62	0.54	0.58	0.53	0.21	0.36
1987	0.00	0.22	0.11	0.52	0.47	0.49	0.34	0.42	0.38
1988	0.04	0.32	0.18	0.50	0.64	0.57	0.73	0.19	0.45
1989	0.01	0.58	0.29	0.90	0.74	0.82	0.84	0.59	0.71
1990	0.17	0.69	0.43	0.68	0.62	0.65	0.30	0.21	0.25
1991	0.01	0.58	0.30	0.35	0.48	0.42	0.27	0.27	0.27
1992	0.29	0.36	0.33	0.49	0.77	0.64	0.48	0.42	0.45
1993	0.13	0.43	0.28	0.80	0.66	0.73	0.37	0.26	0.31
1994	0.23	0.18	0.21	0.73	0.77	0.75	0.97	0.37	0.66
1995	0.28	0.36	0.32	0.83	0.35	0.58	0.30	0.36	0.33
1996	0.44	0.55	0.49	0.72	0.69	0.70	0.46	0.14	0.30
1997	0.07	0.50	0.28	0.41	0.82	0.62	0.84	0.33	0.58
1998	0.30	0.55	0.43	0.72	0.81	0.77	0.71	0.46	0.58
1999	0.11	0.28	0.20	0.84	0.29	0.56	0.82	0.20	0.50
2000	0.11	0.82	0.47	0.50	0.47	0.49	0.59	0.27	0.42
2001	0.25	0.33	0.29	0.32	0.75	0.54	0.60	0.05	0.31
2002	0.25	0.30	0.28	0.43	0.61	0.52	0.40	0.36	0.38
2003	0.10	0.39	0.24	0.65	0.58	0.62	0.46	0.09	0.27
2004	0.05	0.89	0.47	0.72	0.65	0.68	0.70	0.44	0.57
2005	0.01	0.34	0.18	0.28	0.28	0.28	0.82	0.11	0.45
2006	0.49	0.73	0.61	0.32	0.81	0.57	0.50	0.06	0.27
2007	0.14	0.38	0.26	0.57	0.55	0.56	0.60	0.41	0.50
2008	0.31	0.71	0.51	0.85	0.59	0.71	0.22	0.22	0.22
2009	0.32	0.11	0.22	0.60	0.53	0.56	0.56	0.36	0.46
2010	0.22	0.14	0.18	0.56	0.74	0.65	0.62	0.43	0.52
2011[b]	0.05	0.45	0.26	0.54	0.71	0.63	0.62	0.28	0.44
2012[b]	0.07	0.64	0.36	0.67	0.80	0.74	0.67	0.67	0.67
Mean	0.17	0.45	0.31	0.58	0.61	0.60	0.56	0.30	0.42

[a] Average Mosquito Index: if daily maximum temperature <6° C, then index = 0; if daily maximum temperature >18° C, then index = 1; otherwise, index = 1 – [(18 – daily maximum temperature)/13].

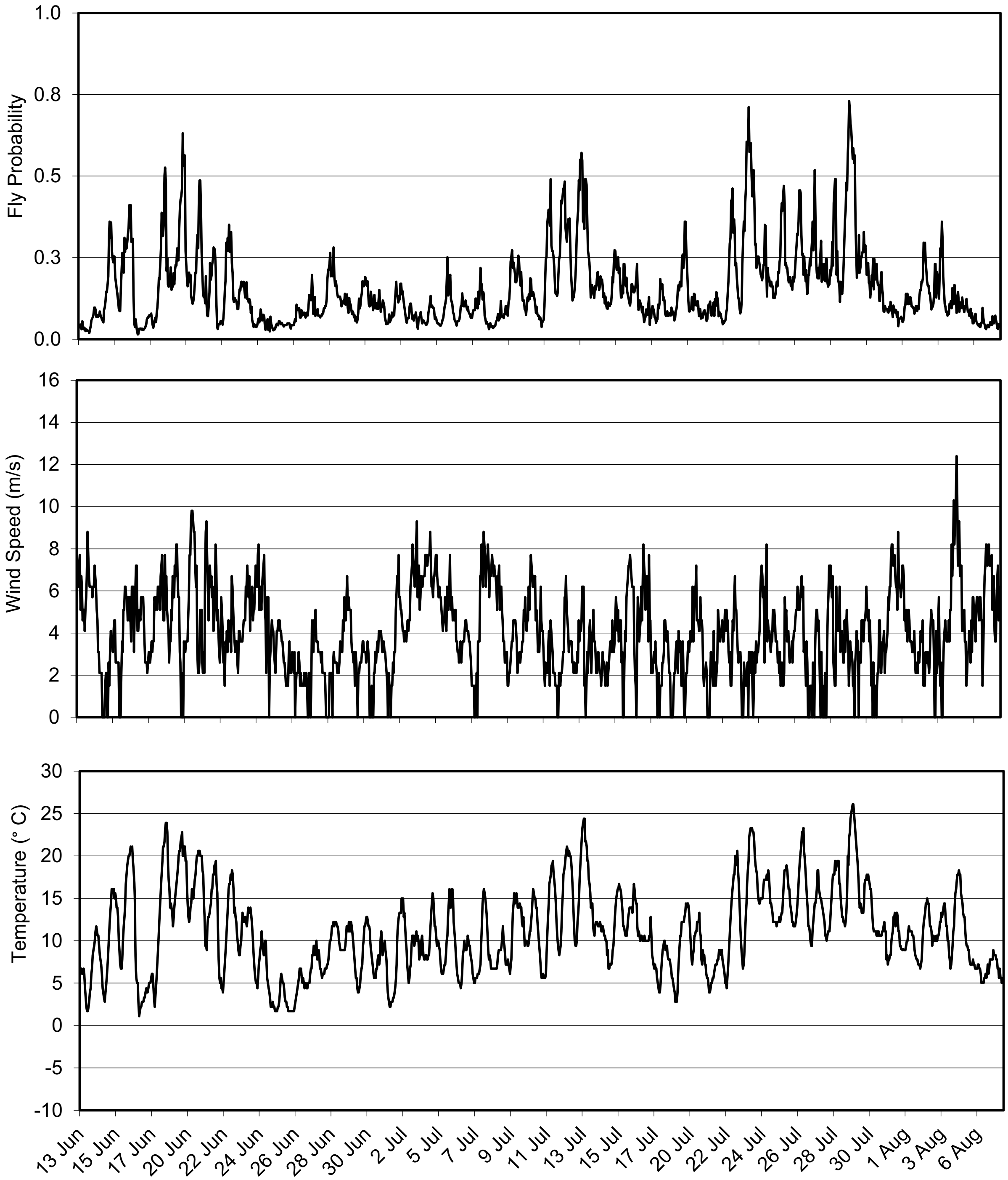
[b] Values for late June through August were estimated by averaging values from Deadhorse and Nuiqsut (see text).

Appendix F. Average index values of oestrid fly activity[a] (adapted from Russell et al. 1993) during June–August 1983–2012, based on daily maximum temperatures at the Kuparuk airstrip.

	June			July			August		
Year	Early	Late	Total	Early	Late	Total	Early	Late	Total
1983	0.10	0.15	0.12	0.04	0.33	0.19	0.25	0.02	0.13
1984	0.14	0.14	0.14	0.40	0.59	0.50	0.34	0.09	0.21
1985	0.03	0.26	0.15	0.29	0.27	0.28	0.36	0.21	0.28
1986	0.00	0.33	0.17	0.49	0.35	0.41	0.38	0.08	0.23
1987	0.00	0.05	0.03	0.29	0.33	0.31	0.09	0.23	0.16
1988	0.00	0.10	0.05	0.26	0.48	0.37	0.60	0.14	0.36
1989	0.00	0.40	0.20	0.85	0.63	0.74	0.75	0.49	0.62
1990	0.04	0.52	0.28	0.62	0.50	0.56	0.09	0.06	0.07
1991	0.00	0.49	0.24	0.21	0.32	0.27	0.17	0.14	0.16
1992	0.20	0.19	0.20	0.33	0.63	0.49	0.36	0.26	0.31
1993	0.02	0.35	0.18	0.69	0.47	0.58	0.24	0.16	0.20
1994	0.06	0.10	0.08	0.58	0.70	0.64	0.95	0.24	0.58
1995	0.16	0.18	0.17	0.73	0.24	0.48	0.11	0.21	0.16
1996	0.31	0.46	0.38	0.63	0.57	0.60	0.34	0.03	0.18
1997	0.00	0.28	0.14	0.32	0.72	0.53	0.74	0.16	0.44
1998	0.16	0.42	0.29	0.55	0.69	0.62	0.52	0.23	0.37
1999	0.01	0.10	0.06	0.74	0.17	0.44	0.70	0.08	0.38
2000	0.04	0.75	0.39	0.39	0.28	0.34	0.49	0.20	0.34
2001	0.19	0.10	0.15	0.24	0.63	0.44	0.41	0.01	0.20
2002	0.18	0.18	0.18	0.23	0.49	0.36	0.30	0.24	0.27
2003	0.00	0.22	0.11	0.45	0.44	0.44	0.34	0.00	0.17
2004	0.00	0.83	0.41	0.57	0.50	0.53	0.62	0.31	0.46
2005	0.00	0.23	0.12	0.11	0.05	0.08	0.75	0.03	0.38
2006	0.39	0.61	0.50	0.15	0.71	0.44	0.29	0.03	0.15
2007	0.01	0.21	0.11	0.39	0.34	0.36	0.38	0.13	0.25
2008	0.12	0.55	0.34	0.75	0.43	0.59	0.00	0.05	0.03
2009	0.14	0.03	0.09	0.41	0.39	0.40	0.42	0.21	0.31
2010	0.13	0.01	0.07	0.34	0.60	0.47	0.54	0.20	0.36
2011[b]	0.05	0.25	0.15	0.31	0.55	0.44	0.44	0.05	0.24
2012[b]	0.03	0.49	0.26	0.46	0.71	0.59	0.48	0.56	0.52
Mean	0.08	0.30	0.19	0.43	0.47	0.45	0.41	0.16	0.29

[a] Average Fly Index: if daily maximum temperature <10° C, then index = 0; if daily maximum temperature >18° C, then index = 1; otherwise, index = 1 – [(18 – daily maximum temperature)/8].

[b] Values for late June through August were estimated by averaging values from Deadhorse and Nuiqsut (see text).



Appendix G. Probability of oestrid fly activity (Mörschel 1999) in summer 2012, based on wind speed and temperature data recorded at the Nuiqsut airstrip.