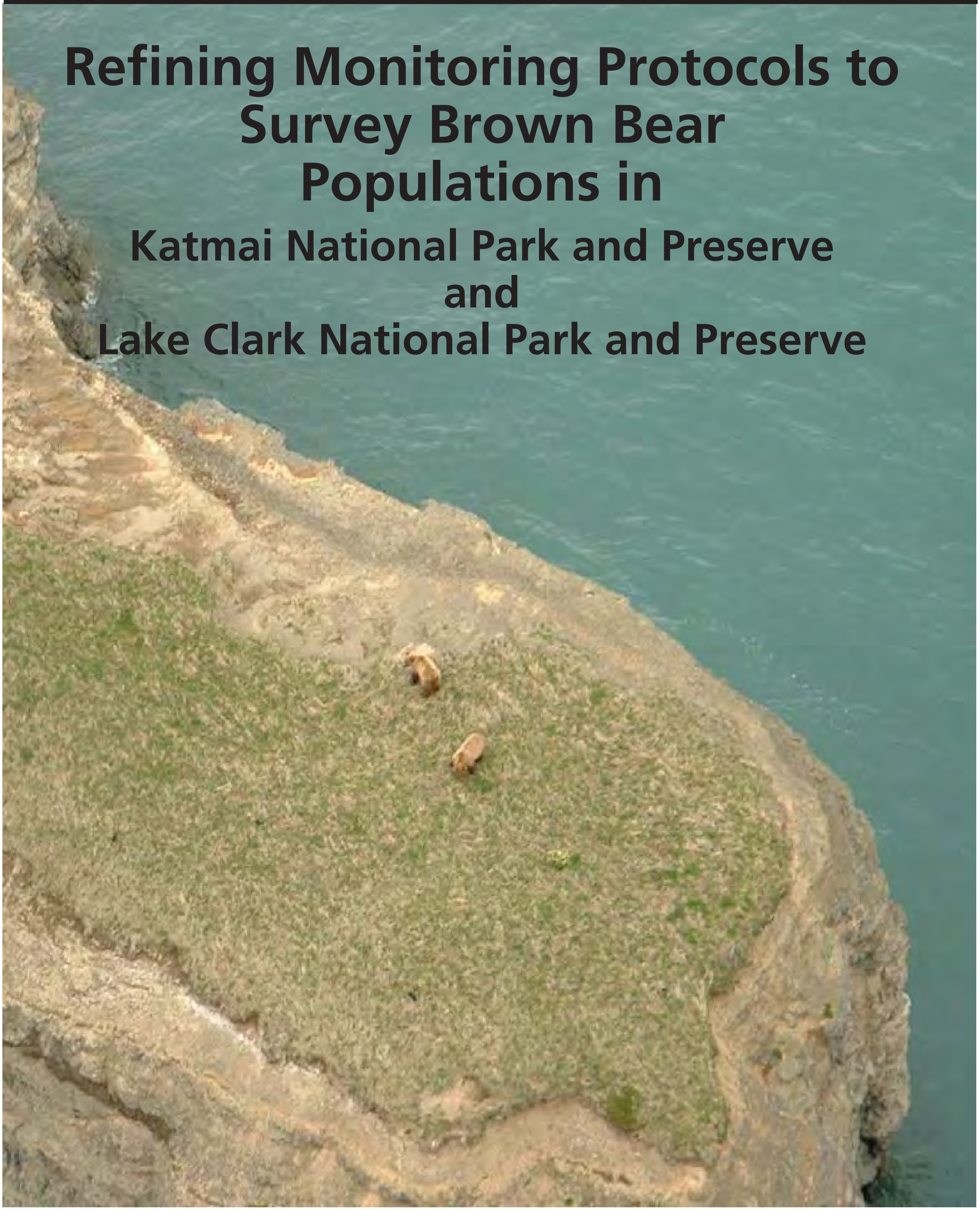
Katmai National Park and Preserve
Lake Clark National Park and Preserve

National Park Service
U.S. Department of the Interior

Refining Monitoring Protocols to Survey Brown Bear Populations in

Katmai National Park and Preserve and Lake Clark National Park and Preserve



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Natural Resources Technical Report NPS/AR/NRTR/2007-66.

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Front Cover: **Two bears observed along an aerial transect flown in Game Management Unit 9A during May 2003. Photo by J. Putera, NPS.**

REFINING MONITORING PROTOCOLS to SURVEY BROWN BEAR POPULATIONS in KATMAI NATIONAL PARK AND PRESERVE and LAKE CLARK NATIONAL PARK AND PRESERVE

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Abstract

Brown bears (Ursus arctos) are a key species in the wilderness ecosystems of Lake Clark National Park and Preserve (LACL) and Katmai National Park and Preserve (KATM) and are a major attraction for wildlife viewers and hunters. Human use pressures on bears are growing and could have long-term effects on brown bear population dynamics. Because of the solitary nature and wide-ranging movements of brown bears, their populations are difficult to monitor. The ability to consistently apply a well-proven survey technique will enable managers to evaluate the effects of management decisions and harvest strategies on brown bears based on accurate population data. We used an aerial line-transect double-count technique developed by the Alaska Department of Fish and Game to derive bear population and density estimates for Game Management Unit (GMU) 9A, which includes the southeast corner of LACL to the north and state land to the south, and GMU 9C, which includes all of KATM and additional state and federal land to the west. In GMU 9A, the brown bear density (± SE) was 150 ± 28 bears/1,000 km² and the black bear (Ursus americanus) density was 85 ± 20 bears/1,000 km², corresponding to estimated population sizes of 703 ± 134 brown bears and 413 ± 62 black bears. The brown bear density in GMU 9C was 124 ± 17 bears/1,000 km², corresponding to an estimated population size of 2,255 ± 306 bears.

Key Words

Alaska, black bear, brown bear, density estimate, Katmai National Park and Preserve, Lake Clark National Park and Preserve, line transect, population estimate, *Ursus americanus*, *Ursus arctos*

Lake Clark National Park and Preserve (LACL) and Katmai National Park and Preserve (KATM) are located at the upper end of the Alaska Peninsula. (Fig. A1). Separated by <80 km, the parks share similar ecosystems and support one of the world's highest density protected populations of brown bears (*Ursus arctos*). Based in part on a capture-mark-resight (CMR) estimate of bear density on the Katmai Coast (Miller et al. 1997), Sellers (2001) estimated that 2,000–2,500 brown bears inhabit federal and state parks on the upper Alaska Peninsula. The parks encompass 25,500 km^2, while the preserves include 5,950 km^2. McNeil River State Game Sanctuary (MRSGS) is located on the northeast boundary of KATM, between the 2 national parks. With no road connections, this entire region is accessible only by air or by boat.

Brown bears are a key species in the subarctic ecosystems of LACL and KATM. The parks' aquatic systems are dominated by enormous salmon (*Oncorhynchus spp.*) runs that are part of the world's largest commercial salmon fishery in Bristol Bay. Brown bears represent an extremely important ecological link to the parks' ecosystems. In addition to their top-down role as a predator that shapes the population dynamics of other animals, bears are a primary conduit moving nutrients from plentiful salmon runs into terrestrial ecosystems via their scats, as well as through salmon carcass remains left behind (Hilderbrand et al. 1999, 2004). Without bears, it is likely that terrestrial systems would look very different for reasons that include: 1) browsing moose (*Alces americanus*) would alter vegetative composition and 2) reduced nutrient input from salmon would result in an overall decline in the rate of productivity.

Katmai National Park and Preserve offers premier bear viewing opportunities at numerous sites throughout the park due to tremendous salmon resources, coastal salt marshes, and other coastal bear food resources that attract seasonal concentrations of bears, as well due to the extent of land within which bears are largely protected. For example, during the peak of the sockeye salmon (*Oncorhynchus nerka*) run and again during the salmon spawning period, 40–>60 bears fish along the 1-mile Brooks River, (T. Olson, KATM, unpublished data). Brooks River is KATM's most popular bear viewing area, with annual visitation that has in recent years exceeded 10,000 visitor days (B. Brock, KATM, unpublished data). This level of visitation contrasts markedly with that of the well-known MRSGS. Strict entry permit requirements at MRSGS have resulted in annual visitation levels of <500 permit days for most years since 1979 (L. Aumiller, ADFG, unpublished report; Aumiller and Matt 1994).

As interest in bears increases, more air taxis and guides are taking increasing numbers of visitors to view seasonal concentrations of bears in the coastal areas of both KATM and LACL. For example, with the addition of a single bear viewing camp in 1997, LACL visitation at a small coastal salt marsh grew from 30 in 1995 to >550 in more recent years (B. Brock, LACL, unpublished data). Three other LACL coastal marshes show similar increases and local residents on both sides of Cook Inlet are strongly promoting this activity. In KATM, bear viewing has been increasing at nearly a dozen sites. Effects of bear viewing, as well as sport fishing, on bear use of aggregation sites have been the subject of several studies in KATM and elsewhere in Alaska (e.g., Olson and Gilbert 1994, Olson et al. 1997, Smith 2002, Tollefson et al. 2005, Rode 2006a,b,c).

The Alaska Peninsula, including Katmai and Lark Clark National Preserves, is also world renowned for sport hunting, producing the highest number of trophy brown bears in North America. During the period of our study (2003–2005), in Game Management Unit (GMU) 9C sport hunting occurred west of Katmai National Park, including in Katmai National Preserve. In GMU 9A, sport hunting occurred south of the Lake Clark National Park boundary and north of MRSGS and associated closures.

In addition to sport hunting, subsistence hunters take bears within LACL. While wildlife enthusiasts travel to the parks to view bears, many local residents believe that bear predation on moose calves diminishes moose availability for hunters. State and Federal game boards annually consider proposals to increase bear harvest within and adjacent to park/preserve boundaries to offset perceived losses. For example, changes approved by the Alaska Board of Game on preserve lands in LACL have included increasing the bag limit from 1 bear every 4 years to 1 bear every year and expanding the season from 3 weeks to 8 months. Also, in 1997 the Federal Subsistence Board established a 9-month hunting season in LACL, and repealed existing sealing requirements. It has been estimated that only 14%–18% of bears harvested by subsistence users are reported (Ballard et al. 1993), therefore it is difficult to ascertain the current subsistence harvest level or its effects.

Although the number of reported ‘Defense of Life and Property’ (DLP) kills in the GMUs encompassing the parks is relatively low, such incidents may contribute an additional unreported kill of at least 50–100 bears annually in GMU 9 (Butler 2005). As the area’s human population grows, the frequency of bear sightings and consequently DLP killings is likely to increase. An additional vulnerability for some segments of the parks’ brown bear populations are their very mobile and wide-ranging movements that can result in some bears traveling from protected areas into hunted ones. For example, 2 young male bears tagged in proximity to Brooks River were later shot near the neighboring communities of King Salmon and Naknek (Troyer 1980).

Brown bears are the most economically and aesthetically valuable wildlife species in Alaska (Miller et al. 1998). Outfitters commonly charge >$15,000 for a guided brown bear hunting trip on the Alaska Peninsula. Overall, it has been estimated that wildlife viewing and hunting in southcentral Alaska directly contributes >$77 million to the local economy, with bears being the most popular species sought by visitors (Matz 2000, based on McCollum and Miller 1994). In fact, Colt and Dugan (2005) found that the bear viewers they surveyed spent about twice as much as the average Alaskan visitor on their Alaska trips. With such high economic incentives, visitor use pressures on brown bear concentrations in the parks are expected to continue to increase.

Because of the solitary nature and wide-ranging movements of brown bears, their populations are difficult and expensive to monitor. In Alaska, previous efforts to estimate bear density have typically involved use of CMR techniques; however, CMR projects are expensive and require intensive field work (Miller et al. 1997). In addition, data inference problems can be a concern because the CMR technique is not designed to estimate population density within large areas such as game management subunits (Miller et al. 1997; Becker 2003).

A relatively recent alternative to the CMR technique for estimating bear density has been developed by E. Becker (ADFG) and Q. Pham (University of Alaska, Fairbanks). The method involves use of an aerial line-transect double-count technique to estimate animal population size at the game management subunit level (Quang and Becker 1996, 1997, 1999; Becker 2001). Survey data, including covariates (e.g., group type, group size, and percent cover, among others) are collected simultaneously by 2 observers on the same sighting platform along transects that follow elevation contours in mountainous terrain. Quang and Becker (1996, 1997, 1999) have progressively developed the line-transect models used to analyze the line-transect double-count survey data (also, see Becker 2001).

Protection of bear populations and their habitat are purposes for which both LACL and KATM were established. The Alaska National Interest Lands Conservation Act (ANILCA 1980) specifically identified these purposes for LACL in the unit's enabling legislation. In addition, ANILCA (1980) identified protection of brown bear habitat and high densities of brown bears and their denning areas as purposes for the expansion of KATM. Protection of brown bear habitat was also identified as a purpose for previous expansions of Katmai's boundaries (Norris 1996). Managers need accurate bear population data to evaluate the effects of management decisions and harvest strategies. Prior to this study, there were no bear population estimates available for LACL, and population information for KATM was limited to extrapolation from a single estimate for a coastal study area of <1,000 km^2 (Miller et al. 1997).

This study reports on our use of the aerial line-transect double-count technique to estimate brown and black bear (*Ursus americanus*) densities in GMU 9A, which includes the southeast corner of LACL to the north and state land to the south, and in GMU 9C, which includes all of KATM as well as additional state and federal land to the west (Fig. A1). In this report we: 1) summarize the results of our survey efforts for GMU 9A and GMU 9C, as well as for LACL- and KATM-specific areas within these GMUs; and 2) document and discuss details regarding the survey methods that may be useful for any future survey efforts.

Study Area

Our study area consisted of the 5,523-km^2 GMU 9A and 20,662-km^2 GMU 9C (Fig. A1; areas included coastal mud flats). Cook Inlet defined the eastern boundary of these two adjacent GMUs. GMU 9A contained the southeast corner of LACL to the north and state land, including MRSGS, to the south. GMU 9C was largely comprised of KATM, with some state lands and federal lands stretching to the west beyond the unit's boundaries. Habitat in GMU 9A and GMU 9C was varied including salt marshes, grass and sedge meadows, shrub thickets, forests, moist lowland tundra, alpine tundra, and snow and ice fields. Salmon streams were numerous throughout much of the study area. Elevations ranged from coastal lowlands to snow-covered mountain peaks of the Aleutian Range that rise >2,134 m from bays along Shelikof Strait. Brown bears were found throughout both GMUs; whereas, black bears occurred only in GMU 9A.

Methods

Survey methods generally followed those of Quang and Becker (1996, 1999) and Becker (2001). A separate survey area boundary was developed for GMU 9A and GMU 9C and all surveys and data analysis were managed separately for each of the 2 areas. Survey area boundaries were primarily based on polygons obtained from the ADFG GMU Arcview® (Environmental Systems Research Institute, Inc. [ESRI], Redlands, California) shapefile (ADFG 1997). However, to include in transect generation coastal mud flat areas that were sometimes used by bears, we modified the coastal portion of the GMU boundary lines to incorporate these areas.

We generated random transects within each study area primarily along elevational contours using a custom Arcview software extension (Strauch 2003a, 2004a; Appendix C). The custom extension also required use of the Arcview Spatial Analyst extension (ESRI, Redlands, California). To generate transects within a survey area, the extension required: 1) a shapefile that contained the survey area boundary polygon and incorporated within that polygon any large lakes to be excluded (we excluded lakes of >4 km^2 [>1,000 acres]); 2) a shapefile containing polygons delineating any large relatively flat areas (we created these by screen-digitizing the areas from 1:250,000 topographic maps); and 3) an elevation grid (we used a subset of the 60-m National Elevation Dataset for Alaska clipped to Alaska [NPS 2003]). For both GMU 9A and GMU 9C we used an elevation cut-off of 914.4 m (3,000 ft) for transect generation. Transect length was 20 km in GMU 9A and 25 km in GMU 9C.

The extension selected random points within the study area below a specified elevation cut-off, then for each point: 1) determined its elevation, 2) interpolated the elevational contour, and 3) used the selected random point as the midpoint to draw a transect of specified length along the contour. Within large areas with little elevational relief, the extension used the random point as the transect midpoint and drew the transect using a random angle. The extension also produced tables that included end point coordinates for each transect generated. Flat coastal areas were typically too narrow to use the angled transect option, so instead we used the random points within these areas as starting points to survey transects paralleling the coastline.

Field Procedures

We conducted surveys for an approximately 10-day period in late May after bears had emerged from dens but prior to significant leaf-out. GMU 9A was primarily surveyed during 2003 and GMU 9C was surveyed during 2004–2005. Surveys were flown daily during the survey period as weather and safety requirements for pilot hours allowed. The maximum number of aircraft used to survey the GMUs simultaneously was 4 in GMU 9A and 5 in GMU 9C.

We used small 2-person aircraft, in which the passenger sits directly behind the pilot, to fly transects about 91 m (300 ft) above ground level. We placed a curtain between the pilot and passenger so that pilot head movement upon sighting a bear would not influence the detection of that bear by the rear passenger. In addition, we installed a light system to signal the sighting of a bear or bear group. The system consisted of 2 small lights, each connected to a switch. We installed the system such that a light was located out of immediate view at each seat and was connected to a switch placed at the opposite seat. By examining the light following a sighting, it could be independently determined whether the other observer had also seen the bear.

Survey data were recorded electronically by the passenger in each survey aircraft using a laptop computer that was connected to a Garmin® 12XL Global Positioning System (GPS) receiver via the computer's serial port (Fig. B1; Appendix D). A custom Arcpad® (ESRI, Redlands, California; 2003 surveys: version 6.0.1; 2004–2005 surveys: version 6.0.3) application (Strauch 2003b, 2004b) was used to automatically record the flight path of the plane at 1-second intervals, and to manually record details for observations and transect lines. For each Arcpad session, data were primarily written to 3 session-specific Arcview shapefiles: 1) a shapefile containing transect-related records and the flight line, 2) a shapefile containing animal sighting records, and 3) a shapefile containing effective sighting distance records (an effective sighting distance location delimited the maximum distance beyond a bear sighting at which a bear could have been detected). A track log (back-up file of flight line coordinates captured at 1-sec intervals) was also recorded to a shapefile. The application allowed the user to set the computer number, which was associated with the data storage directory name, prior to the surveys. In addition, upon starting an Arcpad session the user was able to set observer and pilot names, and those names were retained until manually changed.

To streamline data entry, function keys were pre-programmed to correspond with specific record types (start/end transect, off/on transect, change view side, sighting, effective sighting distance; Appendix D). Transect number and view side could also be set and changed as needed. The application automatically included latitude, longitude, transect number, view side, observer and pilot names, date, and time with each record (Appendix D). Covariate information for sighting records was entered via a custom data entry screen displayed by the application whenever a sighting was marked. Records could also be entered using custom screen-displayed buttons. The Arcpad application provided a real-time moving map display of the flight path and locations of any data records entered superimposed on a 1:250,000 topographic map (Fig. A2).

Each survey team was provided with sets of maps depicting transects to be flown, as well as lists of transect end-point coordinates to assist with locating and navigating transects. Prior to each survey day, pilot-passenger teams coordinated which transects they planned to survey (Fig. B2). Due to weather conditions, further coordination was often necessary once planes were in the field.

To begin recording data, the observer powered up the GPS and laptop, started a new Arcpad session, then set the observer and pilot names. Prior to surveying a transect, the observer entered the transect number and the view side. The start location of the transect was marked when survey of a transect commenced. While on transect, both the pilot and passenger searched for bears by looking out the uphill side of the plane on contour transects (except while in some banking turns in which the downhill side may have been searched) and out the same side (right or left) on angled transects and coastal transects. When an observer saw a potential bear group, he/she turned on a light that was covered but available to be inspected by the other observer. Once the plane passed the potential bear, the observer who spotted the bear examined the other observer's light to determine whether he/she also saw the bear and an announcement was made that a bear was sighted.

When a potential bear or bear group was announced, the plane went off the transect to mark the location of the bear when sighted and the effective sighting distance (Fig. B3, view of a large male brown bear from a survey aircraft). The location where the plane left the transect was marked in the transect data file, as was the location where survey of the transect resumed. A low-level pass was made over the bear (or center of the bear group) to record its location (or if the bear had moved from where it was originally observed, the original location was over-flown and marked instead). Pressing the pre-programmed sighting key captured coordinates for the sighting, then displayed a sighting data entry screen to enter the following covariates: species; group size, type, and activity; percent vegetative cover and percent snow within a 10-m radius around the bear (to the closest 10%; observers were provided with a standardized percent cover diagram for reference [Appendix D, Fig. D4]); who saw the bear group (pilot, passenger, or both); and a 1 to 10 rating by the observer(s) of how repeatable the sighting would be in 10 tries. Sighting information was also noted on a prepared data form. In cases where numerous bears were concentrated in one area, observers sometimes opted to note sighting covariate information on the data form only, in which case this information was later entered into the electronic sightings file. The effective sighting distance was recorded by over-flying the agreed upon edge of the search area and capturing the coordinates using another pre-programmed function key. Sighting and effective sighting distance coordinates were marked by flying parallel to the transect line whenever possible. After the sighting data were recorded, the plane returned to the transect at a point just prior to where it left the transect line. The application tracked the cumulative length of on-transect segments flown for a given transect, and displayed a message when it estimated that the specified transect length was reached.

At the end of each survey day, we transferred the electronic data files from each survey laptop computer to a central data management computer. We then reviewed the electronic data files and corresponding written records and corrected most data entry errors using Arcview software within 24 hours of data collection (Appendix D). We used a relational database to track which transects were completed each day during the survey period and to produce updated transect lists for the survey teams. We also marked completed transects off on poster-sized wall maps after data were reviewed to visually track completion of transects.

Data Analysis

Following the surveys, we used ArcInfo® Geographic Information System (GIS) software (ESRI, Redlands, California; version 8.3) to compile the survey data and to determine: 1) transect lengths, 2) the distance from the transect to each sighting, and 3) the effective sighting distance for each sighting (Appendix E). In addition, we calculated the area surveyed following the methods described by Quang and Becker (1996, 1997, 1999) and Becker (2001) using transect buffers generated by ArcInfo (Appendix E). Data for GMU 9A and GMU 9C were analyzed separately. Analysis followed modeling procedures detailed in the project biometrician's data analysis reports (Quang, 2005a,b) and a series of papers by Quang and Becker (1996, 1997, 1999; also, Becker 2001). Estimates of survey area size used to calculate bear population numbers represented planar areas below 914.4 m (3,000 ft) elevation and also excluded lakes >4 km^2 (1,000 acres).

Results

Game Management Unit 9A

We flew 660 transects during 18–29 May 2003 and 23 transects during 19–30 May 2004, resulting in a total of 683 transects surveyed within GMU 9A (Fig. A3). Due to unexpected early leaf emergence in some low-elevation portions of GMU 9A in 2003, some transects (8% of transects surveyed in 2003) were described by observers as >50% affected by leaf-out. An initial attempt was made in 2004 to resurvey some of the leafed-out transects. However, similar numbers of bear groups per transect were recorded for 13 transects resurveyed in 2004 ($P = 0.33$, Wilcoxon matched-pairs signed-ranks test). In addition, leaf emergence in GMU 9A in 2004 followed a similar pattern to 2003, thus limiting the time period within which we could resurvey transects. Therefore, we decided to include the 2003 transects affected by leaf emergence as part of the dataset analyzed and we discontinued our effort to resurvey them.

Actual length flown per transect averaged 20.0 ± 0.03 (SE) km. Two-hundred-seventy-nine brown bear groups totaling 472 individuals, and 213 black bear groups, totaling 268 individuals, were sighted (Table 1). At least 1 brown or black bear group was observed on 21% (n = 243) of transects surveyed, while both species were observed on only 12% ($n = 30$) of transects. Of transects with bear sightings, 58% had 1 bear group, 20% had 2 groups, and 22% had ≥3 groups. The maximum number of bear groups observed on a single transect was 13 black bear groups (transect was located within the LACL portion of GMU 9A) and 17 brown bear groups (transect was outside the LACL boundary). The number of bear groups seen per transect on each survey day during May 2003 (when most transects were flown) varied and showed no apparent increasing trend that could suggest an appreciable number of bears were still emerging from dens during the survey period (Fig. 1).

Table 1. Population and density estimates (± SE) for brown and black bears in Game Management Unit (GMU) 9A (2003–2004) and GMU 9C (2004–2005), Alaska, as well as for within the boundaries of Lake Clark National Park and Preserve (LACL) and Katmai National Park and Preserve (KATM) within these 2 GMUs.

	GMU 9A		GMU 9C	
	GMU 9A[a]	LACL subarea[b]	GMU 9C[c]	KATM subarea[b]
Total transect length surveyed (km)	13,636	6,997	18,507	14,399
Total transect area surveyed (km^2)	7,380	3,846	13,848	10,657
Brown bear				
Groups	279	113	421	413
Individuals	472	208	674	657
Population estimate	703 ± 134	466 ± 232	2,255 ± 306	2,183 ± 379
Density (bears/1,000 km²)	150 ± 28	147 ±72	124 ± 17	156 ± 21
Black Bear				
Groups	213	165		
Individuals	268	208		
Population estimate	413 ± 62	302 ± 132		
Density (bears/1,000 km²)	85 ± 20	136 ± 60		

[a]Although survey crews made an effort to survey 20-km transects in GMU 9A, there was some minor variability in actual length (km) surveyed per transect ($\overline{x}$ = 20.0, SE = 0.03, *n* = 683).
[b]Transects that extended beyond the subarea boundary were clipped to within the subarea for analysis.
[c]Although survey crews made an effort to survey 25-km transects in GMU 9C, there was some minor variability in actual length (km) surveyed per transect ($\overline{x}$ = 24.8, SE = 0.04 *n* = 746).

Table 2. Characteristics of black bear and brown bear group sightings recorded during aerial transect surveys in Game Management Unit (GMU) 9A (2003–2004) and GMU 9C (2004–2005), Alaska.

	GMU 9A				GMU 9C	
	Brown bear groups		Black bear groups		Brown bear groups	
	n	%	*n*	%	*n*	%
Observer						
Pilot	65	23	70	33	120	28
Observer	42	15	26	12	67	16
Both	172	62	117	55	234	56
Group size						
1	152	55	174	82	267	63
2	72	26	24	11	80	19
3	45	16	14	7	51	12
4	9	3	1	0	21	5
5	1	0	0	0	2	1
Activity						
Feed	56	20	53	25	55	13
Stand	86	31	74	35	100	24
Sit	28	10	2	0	39	9
Bedded	31	11	36	17	87	21
Walk	71	25	48	23	125	30
Run	7	3	0	0	15	3
Percent Cover						
0	203	73	67	31	284	67
10–50	68	24	115	54	129	31
60–90	8	3	31	15	7	2
100	0	0	0	0	1	0
Percent Snow						
0	247	89	204	96	324	77
10–50	8	3	4	2	32	7
60–90	9	3	3	1	25	6
100	15	5	2	1	40	10

Of all bear groups observed, 135, 68, and 289 groups were sighted respectively by the pilot alone, by the passenger alone, and by both observers (Table 2). Seventy-three percent of brown bear groups were unobstructed by vegetative cover, in contrast to 31% of black bears groups (Table 2). Most groups of both species (89% of brown bears and 96% of black bears) were observed in areas lacking snow cover (Table 2). The percentage of bear groups classified as families was 26% for brown bears (43% of brown bears observed) and 16% for black bears (32% of black bears observed; Table 3). The number of independent brown bears seen with yearlings (n = 29) or older offspring (n = 36) was substantially higher than the number seen with spring cubs (n = 8).

Detection distances between 22 m, representing the edge of the blind strip, and 600m were used in the model for GMU 9A (refer to Quang [2005a] for additional details regarding GMU 9A data analysis). To reduce the number of covariates in the model, group types were combined into 1) female with young; 2) unknown adult, large male, or subadult; and 3) breeding pair. Similarly, activity types were reduced to 1) standing; 2) walking; 3) sitting or bedded; and 4) feeding or running. The best-fit model used the covariates logarithm of effective sighting distance (which was an estimate of horizon openness each time a group was detected), group size, group type, and activity. The logarithm of effective sighting distance was highly significant for the pilot and observer in detecting both black and brown bears, and was the only significant variable for detecting black bears (detection functions were assumed to be the same for all pilots and all observers, but detection functions of pilots and observers were allowed to differ; in discussing the models, we refer to the pilots and the observers in the singular). Bear detection increased with increasing values of effective sighting distance. Sitting or bedded brown bears were significantly

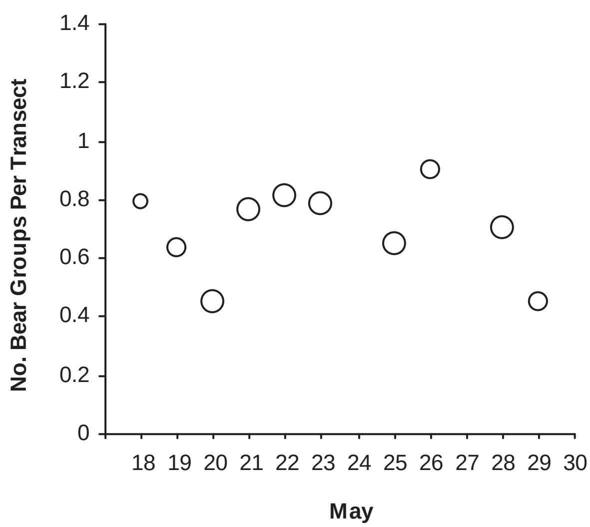

Figure 1. Bear groups per transect seen on each survey day during May 2003 in Game Management Unit 9A, Alaska. Graduated circle sizes indicate the relative number of 20-km transects flown on each day (range: 34 to 82).

more difficult for both the pilot and observer to detect. The observer also detected significantly fewer feeding or running brown bears than did the pilot. Although group size, group type, and most activity types were not significant, they were retained in the model to improve optimization. However, as values for the covariates group size and type did not influence bear detection, they were good estimates of the population percentages. Both the pilot and observer achieved 100% detection at some distance from the transect line, except in the case where the observer only achieved 82% detection of black bears.

Based on the model, bear density estimates in GMU 9A were 150 ± 28 (SE) brown bears and 85 ± 20 black bears/1,000 km^2, and corresponding bear population estimates were 703 ± 134 brown bears and 413 ± 62 black bears (approximate GMU 9A survey area size 4,677 km^2; Table 1). A separate analysis was run to determine bear densities within the LACL portion of GMU 9A (Fig. A1). Three hundred sixty-five transects with 113 brown bear groups (208 individuals) and 165 black bear groups (208 individuals) were included in this analysis (Table 1). Bear density estimates for the LACL subarea of GMU 9A were 147 ± 72 brown bears and 136 ± 60 black bears/1,000 km^2, corresponding to 466 ± 232 brown bears and 302 ± 132 black bears (approximate survey area size was 2,214 km^2; Table 1).

Game Management Unit 9C

We flew 295 transects during 21–30 May 2004 and 451 transects during 16–26 May 2005, resulting in a total of 746 transects surveyed in GMU 9C (Fig. A4). Actual length flown per transect averaged 24.8 ± 0.04 (SE) km. Four-hundred-twenty-one brown bear groups, totaling 674 individuals, were sighted (Table 1). Black bears were not observed in GMU 9C.

At least 1 brown bear group was observed on 30% (n = 227) of the transects surveyed. Of transects with bear sightings 62% had 1 bear group, 19% had 2 bear groups, and 19% had ≥3 bear groups. The maximum number of bear groups recorded on a single transect was 13 (a coastal transect). Relatively few bear groups (8 of 421 groups) were seen on transects west of the KATM boundary. The number of bear groups seen per transect on each survey day in 2004 and 2005 showed no apparent increasing trends that could suggest appreciable numbers of bears were still emerging from dens during the survey periods (Fig. 2).

Table 3. Age-sex composition of black bear and brown bear groups recorded during aerial transect surveys in Game Management Unit 9A (2003–2004), Alaska.

	Brown bears				Black bears			
	Groups		Animals		Groups		Animals	
Group type	*n*	%	*n*	%	*n*	%	*n*	%
Unknown adult	85	30	91	19	132	62	135	50
Large male	55	20	60	13	39	18	39	15
Breeding pair	41	15	84	18	2	1	4	1
Subadult	25	9	31	7	6	3	6	2
Female/cubs	8	3	26	5	15	7	39	15
Female/yearlings	29	10	79	17	18	9	42	16
Female/>yearlings	36	13	101	21	1	0	3	1

Of all bear groups observed, 120, 67, and 234 groups were sighted respectively by the pilot alone, by the passenger alone, and by both observers (Table 2). Sixty-seven percent of bear groups were 50% unobstructed by vegetative cover while 31 % were observed in vegetative cover ranging from 10–50% (Table 2). Most groups (77%) were observed in areas lacking snow cover (Table 2). Twenty-six percent of groups were classified as families (47% of bears observed [adjusted to account for the 5 males that were following females with offspring older than yearlings]; Table 4). The number of independent bears seen with yearlings (n = 50) or older offspring (n = 41)) was substantially higher than the number seen with spring cubs (n = 20).

Detection distances between 22 m, representing the edge of the blind strip, and 800m, representing 95% of all detected distances, were used in the model (refer to Quang [2005b] for additional details regarding GMU 9C data analysis). The best fit model used only the covariate logarithm of effective sighting distance. Bear detection increased with increasing values of effective sighting distance. For GMU 9C, only the pilot achieved 100% detection at some distance from the transect line. The observer achieved 97% detection of brown bear groups and tended to search closer to the transect line than the pilot. For the KATM subarea of GMU 9C, both the pilot and observer achieved 100% detection at some distance from the transect line. Values for the covariates group size, type, and activity did not influence bear detection and were thus good estimates of the population percentages.

Based on the model, brown bear density in GMU 9C was estimated at 124 ± 17 (SE) bears/1,000 km^2, and the corresponding population estimate was 2,255 ± 306 brown bears (approximate GMU 9C survey area size was 18,150 km^2; Table 1). A separate analysis was run to determine the brown bear density

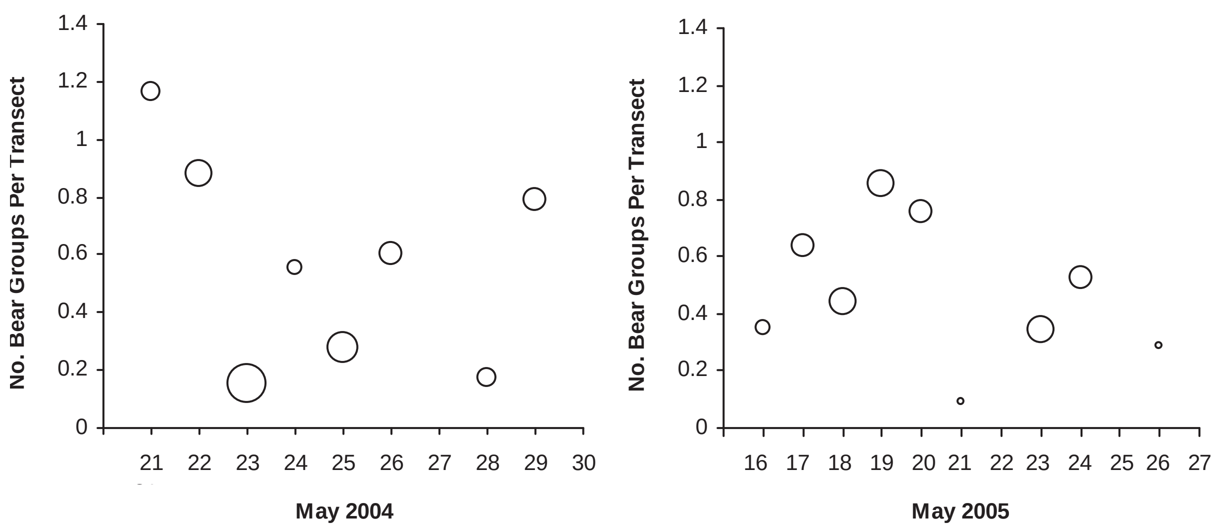

Figure 2. Bear groups per transect seen on each survey day during May 2004 and May 2005 in Game Management Unit 9C, Alaska. Graduated circle sizes indicate the relative number of 25-km transects flown on each day (2004 range: 9 to 60; 2005 range: 7 to 72).

within the KATM portion of GMU 9C. Six hundred thirty-nine transects with 413 brown bear groups (657 individuals) were included in this analysis. The brown bear density estimate for KATM was 156 ± 21 bears/1,000 km², corresponding to 2,183 ± 379 (SE) brown bears (survey area = 14,031 km^2; Table 1).

Discussion

Sellers et al. (1999) reported for a study conducted on the KATM coast that survival of brown bear dependent offspring improved markedly with age. However, the relative age composition of brown bear family groups seen during our surveys in both GMU 9A and GMU 9C showed the opposite pattern, with few sightings of females with cubs of the year and substantially more sightings of females with older offspring. Spring cubs were likely harder to detect due their small size and also because these family groups can be quite reclusive. Some females with spring cubs may also have been missed due to their tendency toward later den emergence relative to other bears (e.g., KATM, unpublished data). Yet, the number of bear groups seen per transect did not appear to increase across survey days in either GMU 9A or GMU 9C, providing some evidence that late den emergence of bears in general was not a widespread problem relative to the timing of our surveys.

Testing and refinement of the aerial double-count line-transect method used in this study has produced density estimates for several study areas on the Alaska Peninsula, as well as for a few other game management subunits in Alaska. In the LACL portion of GMU 9B (a non-coastal area) black bear density was estimated at 77 bears/1,000 km^2 and brown bear density was estimated at 39 bears/1,000 km^2 (E. Becker, ADFG, personal communication). In GMU 9D, which includes the southern portion of the Alaska Peninsula from Port Moller to Cold Bay, brown bear density was estimated at 171 bears/1,000 km^2, and in GMU 10, which extends from False Pass through the Aleutian Islands, brown bear density was estimated at 102 bears/1,000 km^2 (E. Becker, ADFG, personal communication). Lower densities were documented to the north in interior Alaska, with 17 grizzly bears/1,000 km^2 estimated in Gates of the Arctic National Park and 40 grizzlies/1,000 km^2 estimated in Togiak National Wildlife Refuge (Walsh et al. 2006).

Table 4. Age-sex composition of brown bear groups recorded during aerial transects in Game Management Unit 9C (2004–2005), Alaska.

	Groups		Animals	
Group type	*n*	%	*n*	%
Unknown adult	133	31	138	20
Large male	108	26	108	16
Breeding pair	37	9	72	11
Subadult	32	8	37	5
Female/cubs	20	5	56	8
Female/yearlings	50	12	141	21
Female/>yearlings	36	8	103	15
Female/>yearlingsBreed[a]	5	1	19	3

[a]This additional group type, defined as a female accompanied by offspring older than yearlings and by an adult male, was added during surveys.

Although our brown bear density estimates for GMU 9A and GMU 9C appeared to be within the general range of what would be expected for areas with coastal habitat and salmon runs, our KATM-specific density estimate (156 bears/1,000 km^2) was lower than the 551 bears/1,000 km^2 (95% CI: 450–694) reported by Miller et al. (1997) for coastal KATM (using the CMR technique). This difference was not unexpected because the Miller et al. (1997) search area was restricted to a limited area (901 km^2; about 6% of bear habitat below 914.4 m [3,000 ft] elevation in KATM) of prime coastal bear habitat where spring bear feeding aggregations were relatively common, in contrast to our survey area which was much larger and encompassed a broader range of habitats. Conversely, our KATM population estimate of 1,804–2,562 bears was somewhat higher than the 1,500–2,000 bears estimated by Sellers et al. (1999). But it was again difficult to directly compare the results of the 2 studies because the estimate of Sellers et al. (1999) was based on extrapolation from the CMR density estimate and also relied heavily upon subjective impression of relative habitat quality.

The National Park Service Southwest Alaska Network Inventory and Monitoring Program has determined that brown bears are an essential vital sign to monitor (Bennett et al. 2006). A draft monitoring protocol for brown bears has been completed which calls for data on abundance and distribution of brown bears to be obtained using the aerial line-transect double-count technique detailed in this report at 5- to 10-year intervals and for the data to be analyzed to estimate trends. Requirements for conducting future surveys are identified in the draft protocol. These include involvement of a data manager with advanced GIS knowledge and experience, and substantial investment in pre-survey planning and preparations for field work that involves considerable logistics. In addition, analysis of survey data requires either the involvement of a statistician (as was the case for our surveys) or of someone with advanced knowledge and experience with the statistical modeling procedures.

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Appendix A

Maps

Figure A1. Game Management Unit 9A and 9C survey area boundaries for 2003-2005 aerial surveys.

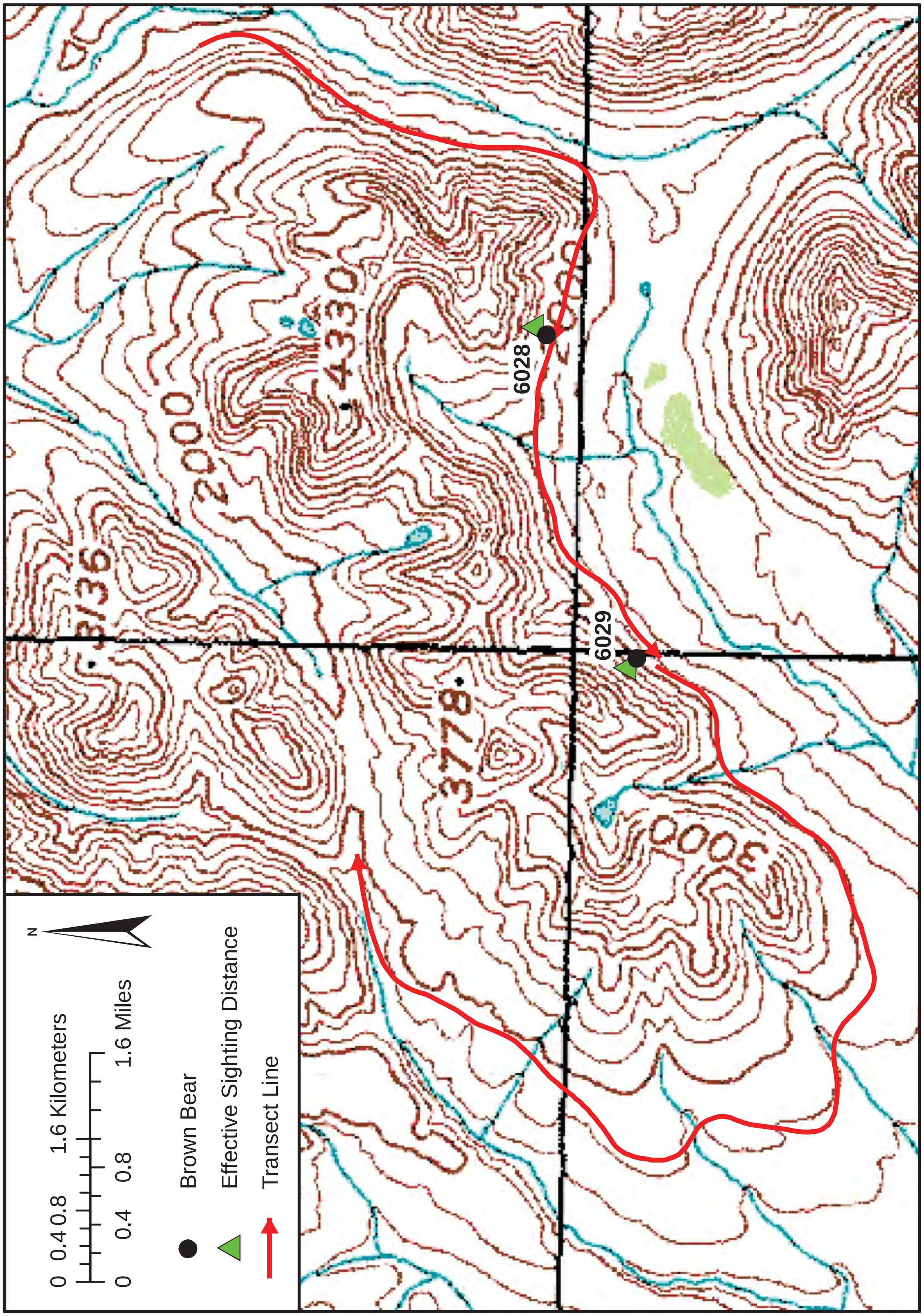

Figure A2. A contour transect with 2 bear sightings and their corresponding effective sighting distances and sighting numbers.

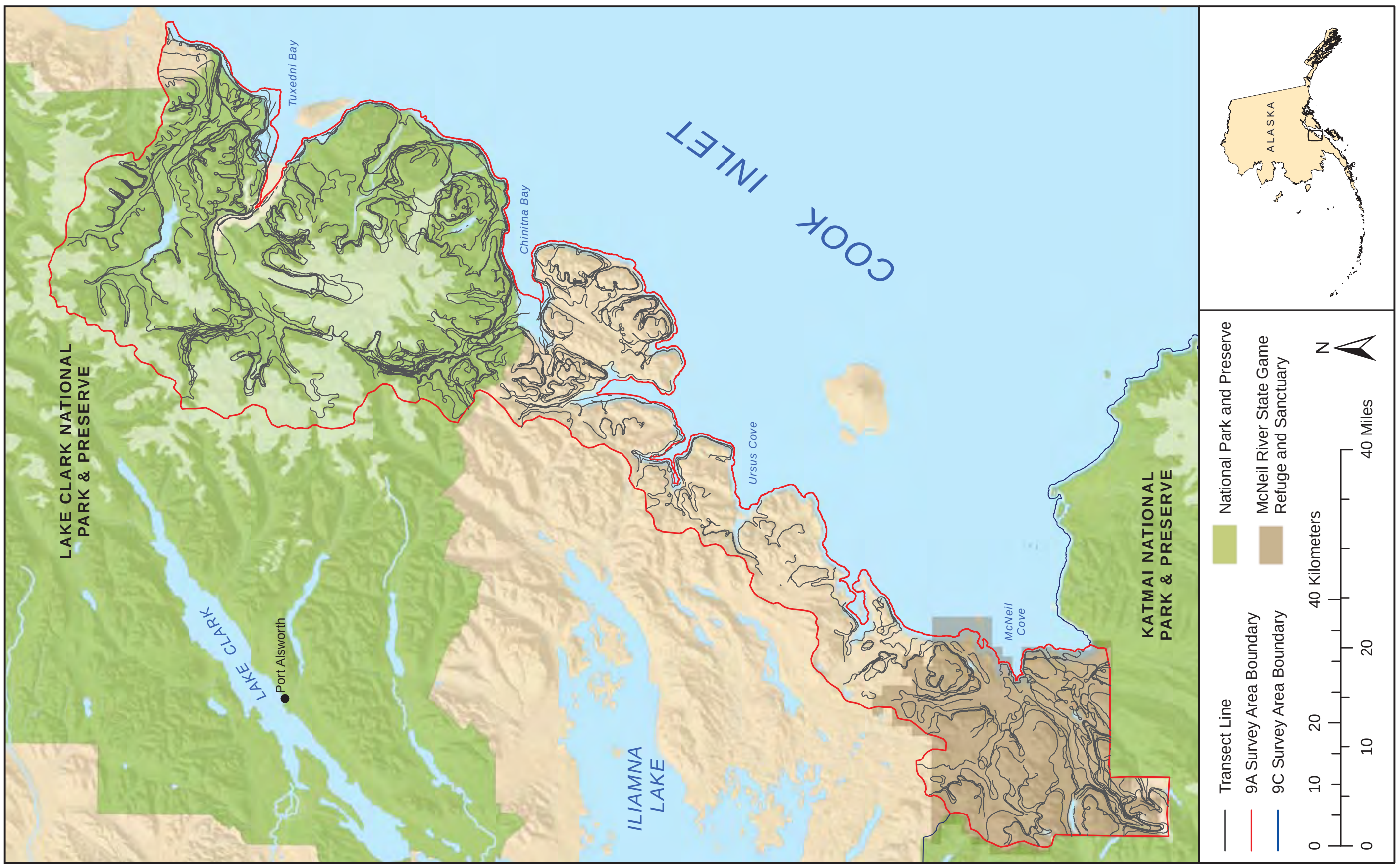

Figure A3. Transects (20-km) flown within the Game Management Unit 9A survey area, 2003-2004.

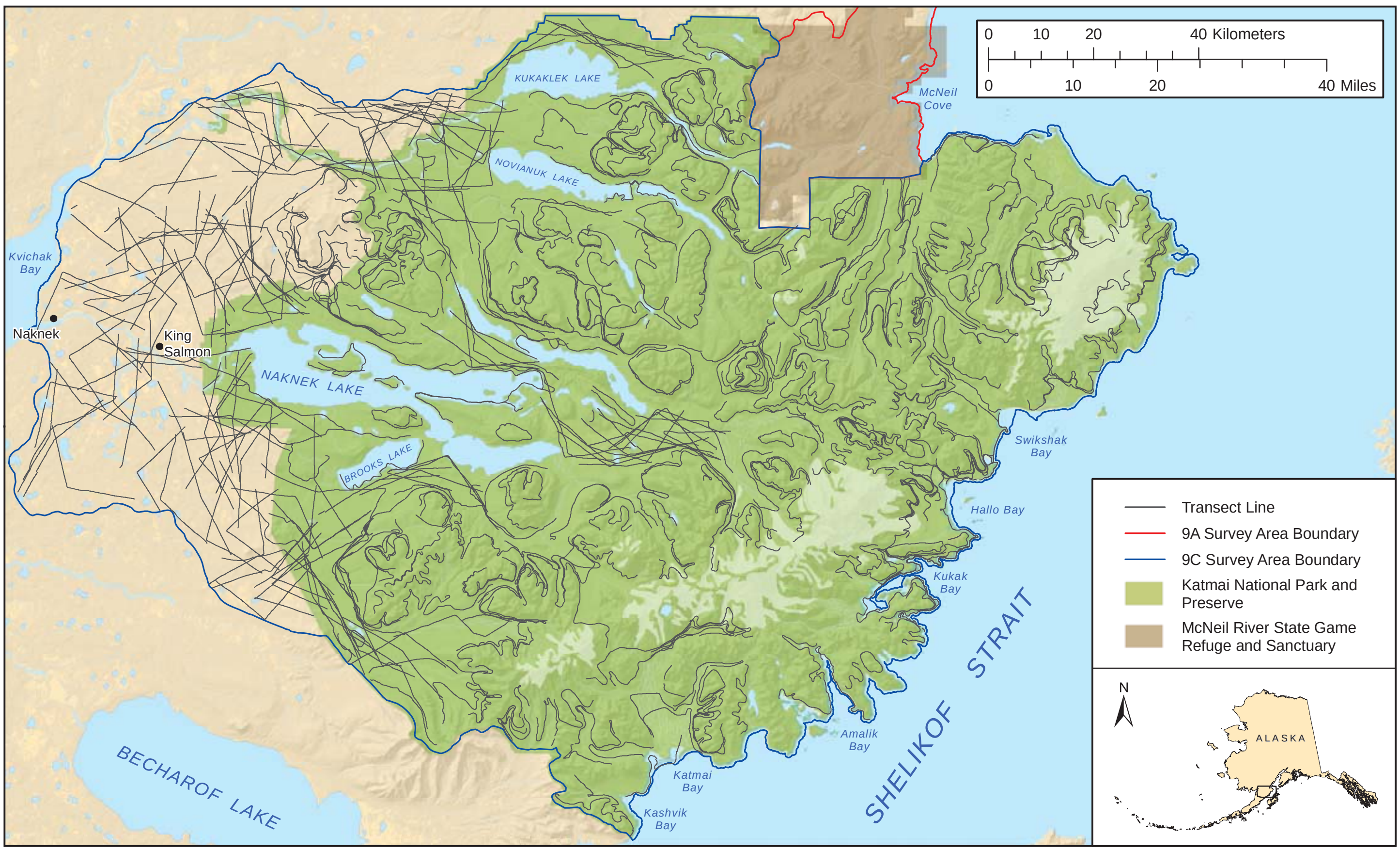

Figure A4. Transects (25-km) flown within the Game Management Unit 9C survey area, 2004-2005.

Appendix B

Images

Figure B1. Observer (J. Irvine) with survey laptop set up, May 2005, Game Management Unit 9C, Alaska.

Figure B2. Observers coordinating transects to be flown, May 2005, Game Management Unit 9C, Alaska.

Figure B3. View of a large male brown bear from a survey aircraft, May 2003, Game Management Unit 9A, Alaska.

Appendix C

Survey Preparation

C.1 GIS Survey Preparation Process: Overview

a. We developed Arcview (using version 3.2a) shapefiles containing survey area boundary polygons for GMU 9A and GMU 9C by editing polygons taken from ADFG's 1:250,000 ArcInfo coverage of game management unit boundaries (ADFG 1997). Editing primarily involved modifying coastal areas of the GMU polygons to incorporate potential salt marshes and mud flats. We also developed a shapefile for each survey area that delineated any large flat areas (within which straight or angled transects would be developed rather than transects drawn along elevation contours).
b. We determined transect length based to some degree on the dimensions of the survey areas and on how many aircraft were expected to survey transects. For survey area GMU 9A, transect length was 20 km and for survey area GMU 9C, transect length was 25-km.
c. We obtained elevation grids for the survey. Based primarily on consultation with the ADFG area biologist (R. Sellers, ADFG, personal communication), for both GMU 9A and 9C we selected an elevation cut-off for transect generation of 914.4 m (3,000 ft).
d. We used an Arcview software extension (named "ADFG-Bear Trans" within Arcview; Strauch 2003a, 2004a) to generate random transects in sets of 100. The extension first created a set of random points, then the random points were used as the "seed points" to plot transects.
e. We inspected any random points skipped during transect generation and included any points that were skipped due to local topography (for example, coastlines and some rivers) as start points for additional transects to be flown. Random points that were skipped during transect generation, were plotted to verify that skipped points resulted due to reasons such as too little area available at the elevation to create a line.
f. We subdivided the survey areas into a workable number of Arcview view extents to produce survey maps of transects sets in 11-by-17-inch format. For each transect set, we also developed a poster-sized 34-by-44-inch layout. Multiple copies of the maps were printed prior to the surveys. Transect lists that included end point coordinates and elevation were also formatted and printed (in addition, in 2005 waypoint files were produced to upload transect end point coordinates to aircraft GPS receivers).
g. We tested Arcpad (2003: version 6.0.1; 2004–2005: version 6.0.3) software customizations to record survey data and other related system settings on a laptop computer prior to conducting surveys. To facilitate set-up of survey computers, notes on customizations and any custom files used were compiled on a compact disk.
h. A note about organization of digital survey files. Because the ArcInfo macros provided by ADFG to compile and analyze the survey data assumed a specific project directory naming format (as ***_projectnameyy***, where ***projectname*** = survey area name, and ***yy*** = last 2 digits of survey year) and organization of files at the root-level, survey files we organized survey files primarily by following these naming conventions (Primary project directories were named: "C:_lacl9a03", "C:\lacl9a04", "C:_katm9c04", and "C:_katm9c05").

C.2 GIS Development of Transects

C.2.1 GIS Data Input

The Arcview transect generation software extension (named "ADFG-Bear Trans" within the software; Strauch 2003a, 2004a) required that input shapefiles and elevation grids were in decimal degrees. To create transects for a given survey area, the ADFG-Bear Trans extension required a survey area boundary shapefile (polygon), a flat areas shapefile (polygon), and an elevation grid, The names and storage locations for these files for GMU 9A and GMU 9C were:

a. Survey Area GMU 9A:
    - Survey area shapefile ("C:_lacl9a03\surveyprep\gis\themes\sa9a.shp"; illustrated in Fig. A1): The survey area shapefile was developed by working from the GMU 9A 1:250,000 boundary polygon (ADFG 1997). Higher resolution coastline was incorporated into the boundary polygon (1:63,360

scale; Alaska Department of Natural Resources 1998); then the coast line of the polygon was buffered by 500 m. Additional editing of the coastline was then done to incorporate potential mud flats and salt marshes (Tande 1996; National Oceanic and Atmospheric Administration [NOAA] 2002) also, based on referencing aerial photos). Lakes > 4km^2 (>1,000 acres) in size were incorporated into the survey area polygon as internal polygons ("donut holes") so that these lakes were excluded from the survey area during transect generation. These lakes were obtained from 1:63,360 hydrography data (U.S. Geological Survey 1999, NPS 2001).

- Flat area shapefile ("C:_lacl9a03\surveyprep\gis\themes\flat9a.shp"): There were no extensive flat areas within GMU 9A, so a file containing a simply polygon outside the survey area was used (so that the ADFG-Bear Trans extension skipped generating straight transects within flat areas).
- Elevation grid ("C:_lacl9a03\surveyprep\gis\grids\9aned_rm"): The elevation grid for GMU 9A was clipped from the 60-m National Elevation Dataset (NED) for Alaska clipped to Alaska (NPS 2003). Null grid cell values were recalculated as zeroes (also, because the initial version of the ADFG-Bear Trans extension assumed grid units were meters, the grid units were converted from meters to feet).

b. Survey Area GMU 9C:

- Survey area shapefile ("C:_katm9c04\surveyprep\gis\themes\sa9c_g27.shp"; illustrated in Fig. A1): The survey area shapefile was developed by working from the GMU 9A 1:250,000 boundary polygon (ADFG 1997). Higher resolution coastline was incorporated into the boundary polygon (1:63,360 scale; Alaska Department of Natural Resources 1998); then the coast line of the polygon was buffered by 500 m. Additional editing of the coastline was then done to incorporate potential mud flats and salt marshes (NOAA 1998; also based on referencing aerial photos). Lakes > 4km^2 (>1,000 acres) in size were incorporated into the survey area polygon as internal polygons ("donut holes") so that these lakes were excluded from the survey area during transect generation (a 25-m internal buffer was first applied to the lakes and the buffers were merged with the lake polygons so that lake shorelines were included during transect generation). These lakes were obtained from 1:63,360 hydrography data (NPS 2001).
- Flat area shapefile ("C:_katm9c04\surveyprep\gis\themes\sa9cflat.shp"): Flat areas within GMU 9C were delineated by screen-digitizing polygons using 1:250,000 digital topographic maps.
- Elevation grid ("C:_katm9c04\surveyprep\gis\grids\9cned_rm"): The elevation grid for GMU 9C was clipped from the 60-m National Elevation Dataset (NED) for Alaska clipped to Alaska (NPS 2003). Null grid cell values were recalculated as zeroes (also, because the initial version of the ADFG-Bear Trans extension assumed grid units were meters, the grid units were converted from meters to feet).

C.2.2 Generation of Random Transects within a Survey Area: Use of the Arcview ADFG-Bear Trans Extension

a. The survey area shapefile, the flat area shapefile, and the elevation grid (Spatial Analyst Arcview software extension loaded) were added to a new view in Arcview; the view projection was set to Albers (or could be set to whatever projection the grid is stored in); and the ADFG-Bear Trans extension was loaded (Fig. C1).

b. To produce shapefiles of random points from which transects were created (random points were generally used by the ADFG-Bear Trans extension as transect center points), with the survey area shapefile active, the "Create Random Points" option was selected from the ADFG-Bear Trans extension menu (or via a corresponding button available on the view's button bars; Fig. C1). Input files required for this step included the survey area boundary shapefile and an elevation grid. B. Strauch (ADF&G, personal communication) suggested that it was preferable to spread out the generation of point sets in time somewhat because the computer time was used as part of the randomization function in Arcview. Information provided by the user in response to prompts displayed by the "Create Random Points" option included:

- The number of sites per point set (the default and suggested value was 100; we used 125 to generate some extra points in case that some points were skipped during transect generation), maximum elevation (specified as 3,000 ft for this project).
- Units of the elevation grid input (feet or meters; this option was a recent addition to the ADFG-Bear Trans extension).
- The point series starting identification number (for example, a point series numbered 1 resulted in random points numbered beginning with 100).
- The user was also prompted to provide a name for the output shapefile (for GMU 9A and 9C the files were named "sa9a_points***n***.shp" and "sa9c_points***n***.shp" respectively, where ***n*** = point set number).

c. To produce transect shapefiles from the random points shapefiles, with the random point shapefile of interest active, the "Create Contour Transects" option was selected from the ADF&G Bear Trans extension menu (or via a corresponding button available on the view's button bars; Fig. C1). Input files required for this step included a random points shapefile, the survey area shapefile, a flat areas shapefile, and an elevation grid. Information provided by the user in response to prompts displayed by the "Create Contour Transects" option included:
   - The length in meters of transects to be created (GMU 9A = 20 km, GMU 9C = 25 km).
   - The type of straight transects to be created within flat areas (single straight lines or angled lines ["hinged']).
   - The names of the grid, survey area boundary shapefile, and flat area shapefile to be used.
   - Also, after transects were created the user was prompted to provide a name for the output shapefile (for GMU 9A the files were named "sa9a_trans***n***_20.shp", where ***n*** = transect set number; and for GMU 9C the files were named "sa9c_trans***n***_25.shp", where ***n*** = transect set number).

   After transects were created and before the user was prompted to name the output file, the extension displayed information regarding any points that were skipped (the brief coded explanations were not entirely accurate regarding the reason a point was skipped, but provided some basic information that guided further review of skipped points). Very occasionally while running the "Create Contour Transects" option the program halted and displayed an "array error" message. This error was consistently reproduced whenever a random points shapefile that was originally associated with such a message was used. A work-around addressed this problem. In the few cases where the error occurred, the random points shapefile was processed using the "Create Contour Transects" option on subsets of the points to ultimately identify which specific point was associated with the error. Then, that specific point was moved a very small distance, which consistently resulted in elimination of further error messages when the "Create Contour Transects" option was run.

d. A note regarding transect numbering. The ADFG-Bear Trans extension assigned transect numbers successively as transects were generated, beginning with the first random point number. Because some points were skipped, ultimately transects created later within a set tended to be assigned transect numbers that differed from their corresponding random point numbers. Also, in cases where the transect created was >5 km less than the requested length (20 km for 9A and 25 km 9C), the transect number included an "A" at the end, for example 123A, which indicated that the survey team needed to find similar nearby terrain to complete the total length of transect line to be surveyed.

C.2.3 Generation of Random Transects within a Survey Area: Additional Processing Steps Necessary to Produce Final Transect Sets

a. The skipped points lists displayed during transect generation (see C.2.2) were printed, and all skipped points were then examined to verify that each point was skipped due to obvious reasons such as too little area available at the elevation to generate a contour transect line. We maintained notes regarding the apparent reason each point was skipped. Streams and coastlines are examples of areas where no line was sometimes drawn due to lack of local elevational relief. Coastal points and points in some areas that had little coverage across all transects sets were included as additional transects (the points were used as starting points). We stored points retained as part of the final transect sets in separate shapefiles (for GMU 9A and GMU 9C named as "sa9a_tran***n***_add.shp" and "sa9c_tran***n***_add.shp" respectively, where ***n*** = point set number).

b. On occasion the program generated transects that were split at the edge of the survey area, resulting in one part of the transect mapped at an edge of the survey area, and other portion(s) mapped at some other location(s) along the edge of the survey area. In those cases, the longest transect segment was labeled as the transect to be flown; but we examined any other segments to determine whether to also include them with different transect numbers. We only included shorter segments as additional transects if coverage of an area in which a short segment was drawn appeared otherwise limited.

c. Transect numbering was primarily based on the numbers assigned by the ADFG-Bear Trans extension. In addition, we adopted a numbering format to number some skipped points to be flown as transects, to number parts of split transects that were included as distinct separate transects, and to potentially number any transect lines unintentionally flown a second time during the field surveys:
   - Transects flown based on skipped points: 8***nnn***, where ***nnn*** was the original point number.
   - Split transect segments: Typically the longer part of the split transect was flown, and the other fragment was not (splits sometimes occurred near the edges of the survey area). However, when it appeared that an area would not receive much coverage if shorter split part were disregarded, some of those shorter segments were included. They were numbered as 9***nnn***, where ***nnn*** was the original transect number associated with the longer segment.
   - Any duplication of transects: If a line was flown twice by accident, it was numbered 9***nnn***, where ***nnn*** was the original transect number.

d. Any points and transect fragments that were identified as transects to be flown had to be added to the transect lists that were prepared for survey crews from the transect shapefile attribute table. Attribute information for these records were obtained from the random points shapefiles and the transect shapefiles.

C.3 Production of Hardcopy Survey Maps, Transect Lists, and Waypoint Files

We produced printed maps for use during the surveys, as well as to track survey progress during the field surveys. Survey flight maps printed on 11-by-17-inch paper were fairly workable for use in the confined interior space of the survey aircraft. The survey area was subdivided into a workable number of Arcview map extents (with a bit of overlap) to produce survey maps in 11-by-17-inch for each transect set (GMU 9A: 6 map extents; GMU 9C: 7 map extents). For each transect set, a poster-sized wall map layout was also produced.

C.3.1 Production of Hardcopy Survey Maps

a. For each transect set, in Arcview we created a set of 11-by-17-inch map layouts for the survey area sub-extents (see Fig. C2 for an example of a map layout), as well as a 34-by-44-inch map layout of the entire study area using the following general steps:
   - Loaded the transect shapefile, any random points to be included (shapefile), and background topographic maps (MrSID) into a view (a separate Arcview project was used for each map set).
   - Auto-labeled transects and any points, then adjusted those labels to make all labels legible.
   - Depicted subsets of transect lines with different colors to make overlapping lines easier to see (legend files were saved to help automate this formatting; see Fig. C2 for survey map example)
   - Added the survey area shapefile to the view and displayed the boundary polygon using an easily visible line style (see Fig. C2 example)
   - Created an 11-by-17-inch map layout was for each corresponding view extent.
   - Created a 34-by-44-inch poster-sized map layout depicting the full survey area and all transects within the same project as the larger-scale layouts.

- Saved the Arcview map project using the standard names sa9a_maps***n***.apr and sa9c_maps***n***.apr for GMU 9A and GMU 9C respectively, were ***n*** = map set number (based on transect set number).
- Exported each map layout to a postscript file (postscript-new, DPI setting = 720). Exported 11-by-17-inch map files for GMU 9A and GMU 9C were named “sa9a_set***n***_sub***s***.eps” and “sa9c_set***n***_sub***s***.eps” respectively, where ***n*** = transect set number and ***s*** = view extent number (consistent numbering was used for each of the several view extents for each survey area). Exported 34-by-44-inch layouts for GMU 9A and GMU 9C were named “sa9a_set***n***_full.eps” and “sa9c_set***n***_full.eps”, were ***n*** = transect set number.

b. We ran Arcpress (ESRI, Version 2.0, 1997) from the DOS command prompt via a batch file to convert the exported postscript files to a file format suitable for printing/plotting (11-by-17-inch postscript files were exported to printer control language [PCL] files and 34-by-44-inch files were exported to raster transfer language [RTL] files).

c. We prepared any second survey year maps to compile together incomplete transect sets from the previous year were in 11-by-17-inch format only. These maps were produced and exported similar to other maps of the same size as described above.

d. Bulk printing of 11-by-17-inch maps was accomplished using batch files to send the PCL files to a printer. We included pauses periodically in the command string so that printer status could be monitored and printer cartridges could be replaced as needed. We determined the number of copies needed for surveys based upon the number of aircraft, as well as observer preference (some survey teams preferred to have 2 sets of maps). A minimum of one set of copies per aircraft and one back-up set were printed.

C.3.2 Production of Hardcopy Survey Transect Lists

We produced lists of transects to be flown by transect set, primarily based on the transect shapefile attribute tables. The list for each transect set included the transect start/end coordinate fields and the corresponding random seed point coordinates (field names: “dm_long1”, “dm_lat1”, “dm_long2”, “dm_lat2”, “dm_longseed”, “dm_latseed”) for transect lines, and the random point coordinates (field names: “ptdm_long”, “ptdm_lat”) for transects to be flown from points. Copies of these lists were printed for each aircraft.

C.3.3 Production of Waypoint Files

Some pilots preferred to upload transect waypoints to their onboard GPS receivers. We did not receive many requests for this, so did not include generation of waypoint files in survey preparations. However, Becky Strauch (ADF&G, personal communication) developed three Access queries to derive waypoint lists of transects left to be flown (queries produced a table for each set of end point coordinates, and a table for transect "seed point" coordinates). These queries were added to the 2005 GMU 9C survey transects database and waypoint files were produced and provided to some pilots during the survey period (see C.4).

C.4 Database Development to Track Transects Completed during Surveys

For each year of the surveys and for each survey area, we developed a Microsoft Access (Microsoft, Office Access 2003, 2003) to track completion of transects and to facilitate other aspects of survey data management. The primary data table in the databases was based on the transect shapefile attribute tables (all were appended together in a single table). Additional fields were added to that transects table to check-off completed transects and to record the dates that transects were completed. We created queries and reports within the databases that produced updated lists of transects completed (and transects left) by transect set. Additional queries were added later to create final formatted data tables for the project biometrician (see Appendix E). Databases for GMU 9A and GMU 9C were named “lacl9a***yy***_sum.mdb” and “katm9c***yy***_sum.mdb” respectively, where ***yy*** = last 2 digits of the survey year.

C.5 Pre-Survey Arcpad Customization

Details here reflect use of the most recent versions of custom Arcpad files and tools(Strauch 2003b, 2004b). Table C1 lists files that were specifically modified for each year of the surveys. To customize the display in Arcpad, any base map files that were to be displayed as background were required (for GMU 9A and 9C, layers displayed in Arcpad during the surveys included the survey area boundary polygon [shapefile], park and preserve boundary polygons [shapefiles], and 1:250,000 topographic maps [MrSID image files]).

a. We modified the dbase files listing pilot and observer last names available for selection during a survey (Table C1) to include the names of current survey crew members. The file named "animals.apl" can also be modified if desired (see Table C1).
b. Shapefiles and other files to be displayed in Arcpad were installed under the directory "C:_bearbase."
c. The transect length specified in the file named "sessionapps.vbs" (file provided by Becky Strauch; stored under the directory named "C:_bear03") was modified to reflect the length of transects to be flown.
d. Arcpad was run with administrative menus available (temporarily replaced the file named "C:_bear03\mainapp.apa" with one named "C:_bear03\mainappsadmin.apa" [both files from B. Strauch] so that additional administrative options were available) so that the following could be set (alternatively, most of these settings can be modified in the "arcpad.ini" file [Table C1]):
    - The "Add Layers" and "Show Layers" options were used to add topographic maps, survey area boundary shapefiles, and any other shapefile boundaries (i.e., park and preserve boundaries). Display settings for shapefiles were modified so that they were easily viewed on the screen with a topographic map in the background.
    - The zoom/pan function was used to set the initial view extent.
    - The computer number was set.
e. The customized Arcpad files, along with survey hardware (GPS, any interface adapter, external antenna, etc.) were tested using the GPS simulator mode and also during a test flight. The complete in-field survey laptop configuration is described under D.1.
f. Any files needed for customization, along with notes regarding computer operating system and Arcpad settings were compiled for efficient set up of computers during the field period. We found it most straight-forward to organize custom files within directories with the same names as those in which the files were to be installed. Each survey year a survey laptop computer set-up compact disk (CD) was created, including the following:
    - "_bear03" directory: Primarily consisted of custom Arcpad files; also included a copy of the "meranimals" font file that was installed on each laptop (font used by custom Arcpad application).
    - "_bearbase" directory: Contained MrSID topographic map files, survey area boundary shapefiles, and any other boundary shapefiles (i.e., park and preserve boundaries).
    - "\program files\arcpad\system\arcpad.avx": Specified which toolbars were visible in Arcpad.
    - "\windows\arcpad.ini": Stored a number of settings used by the custom Arcpad application.
    - Mouse cursor file ("solidb1.cur"): Displayed a large black mouse cursor arrow that was easier to see while flying surveys.
    - Arcpad installation files and key code: Used to install current Arcpad version on survey laptops.

C.6 Arcpad Survey Output Data Files

For each survey session, the following shapefiles were written by Arcpad to time-stamped directories organized within a date-stamped directory (directory structure: "C:_bear03\data\Compu***x**ddmmyyyy*\\hhmmss**", where ***x*** = computer number previously assigned,

ddmmyyyy = date files were written, ***hhmmss*** = time data files were written), depending upon which data were recorded:

- Animals.shp: Animal sighting records
- Effsite.shp: Effective sighting distance records.
- Transect.shp: Transect records (included off-transect segments).
- Tracklog.shp: Log file of 1-second interval flight line coordinates.

In addition, a back-up log file of 1-second interval flight line coordinates was continuously updated during each session and stored with the data files listed above, as well as within a similar directory structure under a directory named "Repairlog."

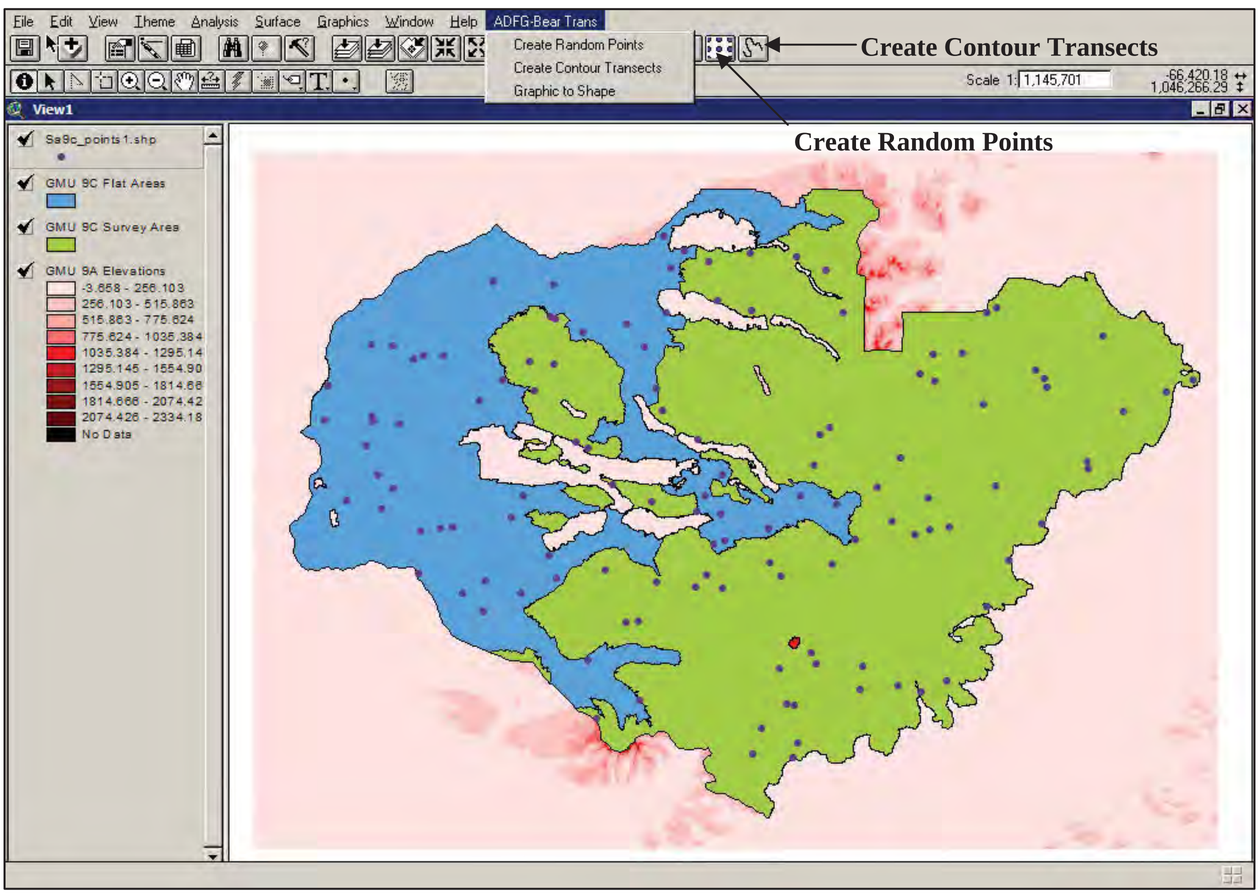

Figure C1. Arcview display with the ADFG-Bear Trans extension loaded and its menu active. Associated buttons are indicated.

Figure C2. Example of survey map layout. A series of map extents that covered the entire survey area was established, then sets of approximately 100 transects each were mapped for these extents.

Table C1. Files customized each survey year prior to setting up survey computers.

File name	File description	Customizations	Installation location
pilots.dbf[a]	List of pilot last names	Edited table to include names of pilots	C:_bear03
observers.dbf[a]	List of passenger last names	Edited table to include names of passengers	C:_bear03
sessionapps.vbs[a]	Custom Arcpad file	Edited to specify length of transects (search for "transect length" in the file, then edit the value)	C:_bear03
arcpad.prj	Projection file referenced by Arcpad	Chose appropriate projection file	User's "\My Documents" directory
arcpad.apm	Custom Arcpad map file which determined the initial view extent and what layers displayed at startup	Set up and save this file with desired topographic map, survey area boundary, and any other display layers and view extent	User's "\My Documents" directory
arcpadprefs.apx	Contains default Arcpad settings such as GPS and default paths	Customized while setting up arcpad.apm	User's "\My Documents" directory
arcpad.ini[a]	Stores information last used by custom Arcpad application including bear number, computer number, and pilot and observer last names	Set by successful session; was modified sometimes to reset the next bear number to be used	C:\windows
animals.apl[a]	List of animal species that appear in drop-down menu displayed by custom Arcpad application	Only edited if species were to be added to the drop-down list, or if list of species was to be shortened	C:_bear03\basefiles
arcpad.apx	Determines visible Arcpad toolbars	No additional editing required	C:\program files\arcpad\system

[a]Custom Arcpad files originally designed by B. Strauch (Alaska Department of Fish and Game, Anchorage, Alaska).

Appendix D

Field Data Collection and Data Management

D.1 Field Survey Set-Up

The following hardware was used in each aircraft to record survey data during the most recent survey year (2005): Garmin 12XL GPS receiver, Garmin external antenna, ruggedized serial-I/O port adapter (if needed), and laptop computer running Microsoft Windows XP.

D.1.1 Field GPS Receiver Set-Up

a. New batteries were installed in the GPS receiver and the GPS was initialized at the field site.
b. The GPS interface was set as NMEA, 9600 baud (Garmin 12XL: Set-Up Menu, Interface; select NONE/NMEA, 9600).
c. The GPS datum was set as NAD27 (however, we later learned of Arcpad datum considerations that suggest the GPS should be set as NAD83 in the future.)

D.1.2 Field Survey Laptop Computer Set-Up

a. Any screen saver was turned off and power conservation settings were changed so that the monitor and hard drive would not turn off due to inactivity.
b. The current version of Arcpad was installed and the registration number was entered.
c. The custom Arcpad-related files listed as part of the set-up CD under C.5 were installed to the directories as named on the CD.
d. Arcpad was started with administrative menus available (see C.5; the file "mainapps.apa" was temporarily replaced with the file "mainappsadmin.apa" under the directory named "C:_bear03"). The computer number and starting bear identification number were set via the computer set-up option (starting animal identification number was set as ***n***01, where ***n*** = computer number).
e. The "meranimals" font file (named "meranimals.ttf") on the CD was installed (Control Panel, Fonts, Install).
f. The Arcpad set-up was tested by connecting a GPS receiver running in simulator mode to the laptop, then running an Arcpad session to test the custom survey settings (testing included simulated transects and recording of hypothetical sightings). The GPS was turned on only after it was connected to the laptop because the computer sometimes otherwise misinterpreted the connection as an external mouse, which resulted in erratic uncontrollable mouse cursor movements.
g. The mouse cursor was changed to a readily visible large black arrow (Control Panel, Mouse, Pointers, Browse, solidb1.cur).
h. An Arcpad pre-programmed keys reference chart was taped above the function keys on the computer keyboard (Fig. D1). In addition, an outline of basic Arcpad survey operations was taped to the computer (Fig. D2).
i. The laptop battery and back-up battery were both checked to confirm that they were fully charged (and charged as needed).

D.1.3 Survey Aircraft Set-Up

a. An opaque curtain was installed between the pilot and passenger seat using Velcro.
b. A light box system (see Methods) was installed with a switch box and light at each seat.
c. An external GPS antenna was placed where it had a clear view of the sky (often atop the crossbar that ran below the ceiling window above the rear seat in a super cub).
d. A power inverter was installed to provide primary power to the laptop computer.

D.1.4 Other Survey Set-Up Procedures

a. Poster-sized wall maps of transect sets were posted along with transect lists on the walls of the survey office space; and sets of survey maps, transect set lists, survey data forms (Fig. D3), and percent cover diagrams (Fig. D4), were put together clipboards for each survey aircraft.

b. During a pre-survey briefing, the basic survey protocol was reviewed with survey teams (see survey hand-out, Fig. D5) and observers were given an opportunity to practice recording data using Arcpad. Additional points covered with survey data recorders included:
   - Record a line on the survey data form for each transect, regardless of whether any bears are observed. This makes it easier to cross-check data later and serves as a secondary written record of which transects were surveyed.
   - Check GPS battery strength occasionally and always carry spare batteries.
   - Be sure to wait to power up the GPS until after it is connected to the laptop to avoid erratic mouse cursor display.
   - Frequent zooming in and out while running an Arcpad session should be avoided because it can sometimes cause program errors.
   - Occasional unrecoverable Arcpad errors have occurred while surveying transects. If such an error occurs, it is best to break off transect (back toward areas already surveyed), reboot the computer and start up a new Arcpad session. Then restart survey of the transect just prior to where surveying was temporarily stopped; the new transect start can be numbered with the same transect number or with an “a” or similar added to indicate it is a continuation. If the transect segment being written when the program failed was not written to the transect shapefile, the data editor can usually recover it later from a back-up log file of 1-second interval coordinates that is constantly updated by Arcpad during each session (so, clearly note occurrence of the program problem on the survey data form).
   - Once you have marked the start of a transect, Arcpad keeps track of on-transect lengths and displays a message when it estimates that the target transect length has been reached. However, brief loss of a position fix from the GPS receiver often affects the real-time transect distance calculations in Arcpad. In such cases, the program is likely to suddenly display a message indicating that the intended transect length had been reached regardless of how much transect length was actually surveyed. The end point for these transects has to be determined based on the survey map, Arcpad transect line real-time display, and length of time spent on transect.
   - An effective sighting distance record should be entered for each bear sighting. In cases where the effective sighting distance is the same as the bear, the effective sighting distance can be marked in the data file at any location, and then a note can be recorded on the data sheet to advise the data manager to move the point to match the bear sighting location.
   - The Arcpad survey application only allows a sighting to be recorded when in off-transect mode. If the recorder is unable to access the sighting data entry screen, verify that “off transect” has been entered.
   - Occasionally the pre-programmed function keys have been found to suddenly not work while running a session. If this happens, the screen-displayed buttons can still be used as an alternative.
   - Explanations regarding known data entry errors should be clearly noted on the survey data forms.
   - In situations where many bear sightings occur within a small area (i.e., coastal bear aggregation areas) sighting covariate information can be primarily recorded on survey data forms to expedite data entry if preferred. It is important to note on the survey data forms when this data recording strategy is used so that the data manager knows to change the default sighting covariate information to written covariate information.

c. Waypoint files were provided to any pilots requesting them (see C.4).

D.1.5 Daily Field Survey Routine

Prior to departure each morning that surveys were flown, survey crews discussed the strategy for surveying transects that day. The data manager provided survey crews with any updated maps, updated transect lists, and additional waypoint files. The data manager also discussed any outstanding data editing questions with survey crew members when possible. Upon return of a survey aircraft at the end of a survey day, the data recorder delivered the survey laptop to the data manager and marked off transects completed on the poster-sized transect set maps.

D.1.6 Daily Field Data Management: Overview

Data management details contained in this section reflects procedures followed during 2005 using the most recent Arcpad customizations written by B. Strauch (ADF&G, Anchorage, Alaska).
General tasks involved in daily data management during the field surveys included:

a. For each survey laptop, download data to the GIS workstation and back up the raw survey data.
b. For each survey laptop, verify that laptop batteries are fully charged and charge as needed; also check AA batteries available for the GPS receiver and replace as needed.
c. For each survey laptop, verify that the computer number setting and starting animal number setting are correct for next day (this was an occasional issue when the program crashed during surveys in 2003, but became less of an issue in 2004–2005).
d. For each survey laptop, review and edit survey data files as described in detail under D.1.7.
e. For each survey laptop, make lists of transects flown from the data sheets and from the survey data files; check off transects completed in the survey transects database after cross-checking these 2 lists.
f. Print reports from the survey transects Access database as needed of transects completed, transects left to be flown within particular transect sets, etc. Use these lists to verify that all transects completed have been marked off on wall maps and on survey crew maps.
g. Copy bear sighting records from the Arcview shapefile attribute tables into the survey transects database to summarize information regarding bear sightings. Update a table summarizing bear sightings and number of transects completed.
h. Check transects completed within sets to determine whether maps combining transects left for several sets are needed. For example, if most transects in Set 1 have been completed, and there are just a few left in Set 2, it may be desirable to plot the transects left in those sets on new composite survey maps to hand out to observers.

D.1.7 Daily Field Data Management: Details

a. We first transferred survey shapefiles from each survey laptop to the GIS workstation for compilation and editing (using a portable storage device such as a zip drive or a memory key); the raw data were also backed up on separate media. Within each year's survey area subdirectory, original data files were stored under a directory named "\raw", and copies were placed in a directory named "\cleaned" for editing (data compiled for analysis and final mapping were from the "\cleaned" subdirectories).
b. As data were downloaded, computer battery level was checked, and the battery was charged if needed.
c. For each survey computer and survey session, we reviewed and edited the survey shapefiles in Arcview. Survey data were edited according to data form notes and per the following steps:
    - Transect lines were edited to delete segments for with the value of the field named "event_actn" was equal to "Flight Setup", "Transect Setup", or "End Trans" (these segments were selected and deleted after visually inspection—this step can be done generally independent of sightings edits).
    - Transect lines were edited to remove any location "spikes" (a relatively rare occurrence; "spikes" resulted when the GPS receiver momentarily lost its position fix and coordinates far outside the survey area were recorded).
    - For each transect number, all records were selected from all the survey shapefiles (animals.shp, effsite.shp, and transect.shp), then the records were inspected in a view zoomed into the extent of the selected records:
        - Transect lines were edited to delete off-transect segments as appropriate. This editing was done methodically for each sighting to be sure that editing was done correctly (for example, sometimes the recorder may have forgotten to mark "off transect" until after the plane had already left the transect line. In this case, the segment previous to the off-transect one was edited to delete the length of the segment that was actually off the transect rather than on). Also, off/on transect

breaks in the transects were checked for significant overlaps—generally, observers tried to minimize this issue, but sometimes segments overlapped some, in which case the segment continuing along the survey line was edited to eliminate the overlap.

- Sightings and effective sighting distances to transects were later calculated by matching these records with the corresponding transect segment based on segment number. The distance calculation macro expected the segment number of the sighting and effective sighting distance locations to be 1 more than the number of the corresponding transect segment. In some cases, the corresponding transect segment had to be renumbered, split or, otherwise edited to have the distance measured correctly. These edits had to be determined through visual inspection of the data, and sometimes with input from the observers who recording the sighting.
- Some transects had to be edited to address tear-drop flight patterns in valleys—these sometimes required breaking the transect segment and renumbering the segment to make sure that the distance measurement from sighting to transect was calculated correctly.
- Occasionally, if the program experienced a fatal error, the current transect segment was not written to the transect shapefile. In most cases, this segment could be recovered from the corresponding transect repair log file (this file was stored in both the directory where the session shapefiles were written and into a similar directory structure under the "\repairlog" directory [as a back-up in case of problems with the primary data directory]; however, under the "\repairlog" directory, log files were always written to the time-stamped directory following the one written for the current survey). To restore the segment to the transect shapefile from the log file; the log file had to first be converted from a z-point file to a point file. Then the file had to be projected to Albers coordinates and the datum transformed from NAD83 to NAD27. Finally, the point file had to be converted to arcs before the missing segment could be copied from this log file into the transect shapefile. After pasting the missing segment into the transect shapefile, the transect shapefile's attribute table was edited to add corresponding attribute information (such as transect number).
- Survey shapefiles were edited per any notes written on the survey data forms.
- Survey data forms were cross-checked with the shapefiles to verify that all sightings and transects listed on data forms were recorded in the shapefiles, and also to cross-check covariate information.
- Sighting and corresponding effective sighting distance shapefiles were reviewed to verify that each sighting had a single corresponding effective sighting distance record. If no effective sighting record was found, one was manually created and attribute information was manually entered. If >1 effective sighting record was found for a given sighting, those records and any data form notes were reviewed to determine which location to retain (sometimes with further observer consultation).
- Effective sighting distance locations were also reviewed relative to sighting locations to evaluate whether they appeared to make sense (an effective sighting distance location should not be closer to a transect line than the corresponding sighting location), and editing was done as needed.
- Sighting locations were reviewed to verify that they were recorded while on a transect (occasionally an observer recorded a bear observation after the transect was already past the designated end length).
- Sighting and effective sighting distance shapefile records were reviewed to verify that corresponding records had the same the same segment number, and that the segment number was 1 more than the corresponding on-line transect segment number. These records were also reviewed to verify that the correct view side was indicated.
- Sighting records were reviewed to verify that each sighting record was assigned a unique identification number.
- It was sometimes helpful to print maps of any sightings in question for the observer to refer to when discussing editing questions. Ideally, an effort was made to consult observers regarding any editing questions before observer left to fly surveys the following day.

d. The edited survey data were backed up once editing work for a particular survey date was completed.
e. While reviewing and editing survey shapefiles for a particular survey laptop, a list was maintained of each transect recorded. A similar list was also made based on the written data records. These 2 lists were cross-checked and any inconsistencies were resolved. Once this cross-check was completed, the final daily list of transects for a computer was used to check off transects completed in the survey transects Access database. Once all survey laptop data were checked in, database queries were used to print reports as needed of cumulative transects completed, completed transects for a particular date, and transects remaining for a particular transect set. The lists of transects remaining in particular sets were especially useful for double-checking that transects marked as completed on wall maps were in fact completed, for specifically identifying quickly which transects still needed to be flown, and for determining when new maps compiling remaining transects from >1 transect set were needed.
f. Bear sighting records from Arcview attribute shapefile attribute tables were copied into a table in the survey transects Access database (this involved appending all sighting records for a day into a single dbase file in Arcview, importing this dbase file into Access, then appending the imported records to the database table containing bear sighting records to date). A double-check for overlapping bear numbers was performed after new sighting records were appended by reviewing the Access table records sorted by bear number. Database queries were used to obtain summary information on number of bear sightings by day, aircraft, and species.
g. Initial animal identification number was occasionally modified in the arcpad.ini file (see Table E1) of a survey computer to avoid duplicate numbering of sightings if any animal numbers were manually assigned during the data editing process (on occasion sightings had to be manually added and animal numbers were then manually assigned).
h. New maps that compiled remaining transects for >1 transect set were prepared as needed by working from the Arcview project files originally used to produce survey maps.

F2	F3	F4	F5	F6	F7	F8	F9
CHANGE SIDES	CHANGE SIDES	OFF TRANS	RESUME TRANS	END TRANS	ANIMAL LOC	HORIZON LOC	MARK SPOT

Figure D1. Pre-programmed Arcpad function keys reference diagram that was attached above the functions keys on each survey laptop computer keyboard.

- **Power PC & Log on as: __________________**
- **Turn on attached GPS; check battery power**
- **Start Arcpad**
- **Start session (select "set pilot, observer…")**
- **For breaks, close session to disconnect GPS**
- **End Arcpad via upper rt-hand X or Ctrl-Q**

- **Transects (9C-25 km in length; 9A-20 km in length):**
- **Before transect, setup transect**
- **Start transect (F2)**
- **Change view side as needed (F3)**
- **Sighting:**

-Turn on signal light, check partner's
-Visually note horizon
-Go off transect (F4)
-Mark animal location (F7)
-Record sighting attributes on form
-Mark horizon (F8)
-Return to where you left transect and resume (F5)

- **End transect when completed (F6)**

Figure D2. Summary Arcpad survey instructions that were attached to each survey laptop computer.

LT - DC Survey Form

Lake Clark (GMU 9A) 2004

Computer #: ______________

Date: ______________ **am/pm**

Pilot/Observer: ______________

Area Name: ______________

Page _____ **of** _____ **pages**

Transect ID	Bear ID	Side Bear observed (L / R)	Species Brown(Br) Black(Blk)	Group Size	Group Type[A]	Activity[B]	% Cover	Refer. Cover Sheet	% Snow	Obs Type[C] (P O B)	Pilot Degree Diff[D]	Obsvr Degree Diff[D]	Got Horizon (Y / N)	Comments
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	
		L / R	Br / Blk					Y / N					Y / N	

A - Bear Group Type	B - Activity	C - Obs Type = Observer	D - Degree of Difficulty
1 Adult - Sex Unknown	1 Bedded	B = Both	Number of times out of 10
2 Subadult - Sex Unknown	2 Feeding	O = Observer	that you would see this
3 Large Male	3 Running	P = Pilot	bear group given the
4 Female with Cubs	4 Standing		same search conditions
5 Female with Yearlings	5 Sitting		
6 Females with > Yearlings	6 Walking		
7 Breeding Pair			

Path Name:	Edit Date:	Complete	Initial

Figure D3. Format of survey data form.

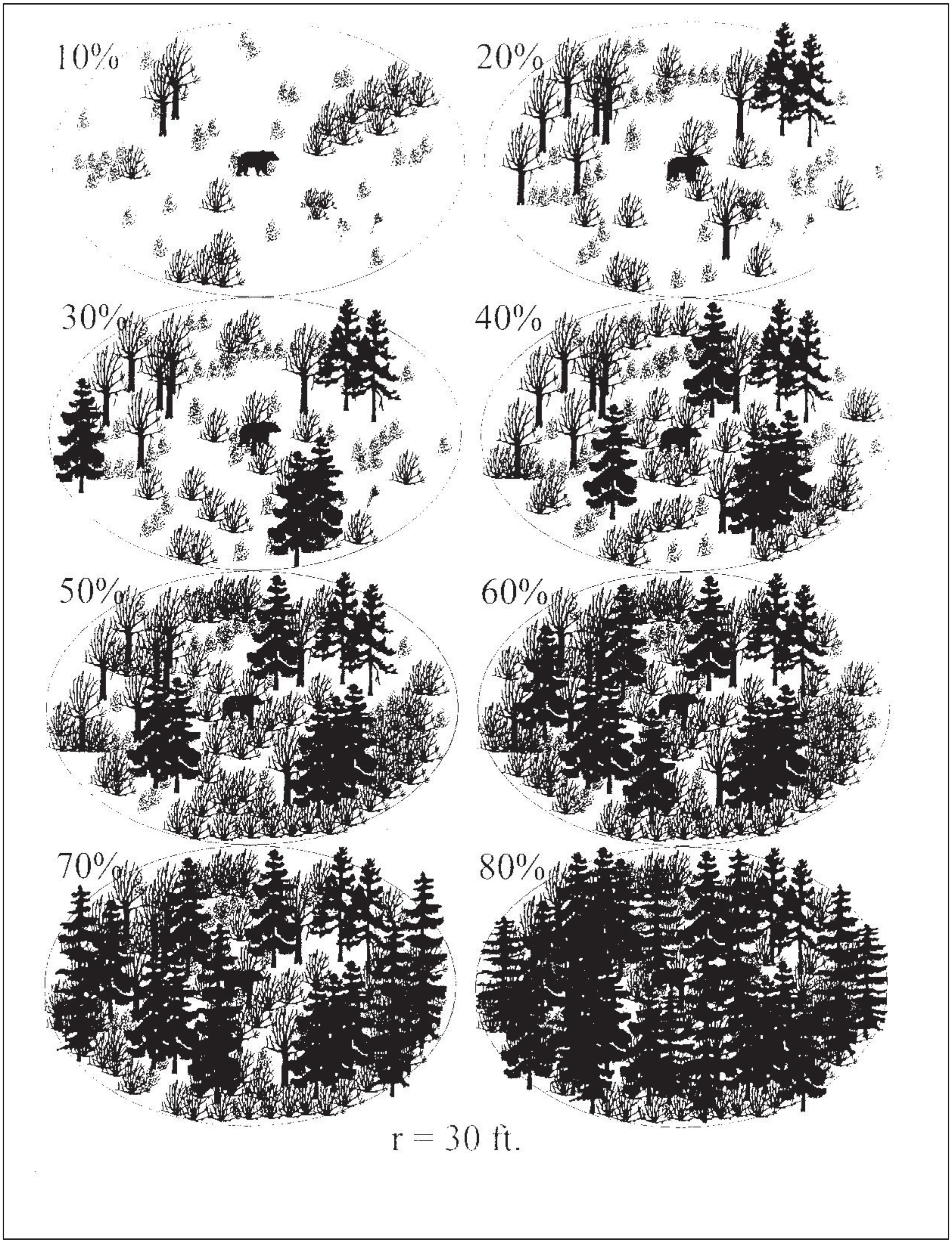

Figure D4. Percent cover diagram provided to survey crews.

<u>OBJECTIVE</u>: We need to determine if the PILOT can see the bear **WITHOUT ANY HELP** from the OBSERVER, and if the OBSERVER can see the bear **WITHOUT ANY HELP** from the PILOT. We need to get an **accurate distance** from the transect to the bear.

<u>PILOT INSTRUCTIONS</u>:

1) PILOTS - FLY 300' Above Ground Level (AGL), adjust distance from the slope to get a good look at the area represented by the line (contour) on the map (~75m from plane on horizontal axis).
2) PILOTS, who see a bear should **A**) **Toggle their light button ON, B) wait until the animal is 5 seconds past the trailing edge of the wing, and C) check Observer's Light before** informing the observer of the bear.
3) PILOTS should avoid INADVERTENTLY ALERTING the OBSERVER to a BEAR SIGHTING.
4) PILOTS SHOULD NOT ADJUST THE PLANE ONCE A BEAR IS SIGHTED - this is a test of the observer.
5) Pilots should CALL OUT THE CHANGE SIDE CALLS (bank turn) – give Computer operator a warning about it coming up.

>><u>IMPORTANT</u>: TRY to mark bear location and HORIZON location w/ <u>Parallel</u> flight pattern to transect.

<u>OBSERVER (BACKSEAT) INSTRUCTIONS</u>:

OBSERVERS who see a bear should **A**) **Toggle their light button, B) wait until the animal is 3 seconds past the trailing wing strut and C) check Pilot's Light before** informing the pilot of the bear. Visually record a location to mark as the extent of the horizon i.e. Max. distance location where you had a chance of seeing a bear. If the pilot's light is not on, he does not get credit for the bear.

<u>ARCPAD PROGRAM SETUP AND OPERATION</u>

1) Hook the computer to the battery via the AC connection with **duct tape.** Connect the cable from the GPS to the PC via the serial port. Hook antenna to the GPS. Turn on computer.
2) Turn on computer first and boot up. Then turn on the GPS. Check GPS batteries (need >= ¼ strength). By pressing page button until satellite page appears, battery power is displayed on the left.
3) Double click on the ArcPad shortcut on the desktop to open the program.
4) Set up new session: Click **"open folder"** (1st icon in 'start and end session' menu). Change pilot and observer names and computer number if necessary. Click OK.
   a. This should open the **"GPS Position Window"** and show your current position.
   b. **DO NOT** click on the "GPS Position Window icon", this may cause a crash.
   c. **DO NOT** constantly zoom in and out on the map; this will also cause a crash.
5) **Prior** to starting a transect: Click **"transect setup"** (1st icon in 'transect actions' menu)
   a. Enter the transect number: first 3 (or 4) numbers of the label
   b. Select view side (right or left) of the plane. Usually the uphill side. Flip a coin on flat transects (or use the seconds on your watch: 00-29 as right, 30-59 as left, or similar).
6) To begin a transect, click **"start transect"** (2nd icon in transect actions menu) or **F2**
7) To change view side, click **"change view side"** (3rd icon in transect action menu) or **F3**
8) To go off transect to check/mark a bear, click **"off transect"** (4th icon in transect action menu) or **F4**
   a. <u>Important</u>: you can only mark an animal group and/or horizon if you are <u>OFF</u> transect
   b. You can click **F9** to mark the location on the transect opposite the bear as a reference
9) To mark bear location, click **"add animal"** (1st icon animal and horizon menu) or **F7**
   a. A popup window will appear. Fill in the information. For 2004, we will only be worried about accuracy in entering species and group size. All else can be primarily recorded on the paper data form.
   b. Fill in paper data form. Be sure to record the Bear ID number displayed in the popup window.
10) To mark the horizon, click **"mark horizon"** (2nd icon animal and horizon menu) or **F8**
    a. Always mark a horizon point for a bear even if the location needs to be edited, make note on the data sheet 'horizon same as bear' or 'move horizon 30 m uphill', etc.
11) Return to where you left transect and click **"resume transect"** (5th icon in transect action menu) or **F5**
12) To end a transect, click **"end transect"** (last icon in transect action menu) or **F6**
13) **BEFORE** you fly the next transect, click on the "setup transect" icon again to enter new transect.
14) Before you take a lunch break or at the end of the day, click the "**close session**" icon to disconnect the GPS. Shut down ArcPad (**Ctl Q**) and turn off the computer and GPS to save power.

Figure D5. Page 1 of 2-page survey methods hand-out provided to survey crews.

GENERAL THINGS TO REMEMBER:

- Carry extra AA batteries at all times for GPS.
- Test the GPS battery strength by hitting PAGE button until the satellite page appears. Battery power is displayed on the left of page (need >= 1/4).
- GPS- a PDOP reading of < 6 indicates a great satellite reception; a PDOP of > 15 is poor.
- Every time you hit the "F" keys or menu buttons for transect actions or animal/horizon/markspots events, you mark that GPS location. The mark is placed at the instant you hit the key.
- Use the geometric center of a group to mark a bear group.
- If you and the pilot decide to change the plane side you are looking out of, hit the "**F3**" key at the spot of the change so the info gets updated in the computer. F3 is a toggle. Each time you hit the button the side changes. You can look at the status line at the bottom of the screen to check on the current view side.
- Sometimes the **"F"** keys don't work. Make sure to check the status line at the bottom of the screen. If the function key doesn't work try clicking the appropriate icon on the menu bar.
- Transects are to be flown to specified transect length. In some cases, you may need to temporarily go off transect to transit to additional habitat at similar elevation to a complete a transect.

Figure D5, Continued. Page 2 of 2-page survey methods hand-out provided to survey crews.

Appendix E

Post-Field Data Management

E.1 Post-Field Period Data Management: Data Review and Editing

a. We compiled all of the separate survey shapefiles for a given survey area and year into ArcInfo coverages using an arc macro language (AML) script written by B. Strauch (ADF&G, Anchorage, Alaska). The following notes describe use of the most recent version of this AML, which was named "domost03.aml." Several types of data errors caused the AML to halt at the problem record, including cases where a sighting record did not have an appropriately numbered corresponding transect segment. By examining the data processing display and messages generated by the AML, typically the specific type of data error and the record needing review could be identified. Such errors were reviewed and corrected in the edited versions of the survey shapefiles before the AML was run again. Once all such errors were corrected and the AML ran completely, the following coverages and other files were produced (these files were written under the specific survey area and survey year directories (named as described under C.1). The AML also calculated distances of bear sightings to transects and effective sighting distances.

- "\bldist***yy***" (where ***yy*** = last 2 digits of survey year): Separate coverages of black bear effective sighting distance records, sighting records, and corresponding transect segments were written within this directory. These coverages were used to measure sighting and effective sighting distances. Dbase files were also written to this directory that contained compiled sighting records (bearpts.dbf) and compiled effective sighting distance records (effpts.dbf). These compiled dbase files included a field named "dist2trans" that contained the distance measured to the corresponding transect segment in meters.
- "\brdist***yy***" (where ***yy*** = last 2 digits of survey year): Separate coverages of brown bear effective sighting distance records, sighting records, and corresponding transect segments were written within this directory. These coverages were used to measure sighting and effective sighting distances. Dbase files were also written to this directory that contained compiled sighting records (bearpts.dbf) and compiled effective sighting distance records (effpts.dbf). These compiled dbase files included a field named "dist2trans" that contained the distance measured to the corresponding transect segment in meters.
- "\covers": Contained a number of coverages that compiled all of the separate survey shapefile data:
  - "animals" (all animal sighting records)
  - :"effsite" (all effective sighting records)
  - "trans***yy***" (all transects, where ***yy*** = last 2 digits of survey year)
  - "blac***yy***" (black bear sightings, where ***yy*** = last 2 digits of survey year)
  - "brow***yy***" (brown bear sightings, where ***yy*** = last 2 digits of survey year)
  - "blaceff***yy***" (black bear effective sighting distance records, where ***yy*** = last 2 digits of survey year)
  - "broweff***yy***" (brown bear effective sighting distance records, where ***yy*** = last 2 digits of survey year)

  Also written to this directory were separate directories for each survey laptop as "\Compu***n***" (where ***n***= computer number). Within these directories separate "animals" "effsite" and "transect" coverages were written for each Arcpad session using the same directory structure as that of the source data shapefiles.

b. We performed several further data checks after the "domost03.aml" was successfully run, and we made any further corrections required in the source edited shapefiles (those stored under the directory named "/cleaned"):

- The dbase files of sighting and effective sighting distance records (see E.1) were compared to verify that a corresponding effective sighting distance record existed for each sighting record.
- Covariate fields were checked for spelling errors by using the FREQUENCY command in ArcInfo and/or by examination of the dbase compilation files (see E.1; and in the case of transects, an exported dbase file containing the transect records) sorted by the field of interest or summarized

using pivot tables in Microsoft Excel. This approach was also used to check for any duplicate transect numbers.

- The "dist2trans" field in the compiled bear sighting records and effective sighting distance records dbase files(see E.1) was examined to look for any unusual distances (such as distances less than the 22-m blind strip and exceptionally far distances; any such records were then reviewed/verified). In addition, the "dist2trans" field value for each sighting record was checked to verify that it was less than or equal to "dist2trans" value for the corresponding effective sighting distance record. Comparison of corresponding distances was most efficiently done in Microsoft Excel (working from the compiled dbase files):
  - Sorted the effective sighting distance records and the sighting records by bear number, then
  - Pasted the "dist2trans" and "animalid" fields from each of the 2 files into a new worksheet.
  - Subtracted the bear sighting distance from the corresponding effective sighting distance and looked for any negative values.

c. The "domost03.aml" was run a final time once all data editing was completed. Coverages and dbase files produced by this final AML run were used to create the summary data files used by the project biometrician to analyze the data.

E.2 Post-Field Period Data Management: Processing of Final Edited Data

Data records used by the biometrician for data analysis included sighting records with corresponding effective sighting distance included; transect records summarizing length flown for each transect surveyed and including corresponding buffer areas based on buffer distances specified by the project biometrician. The following steps produced the data records formatted per the biometrician's specifications. Data were initially processed separately for each survey year (and by survey area), and then records for a survey area were combined across survey years by appending the records in Microsoft Excel. Data were managed separately for each of the 2 survey areas (GMU 9A and GMU 9C).

a. The transects coverages were buffered using an ArcInfo AML script written by B. Strauch ("bufftran.aml"; ADF&G, Anchorage, Alaska). Specific buffer distances were selected by the biometrician (sometimes after initial analysis was performed on an initial data set). Buffering always included a 22-m buffer, which was the approximate blind strip below the aircraft. For both GMU 9A and 9C, buffers were also generated at 600, 800, and 1,000 m. Buffer coverages were stored by the AML under the "\covers" directory described under C.1. Buffer coverages followed a standard naming convention of trans***yy***b***nnnn***, where ***yy*** = last 2 digits of survey year and ***nnnn*** = buffer distance in meters.

b. For each survey area, a data file containing a list of the transects flown, along with corresponding lengths, target elevation (from original file of transects to be flown), flight date, flight time, pilot, and observer was created for the statistician according to the following steps:
   - For each survey year, the FREQUENCY command was used in ArcInfo to summarize transect segment lengths by transect number. The resulting Info files were exported to dbase files using the INFODBASE command. The INFODBASE command was also used to export buffer coverage Info tables.
   - The exported transects dbase files, along with exported buffer dbase files, were imported into their corresponding survey transect Access database files (described under C.4; these files contained a master list of transects originally generated).
   - Within each database, a relationship was established between the imported completed transects table and the master transect list table using the "transno" field, and also between the completed transects table and the imported buffer tables.
   - For each database, a query was used to produce a table containing the fields listed in Table E1.
   - The query output tables were exported to Microsoft Excel workbooks. In Excel, records from separate survey years were appended together into a single worksheet.

c. To produce a formatted sighting records file that included for each record the corresponding effective sighting distance, the compiled sighting and effective sighting distance dbase files (by bear species) were imported into the survey transects databases. Relationships were then established between the imported effective sighting distance tables and the bear sighting tables using the field “animalid.” Queries were then used to produce tables containing the fields listed in Table E2, and the tables were exported into Excel workbooks. In Excel, records from separate survey years were appended together into single worksheets by bear species.
d. Because we were interested in obtaining density estimates specifically for the LACL and KATM subareas of the GMU 9A and GMU 9C survey areas, we also created a set of coverages clipped to within those unit areas from coverages stored under the “\covers” directories (described under C.1). We followed the above steps to produce Excel data files for the LACL and KATM subareas in the same format as described above (for GMU 9A and GMU 9C).

Table E1. Transect data fields included in Excel workbooks for data analysis.

Field name	Field format	Field definition
Frequency	Integer	Number of segments comprising transect (generated by FREQUENCY command in ArcInfo)
Transno	Character	Transect identification number
Obslnam	Character	Last name of observer (passenger)
Pilotlnam	Character	Last name of pilot
Date	Character as M/DD/YYYY	Date transect was surveyed
Length	Decimal	Length of transect surveyed in meters
Tranelevm	Integer	Elevation of transect in meters (from original list of transects to be flown)
Tranelevft	Integer	Elevation of transect in feet (from original list of transects to be flown)
B22aream2	Decimal	22-m blind strip buffer area (in square meters)
B600aream2	Decimal	600-m transect buffer area (in square meters)
B800aream2	Decimal	800-m transect buffer area (in square meters)
B1000aream2	Decimal	1,000-m transect buffer area (in square meters)

Table E2. Bear sighting record data fields included in Excel workbooks for data analysis.

Field name	Field format	Field definition
Species	Character	Bear species (possible values were Brown, Black)
Transno	Character	Transect identification number
Groupsize	Integer	Number of bears in group
Grouptype	Character	Age-sex class of bear group (categories listed in Fig. D3; possible values were LrgMale, AdultUnk, Breeding, AdultSub, FemaleWC, FemaleWY, FemaleWY2)
Activity	Character	Activity of bear group (categories listed in Fig. D3; possible values were Bedded, Sitting, Stand, Feeding, Walking, Running)
Pctcover	Integer	Percent cover in 10% intervals (from 0 to 100)
Pctsnow	Integer	Percent snow in 10% intervals (from 0 to 100)
Pilotrept	Integer	Pilot sighting repeatability assessment (1–10 value, how many times in 10 the pilot thought she/he would have spotted the bear under the same conditions)
Obsrept	Integer	Observer sighting repeatability assessment (1–10 value, how many times in 10 the pilot thought she/he would have spotted the bear under the same conditions)
Observer	Character	Which observer(s) saw the bear(s) (possible values were Pilot, Observer, Both)
Animalid	Integer	Unique sighting identification number
Date	Character as M/DD/YYYY	Data sighting was recorded while surveying a transect
Time	Integer as HHMMSS	Time sighting was recorded while surveying a transect
Pdop	Decimal	PDOP (position dilution of precision): a measure of the geometrical strength of the GPS satellite configuration.
Planespd	Decimal	Estimated aircraft speed (from GPS) when the sighting was recorded
Segment	Integer	Transect segment number from which the sighting distance and effective sighting distance were calculated
Dist2trans	Decimal	Shortest distance between the sighting and the corresponding transect segment in meters
Effdist	Decimal	Shortest distance between the effective sighting distance marked and the corresponding transect segment in meters

Appendix F

Project Budget Summary

Table F1. Final summary bear survey project budget, fiscal years (FY) 2003–2005, Game Management Units 9A and 9C, Alaska.

	FY 2003			FY 2004		FY 2005	
	NRPP[a]	ONPS[b]	ADFG[c]	NRPP	ONPS	NRPP	ONPS
Aircraft costs	26,345	7,040	12,000	38,831		32,616	
Fuel	9,902			13,324		14,163	
Equipment	17,790			5,660		497	
Statistician	9,680			12,000			
CESU agreement				47,519		11,350	
Salaries	4,212	25,300		19,168	19,740	5,382	22,464
Travel	2,213			4,770		2,992	
Total	70,142	32,340	12,000	141,272	19,740	67,000	22,464

[a]Natural Resource Preservation Program
[b]Park base funds
[c]Alaska Department of Fish and Game