BLACK BEAR MONITORING IN EASTERN INTERIOR ALASKA

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Abstract: American black bears (*Ursus americanus*) are common predators of ungulates in interior Alaska, yet little research has described bear demographics. This study examines movement, denning, and reproductive characteristics of a black bear population in the Yukon Flats in eastern interior Alaska. To our knowledge, this location at 66°N latitude is the northernmost study of black bears. A total of 29 individual black bears were captured 53 times between 1995 and 1997. Capture rates were high with a mean annual rate of 2.3 black bears/10 trap days. A total of 900 telemetry locations was obtained from 23 radiocollared black bears. Mean annual home ranges for adult female and male black bears were 15.5 and 182.5 km^2, respectively. The mean date of den entry was 26 September (range: 19 Sep–8 Oct, $n = 42$) and the mean date of den emergence was 2 May (range: 26 Apr–6 May, $n = 31$). Mean length of denning exceeded all previous reports at 220 days (range: 213–229 days, SD = 4, $n = 31$). Females excavated all dens in well drained terrain in forested areas. Mean litter size for 7 adult females was 2.1 ($n = 10$). The recruitment and reproductive intervals were 2.0 years ($n = 2$) and 1.6 years ($n = 5$), respectively. The survival rate for cubs weaned to 1 year was low (0.45). The mean annual survival rate for adult males was 0.86. We report 2 likely instances where, during spring, grizzly bears (*Ursus arctos*) preyed on adult female black bears with young.

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The range of the American black bear extends over much of North America including all or part of 38 continental states, 7 Mexican states, and much of Alaska and Canada (Beecham and Rohlman 1994). The northern limit of their range is found in Alaska near the Brooks Range at the terminus of the northern boreal forest. Records of black bear north of the Brooks Range are rare (Bee and Hall 1956).

Few studies have been conducted of black bears in northern latitudes. Previous work has described regional demographics and specifically examined the influence of environmental factors on denning ecology and reproductive parameters (Tietje and Ruff 1980; Schwartz et al. 1986; Kolenosky and Strathearn 1987; Miller 1990, 1994; Smith et al. 1994). This work has provided a broad framework to begin to understand black bear biology in Alaska.

Herein, we describe seasonal use patterns, den site characteristics, denning chronology, and reproductive and mortality parameters of black bears in the northern boreal forest of eastern interior Alaska. To our knowledge, at 66°N latitude and approximately 35 km south of the Arctic Circle, this is the northernmost black bear study. We present these findings to better describe extremes in the black bear's range.

STUDY AREA

The 16,835 km^2 study area was located in the western Yukon Flats in the northern boreal forest of eastern interior Alaska (Fig. 1). The study area encompassed the Yukon Flats National Wildlife Refuge and included the western half of the Alaska Department of Fish and Game (ADF&G) Game Management Unit 25 D. It was situated 35 km east of the village of Beaver, Alaska (66°21'N, 147°23'W) and about 35 km south of the Arctic Circle. The Yukon Flats is a vast wetland basin bisected by the Yukon River. The basin is underlain by discontinuous permafrost and includes a complex network of lakes, streams, and rivers. The landscape is heavily influenced by flooding and wildland fire. Due to the area's low annual rainfall, high summer temperatures, and high inci-

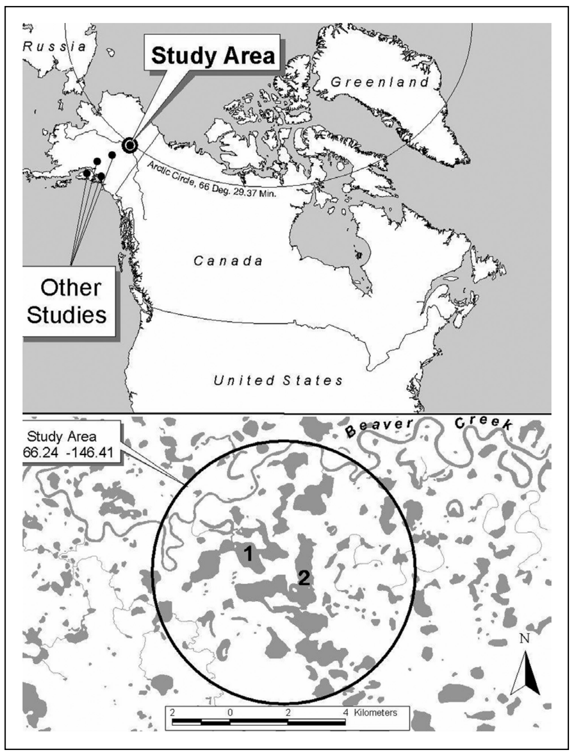

Fig. 1. Study area for black bear in Interior Alaska, 1995–97, including major lakes (in gray). Bears were captured at lakes marked 1 and 2 on lower figure.

dence of lightning, fire activity is often intense and widespread. Since 1981, the Yukon Flats region has had 256 fires burn over 2.5 million acres, averaging 510 km^2/year (Perry Grissom, U.S. Fish and Wildlife Service, Fairbanks, Alaska, USA, unpublished data). The southern edge of the study area includes uplands and foothills of the White Mountains, with elevations ranging from 91 to 912 m.

The area was characterized by mixed forests dominated by white spruce (*Picea glauca*), black spruce (*P. mariana*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*). Shrub communities of alder (*Alnus* spp.) and willow (*Salix* spp.) are most common in riparian sites and edges surrounding lakes and meadows. Dwarf shrubs such as glandular birch (*Betula glandulosa*), Labrador tea (*Ledum decumbens*), crowberry (*Empetrum nigrum*), and blueberry (*Vaccinium uliginosum*) were common in the uplands.

The Yukon Flats has a continental subarctic climate characterized by large seasonal extremes of temperature and daylight. Summer temperatures can exceed 38°C and are warmer than any other comparable latitude in North America. The mean minimum January temperature is -33°C with winter temperatures reaching -59°C or lower. Although the area has a short growing season of about 81 days, the long hours of sunlight during the spring and summer months produce abundant vegetation. The mean annual precipitation is 16.7 cm, ranging from 9.1 to 27.2 cm. Snow accumulations rarely exceed 76 cm.

The Yukon Flats Ecoregion was largely unexploited, included no significant development, and was roadless with only air and water transportation available. The region was settled by 3 villages of Kutchin Athapaskan with populations totaling approximately 250 individuals. Black bear hunting was not a traditional subsistence activity, thus, hunting pressure was light. During the study period, a licensed guide used the area and harvested up to 10 black bears annually.

METHODS

Capture

Bears were captured at Beaver Creek and near 2 adjacent lakes (Fig. 1). Aldridge foot snares were anchored to mature paper birch or white spruce trees (minimum 6 inches diameter) and vegetation was cleared in a 3.6-m (12–foot) perimeter around each tree. Traditional cubby sets (Beecham and Rohlman 1994) were constructed at the tree base and were baited primarily with chum salmon (*Oncorhynchus keta*). Up to 4 snares were placed at each site. Bait sites were monitored daily in 1995 and twice daily in 1996 and 1997. Trapping effort was expressed in bears captured per 10 days of trapping effort. A trap day was defined as a baited site with ≥1 active snares for a 24-hour period.

Black bears were immobilized with Telazol (A.H. Robins Company, Richmond, Virginia, USA; 300 mg/ml at 0.005ml/estimated kg of body weight) and fitted with model 500 expandable break-away radiocollars (Telonics Inc., Mesa, Arizona, USA) containing a motion-sensitive mortality switch (12.5 hour delay). Black bears captured in 1997 were fitted with radiocollars designed to drop-off after several years of use (Hellgren et al. 1988). Button Duflex tags (National Band and Tag Co., Newport, Kentucky, USA) were attached to each ear. A unique right–left combination of brightly colored heavy vinyl was pressed between ear tags to assist as visual markers. Black bears were permanently marked by a right upper lip tattoo.

Standard morphometric data including body weight were recorded. In addition, pelage color and condition and any distinguishing marks, scars, and injuries were recorded. A vestigial premolar (PM1) was extracted with dental pliers and age was estimated using cementum annuli analysis (Willey 1974; Matsons Lab, Milltown, Montana, USA). Mammary glands and vulva were examined to determine female reproductive status. Blood was drawn from femoral arteries and later transferred to freezer storage and analyzed for *Toxoplasma gondii,* a parasitic disease carried by domestic cats that can cause birth defects in humans (ADF&G, Fairbanks, Alaska, USA). Black bears were classified as cubs (0–1 yr), yearlings (1–2 yr), subadults (2–4 yr), and adults (>4 yr).

Monitoring

Black bears were located from 1995 to 1997 by fixed-wing aircraft at approximately 10-day intervals between mid-April and early-October. Telemetry data included latitude and longitude of location, activity pattern, and habitat type.

Den Investigations

The reproductive status of adult females was monitored annually from early March to early April 1996 to 2001. In most instances, we were able to gain close access to den sites (<0.5 km) with a ski-equipped fixed-wing aircraft. Females were immobilized in the den and cubs, if present, were counted, sexed, and weighed. Yearling female cubs were fitted with a radiocollar and the right upper lip was tattooed. Adult females were weighed, and radiocollars were replaced every 2 years.

Physical characteristics of each den site were measured, including the location, structure, and aspect of the den and the snow depth. We also measured the height, width, and depth of the entrance hole and the den chamber. Entrance and chamber volume were calculated from these measurements.

Dates when den entry occurred were recorded as the median date between the last active observation and the first denned observation. Dates when black bears emerged from the dens where recorded as the median date of the last denned observation and the first active observation. Bears that were observed out of their den on the first spring telemetry flight were removed from the sample. Den period was the total numbers of days in the den. We used temperature and snow course records (National Oceanic Atmospheric Administration, Natural Resources Conservation Service, Fort Yukon, Alaska, USA) to compare differences between years for den entry and emergence dates.

Recruitment interval was defined as the period between production of a litter that had successfully reached yearling age and production of a subsequent litter reaching yearling age. Reproduction (interbirth) interval was the period between production of a litter and production of a subsequent litter regardless of annual survival.

Statistical Analyses

We used the nonparametric adaptive kernel procedure (Home Ranger; Ursus Software, Revelstoke, British Columbia, Canada) to estimate black bear home ranges, selecting the bandwidth with least squares cross validation and using the 95% contour interval. We chose not to use the fixed kernel method because 5 black bears had <30 location samples. We also calculated minimum convex polygons (Mohr 1947) to estimate black bear home ranges to compare with previous studies (Calhome Software, Fresno, California, USA). *Z*-tests were conducted to examine between-year variation in adult survival rates and differences between sex and age groups for sightability, activity patterns, and habitat preferences (Freund and Wilson 1997:200). Two tailed *t*-tests using pooled variances were used to analyze annual variation in home ranges, den entry, emergences dates, and den period between sex and age groups (Zar 1984:126). Black bear survivorship was determined using the Kaplan-Meier method with staggered entry design (Pollack et al. 1989). Because of small sample sizes, cubs were pooled for all years for survival analyses. Survival of adults was analyzed by year. All groups were considered independent for all analyses.

RESULTS

Capture

Black bears were captured annually between 24 May and 9 June 1995–97. Most captures (93%) used Aldrich foot snares; the remaining black bears were darted while they free ranged at or near the trap sites. We concentrated each annual trapping effort (range: 11–13 days) in a 5 km^2 area that was accessible by boat. Annual trapping areas overlapped and were within a 13-km^2 area; 29 individual black bears were captured and 25 were fitted with radiocollars (Table 1). We recorded 25 captures of black bears we had caught previously. Two yearling males were released unmarked, and 2 adult males were tattooed but not collared.

The capture sample (excluding den investigations) included 2 yearling males, 3 subadult males (mean age 2.3 years, range: 2–3), 16 adult males (mean age 8.3 years, range: 5–19), 1 subadult female (age 3 years), and 7 adult females (mean age 9.6 years, range: 4–15).

Annual capture rates for newly captured black bears were 2.30, 0.70, and 0.44 captures/10 trap days, with a mean of 1.26 (Table 1). Annual capture rates for all captured black bears were 3.45, 1.69, and 1.62 captures/10 trap days with a mean of 2.35. Recapture rates increased annually (range: 32–73%) reflecting a high proportion of marked black bears in the capture area. Daily visitation to trap sites by black bears was high. The mean incidence of black bears tripping snares but avoiding capture was 60% (range: 54–73%). No mortalities were associated with capture activities.

Physical Characteristics

We recorded 2 color phases during the study: black and cinnamon or brown. Four of the 29 (14%) captured bears were cinnamon phase; 3 of the 4 were female. Only 1 of 21 cubs was cinnamon phase. The incidence of cinnamon phase was similar to the 11% reported from sealing records by the ADF&G. One black yearling male had a white chest blaze. Mean mass of subadult males was 37.3 kg (range: 31.8–47.6 kg, SD = 5.2, *n* = 3). Mean mass of adult males was 87.3 kg (range: 59.1–117 kg, SD = 15.6, *n* = 16). The only subadult female captured weighed 35.2 kg. Mean mass of adult females was 63.4

Table 1. Capture statistics for black bears in the western Yukon Flats, eastern interior Alaska, 1995–97

	n			
Parameter	1995	1996	1997	All years
Trapping period[a]	13	12	11	36
Trap days[b]	91	71	68	230
Snare disturbance[c]	73	54	54	60
New captures	21	5	3	29
Recaptures	10	6	8	24
Total captures	31	12	11	54
Newly collared	19	4	2	25
New captures/10 days	2.3	0.70	0.44	1.26
Total captures/10 days	3.4	1.69	1.62	2.35

[a] Trapping period = total number days trapped
[b] Trap days = number open trap sites multiplied by trap period
[c] Snare disturbance = incidence of dislodged snare resulting in no capture

kg (range: 43.2–76.4 kg, SD = 14.3, n = 7). Twelve of 20 blood samples tested positive for *T. gondii*.

Home Range, Habitat Use, Annual Movement

We obtained 900 locations from 23 radiocollared bears between 1995 and 1997. Two individual black bears were removed from the sample due to insufficient size of location samples. Mean annual 95% contour home ranges for adult females and males were 15.5 km^2 and 182.5 km^2, respectively (Table 2). The mean home range for subadult males (n = 3) was 137.6 km^2. Mean annual minimum convex polygon home ranges for adult females and males were 9.4 km^2 and 81.8 km^2, respectively. Males had larger home ranges than females (t = 2.3, 17 df, P = 0.03).

We observed 33% of all located bears on radio relocation flights. Visual relocation rates of subadults were lower than adults (Z = -2.64, P = 0.004), and visual location rates of females were lower than males (Z = 1.68, $P <$ 0.05). Visual location rates of adult females without cubs and adult females with cubs did not differ (Z = 0.13, P = 0.55).

Den Ecology

We examined 25 adult female dens in March and April between 1996 and 2001. Twenty-four dens were excavated on well drained terrain in forested areas. Of these, 10 were excavated at the base of toppled or leaning trees; the remaining 14 were excavated from open areas between live trees. One den was excavated in an alder stand which was poorly drained. All dens were situated on flat terrain with a slope of 0° and elevation of approximately 275 m. The mean aspect for den openings was 133° (range: 0–270°, SD = 98.5, n = 25) and was evenly distributed between all quadrants. We did not have adequate sample sizes to test for differences in den aspect. All den chambers included a cupped nest of plant material about 8 cm thick. Most den entrances had twigs, leaves, and woody debris around the perimeter, and the holes were plugged with crystalized snow and ice. Mean height, width, and length of den chambers were 59.9, 93.2, and 137.8 cm, respectively, and included a volume of 0.82 m^3. Mean height, width, and length of den entrances were 36.0, 44.0, and 54.12 cm, respectively, and included a volume of 0.16 m^3. We did not test for differences in den morphology among sows with cubs, without cubs, or with yearlings due to inadequate sample sizes. Mean annual snow depth was 58.8 cm (range: 42.7–88.9 cm, SD = 16.8, n = 24).

The mean time interval used to establish den entry and emergence dates between location flights was 7.6 days (range: 6–15, SD = 2.5, n = 67). Generally, bears entered dens between 19 September and 8 October (20-day span). Den entry was later in 1997 (t = 4.1, 9 df, P = 0.002) than in 1995 or 1996 (Table 3). We did not detect differences in den entry within sex or age classes. Bears emerged from their dens between 25 April and 6 May (12-day span). This range of dates was more constricted than den entry and was a conservative estimate because several bears were already active prior to our first spring location flights. Mean den emergence for all bears was different between 1996 and 1997 (t = 3.7, 27 df, P = 0.001). Den emergence also differed between adult males and subadult males in 1996, but sample size of subadult males was low (n = 3). Mean length of denning was 220 days (range: 213–229, SD = 4, n = 31). Mean den periods were consistent between years for all sex and age groups combined, but significant inter-year differences were noted for adult males (t = 2.3, 22 df, P = 0.03).

Reproduction

Seven adult females were monitored for reproductive status between 1996 and 2001. Den visits to females with litters occurred between 3 March and 1 April. The mean breeding age of adult females in our sample was 15 years (range: 9–21, n = 15). Five females produced 10 litters, which were comprised of 2 single cubs, 5 sets of twins, and 3 sets of triplets ($\bar{x}$ = 2.1). The sex ratio for newborn cubs was 14 males:7 females. The mean weight for 2 yearlings was 15 kg. Ages and weights for parous females ranged from 9 to 21 years, and 64 to 82 kg, respectively. We established age at first reproduction for only one female (age 9). One adult female gave birth to cubs during 3 consecutive years; after losing the first 2 litters she successfully raised the third litter to one year of age. The recruitment and reproduction intervals were 2.0 years (n = 2), and 1.6 years (n = 5), respectively.

Table 2. Adaptive kernal home range (km^2) estimates in the western Yukon Flats, eastern interior Alaska, 1995–97

	Home range				Locations			
Group	Mean[a]	SD	n	Range	Mean	SD	n	Range
Adult	147.4	52.3	19	3.3–753.2	38	11	716	22–57
Males	182.5	245.9	15	9.2–753.2	37	10	548	22–55
Females	15.5	17.8	4	3.3–41.9	42	13	168	32–57
Subadult	106.4	107.5	4	12.9–261.2	46	2	184	43–48
Males	137.6	107.2	3	70–261.2	45	2	136	43–47
Females	21.2	0	1	12.9	48	-	48	

[a] Mean represents individual bears across years.

Table 3. Denning chronology among sex and age in the western Yukon Flats, eastern interior Alaska, 1995–97.

	Den entry dates[a]				Den emergence dates[b]				Den period (days)			
Group	Mean	SD	*n*	Range	Mean	SD	*n*	Range	Mean	SD	*n*	Range
All years	26 Sep[c]	5	39	19 Sep–8 Oct	02 May[d]	4	31	25 Apr–6 May	220	4	31	213–229
Males	25 Sep	5	27	19 Sep–8 Oct	02 May	4	24	25 Apr–6 May	221	3	24	213–229
Adult	27 Sep	5	20	19 Sep–8 Oct	03 May	4	19	25 Apr–6 May	220	3	19	213–223
Subadult	19 Sep	6	7	19 Sep–8 Oct	02 May	4	5	29 Apr–6 May	223	4	5	220–229
Females	27 Sep	6	12	21 Sep–8 Oct	03 May	4	7	26 Apr–6 May	219	5	7	213–226
Adult	27 Sep	7	7	21 Sep–8 Oct	02 May	4	5	26 Apr–6 May	219	6	5	213–226
Subadult	26 Sep	4	2	21 Sep–8 Oct	29 Apr	1	2	29 Apr	219	2	2	217–220

[a] Median of last active observation and first denned observation.
[b] Median of last denned observation and first active observation.
[c] Entrance dates were significantly different between 1997–98 and both 1995–96 and 1996–97.
[d] Emergence dates were significantly different between 1995–96 and 1996–97.

Cub mass ranged from 0.6 to 2.6 kg with the lightest recorded weight on 6 March and the heaviest weight on 1 April.

Bears were observed in breeding condition between 24 May to 9 June during the capture period and on telemetry flights 12 and 14 June 1995 to 1997. One adult female was captured annually in estrus, as noted by vulval swelling. Another newly captured female was observed consorting with a marked male at a trap site. In addition, 5 marked black bears were observed with members of the opposite sex on 5 separate occasions during telemetry flights. We did not observe any breeding behavior beyond 14 June.

Survival

The survival rate estimate for cubs weaned to one year was 0.45 (95% CI = 0.33, $n = 20$). Mortality sources for cubs were largely unknown, but we did document instances of suspected grizzly bear predation on 2 denned female black bears with cubs.

Among adults through June 1998, we documented mortality only among males. Two adult males died of unknown causes, 1 of which was observed being eaten by an adult black bear. Another male was killed by a grizzly bear and another was harvested by a hunter. The mean annual survival rate for adult males was 0.86 (95% CI = 0.25, $n = 15$). The mean annual survival rate in 1997 was lower than 1995 ($Z = 1.97$, $P = 0.02$).

DISCUSSION

Black bear capture rates in the western Yukon Flats are among the highest reported. Our mean capture rate (2.3 bears/10 trap nights) was higher than those reported on the Kenai Peninsula in Alaska (Schwartz and Franzmann 1991), Idaho (Beecham and Rohlman 1994), Louisiana (Beausoleil 1999), and Mexico (Doan-Crider and Hellgren 1996). Our short annual capture periods (11–13 days), however, may have inflated capture rates for comparison to other areas.

We did not estimate black bear densities in the study area, but we suspect, based on high capture rates and low hunting pressure, that densities are within the range of densities previously reported in Alaska (86–265/1,000 km^2; Hechtel 1991, Schwartz and Franzmann 1991, Miller 1994).

Similar to other studies across North America (Novick and Stewart 1982, Young and Ruff 1982, Meddleton and Litvaitis 1990, Hechtel 1991, Hirsch et al. 1999), we recorded the largest mean minimum convex polygon home ranges in adult males. Our mean estimate for adult males (81.8 km^2, SD = 61, $n = 15$) was, however, considerably less than the minimum convex polygon ranges observed in other Alaska studies (151–358.7 km^2). Likewise, the mean home range for adult females (9.4 km^2, SD = 14, $n = 4$) was outside the range of estimates previously reported in other Alaska studies (21 km^2, Schwartz et al. 1983; 67.1 km^2, adult and subadult, Miller 1987; 72.1 km^2, adult and subadult Hechtel 1991).

Den sites were commonly situated 100–300 m from wetlands in mature and well drained deciduous and conifer forests. These sites were situated on relatively high ground and elevated 1–2 m above the nearest wetland, which presumably aided in preventing the den from flooding. With one exception, bears avoided denning in bog habitats, an area susceptible to flooding during spring thaw.

Previous studies in Alaska and Canada related den site selection to topography and climatic conditions. Black bears in Prince William Sound and the Susitna River Basin used natural den sites, which included rock piles, caves, and trees (Schwartz et al. 1986). Black bears that occupied heavily forested lowlands with relatively flat terrain typically excavated den sites and insulated the den cup with plant materials (Tietje and Ruff 1980, Schwartz et al. 1986, Smith et al. 1994). Given the heavily forested areas of the Yukon Flats, the lack of suitable den trees, the prolonged periods of temperatures reaching -59°C during the den period, and low average snowfall, it was not surprising that all dens we investigated were newly excavated and lined with grasses and sedges.

Den morphology was similar to previous studies at northern latitudes (Tietje and Ruff 1980, Schwartz et al. 1986, Smith et al. 1994; Table 4). Generally, den entrances were just large enough to allow black bears into dens, and chambers provided minimal space for black bears to shift position. Small den chambers, which restrict movement and prevent excessive heat loss, are likely an adaptation to cold climates (Tietje and Ruff 1980). Vegetation material in the den nest is common in northern areas with layers reported up to 30 cm (Smith et al. 1994). Reynolds et al. (1976) reported similar thicknesses for grizzly bears in the Brooks Range in northeastern Alaska. It was interesting that we did not observe nesting material thickness >8 cm despite the high availability of nesting materials surrounding dens.

Smith et al. (1994) summarized entrance, emergence, and total time in the den for bear populations across North America and suggested that environmental factors likely contribute to lengthening den periods across latitudinal and elevation gradients. Studies conducted in Alaska support this reasoning with the longest den periods on record, which can be attributed to long winters and elevation changes (Schwartz et al. 1986, Smith et al. 1994; Table 4). Our study area is very near the northern boundary of suitable black bear habitat in North America, so it was not surprising that our mean den period (220 days) surpassed all other studies conducted to date. However, our longest den period for a 3-year old subadult male (229 days) did not approach some of the records (245–247 days) reported by Schwartz et al. (1986) from the Susitna River Basin (62°N), which is approximately 400 km south of our study area and situated in mountainous terrain at elevations up to 2,300 m (Miller 1987).

We detected little variation in annual weather data and no correlation to the late mean den entry in 1997 (3 Oct). Relocation flight schedules were comparable in timing between years and likely did not contribute to the late den entry observed in 1997. This late date may be artificial due to inadequate sample size and high variation (*n* = 8; 6 days). Although we identified differences in den emergence dates and den periods between years, there were only 3 days separating the annual means. Although larger sample sizes would bolster confidence in our data, we infer from low standard deviations for entry, emergence, and den period dates that age and sex classes of bears acted similarly in denning entry and emergence. This behavior is consistent with weather in northern latitudes where the onset of spring and winter can occur in a short period of time.

Reproductive parameters were within the ranges reported by Garshelis (1994) for North American studies and were similar to other studies in Alaska (Miller 1987, Schwartz and Franzmann 1991). We were largely unsuccessful at retaining collars on yearling and subadult females to determine age at first reproduction. However, an unexpected observation occurred in 2001 when a 9-year old female gave birth to her first litter (single cub). She had been monitored annually in the den since the age of 3 and had shown no previous signs of lactation or giving birth.

There is well documented data on adult and subadult black bear mortality caused by humans and food shortages, but as LeCount (1987) pointed out, limited information exists on natural mortality sources such as disease, cannibalism, and predation, and data on cub mortality are rare. Determining sources of cub mortality is problematic because it is difficult to attach radiotransmitters to cubs. Our survival rates for young to the age of one year (0.45) were among the lowest summarized by Garshelis (1994) in populations across the continent. Conversely, the annual survival rate for adult males was high at 0.86. Alt (1984) found that cub mortality was a function of both den selection and environmental conditions; flooding of natal dens contributed 5.2% of cub mortality in Pennsylvania. Others have attributed high cub mortality to the smaller size and poorer condition of first-time producers or their lack of experience in caring for young (Elowe and Dodge 1989, McLaughlin et al. 1994). LeCount (1987) found that 88% of radiocollared cubs (*n* = 8) died from predation; of this total, 50% died from cannibalism,

Table 4. Denning chronology for black bears in Alaska in areas of decreasing latitude. Unk = unknown.

Region	Den entry dates				Den emergence dates				Den period (days)				
(latitude; elevation)	Mean	SD	*n*	Range	Mean	SD	*n*	Range	Mean	SD	*n*	Range	Reference
Yukon Flats (66°; 275 m) eastern Interior	26 Sep	5	42	19 Sep–8 Oct	02 May	4	31	25 Apr–6 May	220	4	31	213–229	This study
Tanana Flats (64°; 185m) Interior	01 Oct	9	41	19 Sep–19 Oct	21 Apr	6	26	10–26 Apr	205	10	20	187–217	Smith et al. 1994
Susitna River Basin (62°; 2,300m) south-central	09 Oct	unk	116	09 Sep–8 Nov	06 May	unk	116	08 Apr–23 May	218	15	116	maximum 247	Schwartz et al. 1986
Kenai Peninsula (60°; 90m) south-central	18 Oct	3	164	21 Sep–11 Nov	19 Apr	unk	164	29 Mar–09 May	196	13	164	not reported	Schwartz et al. 1986

presumably by adult male bears. Clark (1991) hypothesized that cannibalism was responsible for low cub survival in Arkansas (31%) due to the skewed male:female ratio, which increased the likelihood of encounters between adult males and cubs. He surmised that adult male bears will kill cubs prior to or during the breeding season to enhance breeding opportunity. Lindzey et al. (1986) documented cannibalism of 2 subadult males and 2 denning adult females with cubs in a high density Washington population with low annual cub survival (27%). Schwartz and Franzmann (1991) reported that an adult male killed and consumed an adult female and possibly her 2 cubs; another instance involved cannibalism of a yearling male.

We do not suspect that dens in our study area commonly flood prior to den emergence based on den emergence dates (range: 26 April to 6 May) and regional flooding patterns (late May). Because the mean breeding age of adult females in our sample was 15 years, it is unlikely that lack of maternal care contributed significantly to cub mortality. Although we did not document cannibalism in our study, the high proportion of males in our sample and one case of an adult female giving birth 3 consecutive years leads us to believe cannibalism likely contributed to low cub survival.

Instances of inter-specific predation on black bears by grizzly bears and wolves (*Canis lupus*) has been previously summarized by Smith and Follmann (1993) and Boyd and Heger (2000). Data pertaining to predation on black bear at the den site are rare. Schwartz and Franzmann (1991) documented a radiocollared cub consumed by a brown bear. Ross et al. (1988) and Smith and Follmann (1993) documented predation on denned female black bears in the fall. We report 2 instances of probable grizzly bear predation on denned female black bears with cubs in the spring, which are, to our knowledge, the first such recordings. Between 3 March and 8 July 1999, a 15-year old adult female (weight = 66 kg in March 1999) and 2 neonate cubs were excavated and consumed, presumably by a grizzly bear. A second instance occurred between 3 April and 25 July 2000, to a 16-year old adult female (weight = 60 kg in March 2000) and her recently marked female yearling (weight = 15 kg). In both cases the den sites had been completely excavated and the remaining hole was approximately 1 m wide, 3 m in length, and 2 m deep. The terrain surrounding both areas was highly disturbed with crushed and broken saplings, uprooted vegetation, and exposed earth, suggesting a violent struggle. The recovered collars were moderately chewed, and bone fragments and black bear hair and hide were scattered at the den sites. We cannot confirm the death dates precisely due to irregular location flights during these periods, but the similar manner in which both dens were excavated leads us to believe grizzly bears predated both den sites, likely near black bear den emergence. Grizzly bear predation was also documented on a 16-year old male in late August 2000. The site was adjacent to the study area in the foothills of the White Mountains at an elevation of approximately 300 m. The area was severely disturbed, indicating an intense struggle had occurred, and the black bear's skin had been inverted with most of the carcass consumed. Miller (1990) estimated mean den emergence dates of 23 April (range: 5 April–5 May) for male grizzly bear and 6 May (range: 8 April–23 May 23) for black bears in southcentral Alaska. We suspect that adult male grizzly bear mean emergence dates in our study area also precedes that of black bears. A radiocollared adult cow moose (*Alces alces*) was killed by a grizzly bear in the study area between 1–17 April 1998. Observations of grizzly bear or remains of prey are documented annually by researchers and local residents in or near the study area. A recently completed moose calf mortality study documented 39% of collared moose calves were killed by grizzly bears, second only to predation by black bears (M. Bertram, unpublished data). Grizzly bear densities have not been adequately studied in the Yukon Flats but are suspected to be approximately 10/1,000 km^2, which is in the low range of densities reported by Miller et al. (1997) for Alaska. Despite low estimated densities, grizzly bear predation was common in the study area among all sex and age groups of black bear. Because moose and black bear are the 2 largest sources of food mass for grizzly bear emerging from the den, we suspect that grizzly bear predation on black bears is uncommon in our study area.

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