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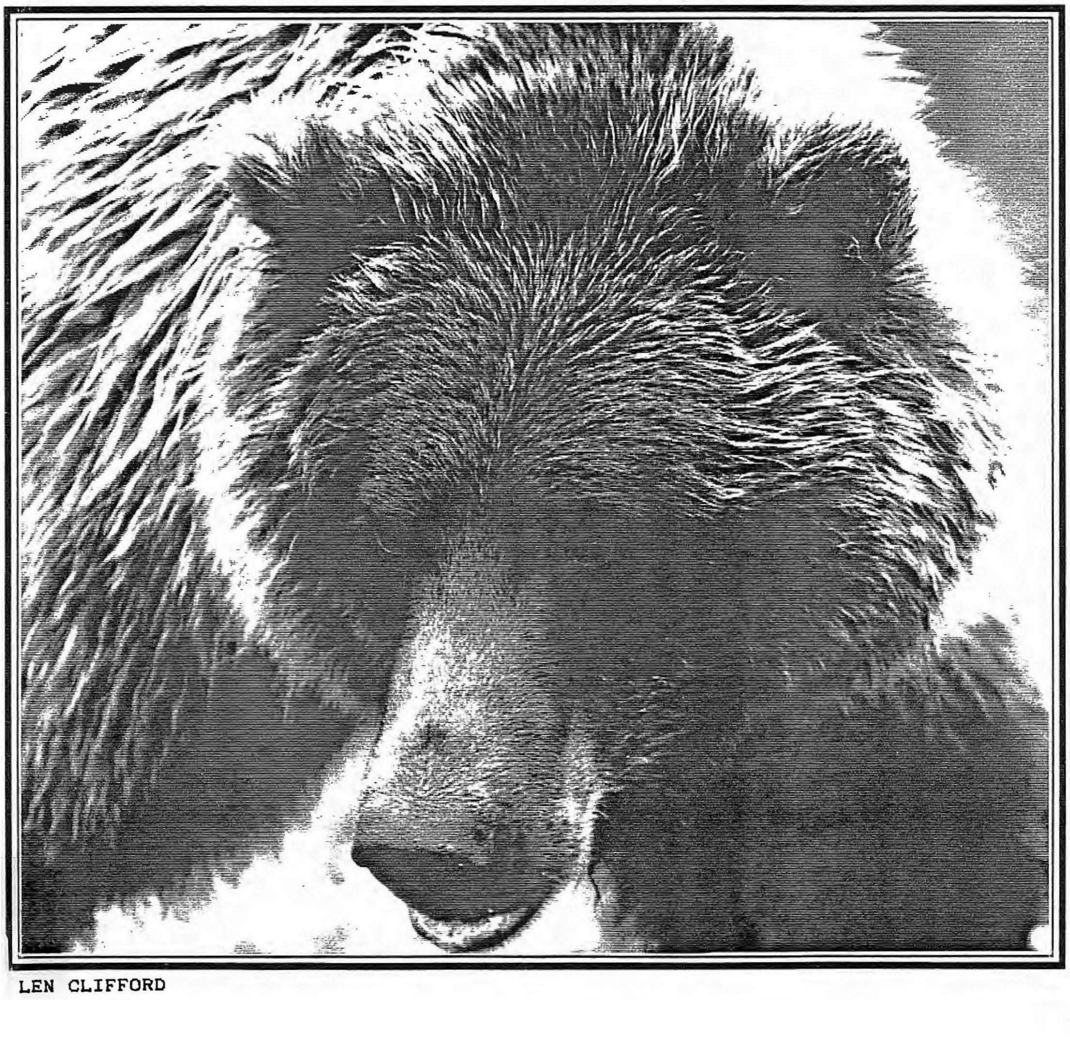
Impacts of Heavy Hunting Pressure on the Density and Demographics of Brown Bear Populations in Southcentral Alaska



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STATE OF ALASKA
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RESEARCH PROGRESS REPORT

STATE: ALASKA **STUDY NO:** 4.26

COOPERATORS: NONE

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STUDY TITLE: Impacts of Heavy Hunting Pressure on the Density and Demographics of Brown Bear Populations in Southcentral Alaska

PERIOD: 1 JULY 1994 TO 30 JUNE 1995

SUMMARY

Brown bear (*Ursus arctos*) populations have been exposed to intensive harvest pressure in Alaska's Game Management Unit 13. Since 1980 varying kinds of liberal brown bear hunting regulations in Unit 13 have been adopted by Alaska's Board of Game. The objective for these regulations was to reduce bear abundance to increase moose (*Alces alces*) calf survivorship and moose availability for harvest by hunters.

Progress in this effort to reduce bear density was measured in a remote portion of Unit 13E where density was expected to be reduced as a consequence of high harvests in the subunit. Previous efforts had revealed significantly lower densities in nearby highly accessible portions of Unit 13E compared with more remote areas. There was no direct measure of trends in either remote or accessible portions of the subunit. Such a measure in a remote portion of Unit 13 was obtained during spring 1995 by repeating a density estimate done 10 years earlier in the same study area. This earlier estimate was part of the study associated with the proposed Susitna Hydroelectric Project. In this study area, density changed from 18.75 independent bears/1000 km^2 (95% CI = 15.9-23.8) in 1985 to 23.31 independent bears/1000 km^2 in 1995 (95%CI =19.3-30.1). An anticipated decline in bear density was not documented during this study. In 1985, the sex ratio of the population was 82.4 males/100 females compared with 27.8 males/100 females in 1995 (P = 0.02). Mean age of population appeared unchanged. An effort will be made to interpret these results in the final report for this project due next year.

These results should not be interpreted as characteristic of the status of bear populations throughout Unit 13 because bear density that was 30% of that documented in the 1995 study was found in a nearby area with much easier access to hunters than in a 1987 study. The low density found in this 1987 study area was attributed to heavy hunting pressure (Miller 1990*a*).

CONTENTS

BACKGROUND

Little is known about trends in bear populations in Unit 13 before the 1980s. Between 1948 and 1953, the federal government conducted a poisoning campaign directed at wolves, reducing wolf numbers in Unit 13 to as few as 12 (Rausch 1969, Ballard et al. 1987). Because the poison was distributed around carcasses of dead animals (J. Didrickson, Palmer AK, pers. commun.), mortality to bears that scavenged these carcasses occurred "often" (Rausch 1969:126), and it is believed bear populations were depleted. After statehood, bears were managed conservatively and bear populations probably increased gradually over the next 20 years.

Systematic brown bear studies in Unit 13 began in 1978. These studies yielded information on bear movements, predation rates on ungulates, and sex and age composition of the bear population (Spraker et al. 1981). Additional bear studies focused on the role of bear predation on moose calf survival (Ballard et al. 1980, 1990, 1991; Ballard and Larsen 1987; Ballard and Miller 1990). These studies resulted in a bear density estimate and bear population composition estimates for 1979 in a study area surrounding moose Count Area 3 near the Denali Highway in northern Unit 13 (Subunit 13E)(Miller and Ballard 1982). This bear density estimate was done during a bear transplant experiment (Ballard and Miller 1990) and was subsequently adjusted downward to correct for suspected overestimation bias based on lack of population closure (Miller 1990*a*). During 1980-1986 the Alaska Power Authority financed a major bear study in a nearby area with similar bear habitat but where bear hunting was more difficult because of the absence of road access. In this area south of the Denali Highway, a large 2-dam hydroelectric project was proposed but never built. In this Su-hydro area studies were designed to evaluate the proposed project's effects on wildlife and included intensive studies of black bear, brown bear, moose, caribou, wolves, and other species. The bear studies significantly increased the amount of available information about bear biology, density (in 1985), population composition, movements, and predation rates (Miller 1987).

In addition to these research projects, Alaska Department of Fish and Game (ADF&G) management staff produced annual federal aid reports designed to track the status of bear populations in Unit 13, based on research findings, harvest data, incidental observations, and other available information. Excerpts from these reports demonstrate uncertainty about the status of this population during the heavy harvests of the 1980s (Miller 1993, Appendix A).

The predator-prey research conducted in Unit 13 during the late 1970s and early 1980s indicated brown bears were killing many moose calves and that an experimental reduction in bear densities increased calf survivorship (Ballard and Larsen 1987, Ballard and Miller 1990). This research was completed in the early stages of the moose population's recovery from the severe winters of the early 1970s (Ballard et al. 1991). These calf mortality study results led the Alaska Board of Game to expand opportunity to hunt brown bears in Unit 13. This liberalization was intended to increase the number of moose available to hunters in Unit 13 and led to increased bear harvests starting in 1980. Similar liberalizations and increases in harvest occurred elsewhere in southcentral Alaska (Miller 1990*b*). In 1986, this project began evaluating the response of the brown bear population to increasing harvests in Unit 13.

Strong support for further reductions in bear numbers in Unit 13 comes from residents and owners of recreational cabins (especially in Subunit 13A) as well as from ungulate hunters. Transfers of small state land parcels to private ownership in the area during the early 1980s greatly increased human presence in bear habitat that formerly was lightly occupied by humans. These changes corresponded to an apparent increase in nuisance bear problems and property damage by bears, an increase interpreted by many locals to indicate bear population increases or, at least, that bear densities were higher than desired.

In fall 1995 still more liberal bear hunting regulations were implemented in Unit 13. Regulations adopted by the Board of Game changed the bag limit from 1/4years (the limit in most other portions of Alaska) to 1/year, eliminated the need for resident brown bear hunters in Unit 13 to purchase a $25 tag. These regulations opened the fall hunting season on August 10 (instead of September 1) to encourage August caribou hunters to take bears. The intent of these regulations was to further augment brown bear harvests by encouraging incidental and nondiscriminatory harvests.

These studies in a heavily hunted portion of Unit 13 complement studies in Unit 20A where brown bear populations were intentionally reduced and are now being allowed to recover (Reynolds 1990, 1995), and in Unit 9 where bear populations have recovered from heavy harvests in the late 1960s (Sellers and Miller 1990, Sellers 1994).

OBJECTIVES

Objectives for this study were to: 1) document changes in density and in the sex and age composition in a brown bear population subjected to heavy rates of harvest by hunters; 2) monitor changes in individual bear reproductive performance and survivorship in a population subjected to heavy harvest rates; and 3) investigate the hypothesis that brown bear cub survivorship is inversely related to hunting pressure or the proportion of adult males in the population. Only objective 1 is addressed in this report.

METHODS

Density was estimated in the 1985 search area using the same study procedures (Miller et al. 1987). The study area was subdivided into the same 9 quadrats used during the 1985 study (Miller 1987). The location of this study area and comparison study areas along the Denali Highway are illustrated in Fig. 1.

Four fixed-wing aircraft (PA 18), each with a biologist and pilot, searched assigned quadrats during each replication. All quadrats were searched during each replication. Teams in each aircraft rotated between quadrats on successive replications to lessen potential bias based on previous experience in a quadrat. Searches were conducted without using telemetry equipment. When bears were spotted, telemetry equipment was activated to determine whether bears were radiomarked. If radiomarked, locations were plotted and searches continued. If not radiomarked, in most cases a marking team in a helicopter (Hughes 500) captured and marked the bears. Unmarked bears were not captured and marked on the last day of the density estimate and several days prior.

One of the fixed-wing aircraft was also used to establish closure during each replication. This aircraft flew around the periphery of the search area and used telemetry equipment to determine whether each radiomarked bear was within or outside the area being searched. In most cases, radiomarked bears were not precisely located during these periphery flights. Precise locations were obtained only when the telemetry signal from a bear was close to the search area periphery to determine whether the bear was in or out. I was the biologist in the aircraft conducting the closure flights for all replications. On one day the PA-18 normally used for periphery flights was not available. On this day the periphery flight was conducted in a Cesna 180.

One bear (501) had been incorrectly recorded as having shed its collar the previous year based on location of the shed collar transmitting on that frequency on the ground. It turned out the shed collar had been shed years previously by another bear and 501 was still radiomarked. Because not all aircraft were scanning for this frequency when they saw "unmarked bears," 501 was treated as unmarked even when correctly identified.

Five replications were completed on 5 successive days during May 15-19, 1995. More replications were originally scheduled, but the study was terminated early to conserve funds when it became clear that results would not be different from the 1985 results.

RESULTS AND DISCUSSION

Complete analysis and interpretation of results will be conducted for the final report due in 1996. Only the results of the density estimate, without interpretation, are presented here.

females, 5 were alone, 4 were with a total of 9 newborn cubs, 6 were with 12 yearlings, and 3 were with 5 two-year olds (Table 1).

During the density estimate an additional 10 bears were captured and radiomarked. These included 3 subadult females, 0 females with newborn cubs, 1 female with 2 yearlings, 2 females each with a litter of 2 two-year olds, 1 subadult male, and 3 adult males (Table 1).

Population Composition

Population composition is based on the sexes and ages of captured individuals. Composition can be measured in a variety of ways depending on which individuals are included. It is important to standardize and clearly define population composition to permit comparisons with other areas or with other times in the same area. For age composition, I excluded subadult bears to minimize the effects of pulses in cub production on age statistics. For sex composition, I calculated population sex ratios in several different ways based on bears alive and present (at least once) in the search area, based on these bears plus those alive in the general area in 1995, and based on bears captured in the general area during the previous 2 years and not known to have been shot.

The most parsimonious way is to include just the individuals present in the study area at least 1 time during the density estimation period. Excluding offspring still accompanying their mothers, 31 bears were present at least once in the search area during the density estimation procedure in 1995 (Table 1). There were 27.8 males per 100 females in this subpopulation (Table 1).

Including bears alive in the general study area but not present in the actual search area during the density estimate increases sample size for population composition to 43 bears (excluding dependent offspring) (Table 1). Sex ratio in this subpopulation was 29.2 males per 100 females. Sex ratio was similarly skewed toward females in both subpopulations of bears ≥ 5 (Table 1). Age structure in both subpopulations was similar with no significant differences in mean age between males and females (Table 1).

Sample sizes for composition calculations can be further increased by including bears marked in or near the search area during 1 or 2 of the previous years of premarking. This subpopulation includes bears that could still be alive and present in the area. This includes all bears captured in the area (excluding dependent offspring) not known to have died or been shot by hunters before the density estimate in spring 1995. For this subpopulation of 49 known and potentially alive bears, ages of bear with unknown status in 1995 was based on extrapolating from age at capture in previous years (Table 2). In this subpopulation, the ratio of males was higher (58.1 per 100 females) than for the subpopulations included in Table 1. This is because adult males frequently shed their collars and subadult males frequently emigrate.

Regardless of what subpopulations are used, population composition was strongly biased towards females (Tables 1, 2). Actual population composition was doubtless even more skewed toward females than indicated in these calculations because males have significantly larger home ranges than females (Miller 1987). Consequently, any specific study area will be overlapped by male home ranges from a larger area than for females. This bias will be directly related to the length of study which is why the number of males in the 1979 Denali Highway study, which lasted for 17 days, was inflated (Table 3).

I compared population composition with results obtained in the same Su-hydro area during 1985 and with results from other studies in an area more accessible to hunters along the Denali Highway (Table 3). For bears ≥ 2 and for bears ≥ 5, proportion of males in the Su-hydro area was lower in 1995 than in 1985 ($X^2 = 5.10$, $P = 0.02$, and $X^2 = 2.75$, $P = 0.10$, respectively). For bears ≥ 2, proportion of males in the Su-hydro area in 1995 was lower than in the 1987 study along the Denali Highway ($X^2 = 4.8$, $P = 0.03$) (Table 3). The 1987 study along the Denali Highway used the same technique employed in the Su-hydro area during 1985 and 1995 (Miller 1990*a*). Both mean and median ages were similar for populations in the 1985 and 1995 studies in the Su-hydro areas (Table 3).

DENSITY ESTIMATES

Density estimates in the 1985 and 1995 studies in the same Su-hydro study area, as well as estimates in 1987 in the Denali Highway study area, are given in Table 4 for the maximum likelihood estimator and in Table 5 for the bear-days estimator. Density estimates are given in 3 measurement units:

1 <u>independent bears</u> does not include any offspring accompanying their mothers regardless of the age of these offspring but includes observations of a breeding male and female as 2 independent observations,

2 <u>bears > 2</u> includes all independent bears as well as 2 year-old bears still accompanying their mothers as independent observations, and

3 <u>bears of all ages</u> includes cubs-of-the-year, yearling, and older bears still accompanying their mothers as independent observations.

These units have different applications. Because of year to year variations in cub production, density comparisons within an area over time are best expressed as independent bears. Comparisons between areas are best expressed in units of bears ≥ 2 years-old because of potential differences in age of weaning. Density in units of bears of all ages is calculated to permit comparisons with studies elsewhere which report density in this way. The capture-mark-recapture studies conducted in Alaska make the assumption that observations are independent of each other; this assumption is clearly violated when offspring still with their mothers are counted as independent observations. Simulations studies suggest this assumption violation results in little bias in point estimates but results in underestimation of CI coverage (Miller 1990*b*, Appendix D).

Density Comparisons within the Su-hydro Study Area

Density was estimated at 18.75 independent bears/1000 km^2 in 1985 and at 23.31 bears/1000 km^2 in 1995. The 95% CI for the 1985 estimate overlapped the 1995 estimate but the 80% CI did not (Table 4). Only 5 replications were completed in 1995 compared with 7 in 1985. Had we completed 7 replications in 1995, the CI would have been smaller and the differences may have been significant.

These results suggest that density in this area has increased marginally between 1985 and 1995 and do not support the prediction by Miller (1992, 1993) that populations in this area should be lower. The prediction of a decline was based on reported harvests in excess of calculated sustainable harvest levels in Unit 13E. Possibilities for the failure of this prediction include:

1 Inflated harvest statistics caused by incentives to falsely report bears as having been taken in Unit 13 that were actually taken elsewhere. These incentives resulted from a 1/year bag limit during 1982-1986, years of record reported harvests (Miller 1993).

2 Immigration subsidy of Unit 13E bear populations from surrounding unhunted refugia, especially Denali National Park.

3 Population underestimation biases. Such bias could result from systematic biases in the technique utilized to estimate density, from errors in extrapolation from intensively studied areas to surrounding bear habitats, or from disturbance of bears in the 1985 study that lead to underestimation (such disturbance may have resulted from intensive helicopter and other activities associated with Su-hydro impact assessment studies).

4 Augmented productivity or survivorship caused by compensatory responses of the bear population to heavy hunting pressure concentrated on males. Density dependent responses in bear populations have not been demonstrated in the literature (Miller 1990*d*; Reynolds 1990, 1994, 1995; McLellan 1994; Garshelis 1994; Taylor 1994; Derocher and Taylor 1994). Alternatively, input data for productivity and survivorship parameters could have been underestimated.

5 Differences in distribution patterns based on the early spring in 1995 compared with a late spring in 1985. As a consequence of these differences, the 1995 estimate was completed 2 weeks earlier than in 1985. From the standpoint of plant phenology, these estimates were conducted at roughly equivalent times.

These possibilities will be evaluated in the final report for this project.

Comparisons Between Su-hydro and the Denali Highway Study Area

The 1987 density estimate in the Denali Highway study area which is readily accessible to hunters was 8 independent bears/1000 km^2 (95% CI = 5.6-7.6) (Table 4). This density was significantly lower than in either the 1985 or 1995 studies in the Su-hydro area. Habitat in the Denali Highway study area appears equivalent to that in the nearby but relatively inaccessible Su-hydro study area. A higher density was reported in the Denali Highway study area in 1979 using different techniques that resulted in a large CI (Table 3). Consequently, it could not be proven that density in the Denali Highway actually declined between 1979 and 1987 but Miller (1990*a*,*c*; 1993) concluded this was probably the case based on high kill densities, on differences in population composition, and on the decline in point estimates, albeit nonsignificant because of the large 1979 CI.

Comparisons Between CMR Estimator

Population and density estimates presented in Table 4 were based on the maximum likelihood estimator described by White (1993) which is a modification, designed to accommodate immigration and emigration of an estimator described by White and Garrott (1990). The original "bear-days" estimator for use with data of this kind was described by Miller et al. (1987). As noted for other CMR bear studies in Alaska (Miller et al. in prep.), population estimates and CIs for 1995 based on the bear-days estimator (Table 6) were similar to estimates based on the maximum likelihood estimator (Table 4). The population of independent bears was 29.3 (95% CI = 23.1-41.6) based on the bear-days estimator (Table 6) compared with 30.7 (95% CI = 25.4-39.7) based on the maximum likelihood estimator (Table 4).

Population Closure and Sightability

The importance of documenting the presence of bears during each replication with periphery flights was demonstrated by data on population closure for bears present at least once on the study area (Table 7). During the 5 day density estimation period, radiomarked bears were available on the study area 90 times but were actually on the study area only 75 times (79%) (Table 7). Closure for males was 73% (11 of 15) and for females closure was 85% (64 of 75) (Table 7). Closure was highest for females with 2-year old offspring (100%) and females with newborn offspring (93%) (Table 7).

Lowest sightability in 1995 studies was for males (9%)(1 of 11) followed by females with newborn cubs (14%)(2 of 14), solitary females (25%)(6 of 24), and females with yearling or 2 year-old offspring (38%)(10 of 26) (Table 7). Overall, sightability was 25% (19 of 75) (Table 7) compared with 24% during 1985 in the same study area and 47% during 1987 in the Denali Highway study area (Miller et al. in prep).

Number of Marks Available

The maximum likelihood estimator modified for immigration and emigration (White 1993) used in the above analysis requires a parameter not required for the traditional Chapman estimator. This is the number of marked animals available during the study, or m_i. For our study m_i was defined as the total number of marked bears present on the search area at least once during the capture period. Because bears move across the border of the search area, this value is larger than the number of marked bears available during any particular replication. Because unmarked bears observed were captured and marked during the search period, the value for m_i increased during the capture period (Table 8).

COMPARISONS OF BEARS SEEN PER HOUR OF SEARCH EFFORT

Allocation of search effort between teams is documented in Table 9. Teams rotated between quadrats on different replications to minimize the significance of previous experience in a quadrat on locating bears.

A total of 7640 (127.3 hours) minutes was spent in active search for bears during the 5 replications, an average of 25.5 hours per replication (Table 10). These times do not include time spent commuting to and from search areas or time spent circling unmarked bears before capture.

Search intensity averaged 70 seconds/km^2 during the 1995 density estimate. This search intensity was higher than during the 1985 estimate in the same area (45 seconds/km^2) or than during the 1987 estimate in the Denali Highway study area (60 seconds/km^2) (Table 11). Higher search intensity should result in observing a higher proportion of both marked and unmarked bears in the study area. In 1995, however, sightability of marked bears was 25% (Table 7), almost identical to the 24% obtained with less intensive searches in 1985. These limited data do not support the existence of a relationship between sightability and search intensity.

The limited data available on catch per effort (search hours per independent bear seen) support a possible relationship between observation frequency and density (Fig. 2). During 1985 2.7 hours of search effort per independent bear observed were required, compared with 2.4 hours during 1995 (Table 11). This is the same as 0.36 hours/independent bear in 1985 compared with 0.42 hours in 1995.

COSTS OF 1995 DENSITY ESTIMATE

Capture-mark-resight estimates of bear density are expensive. The 1995 density estimate cost approximately $150,000 spread out over 3 years (Table 12). The actual density estimate in spring 1995 cost about $57,000 compared with about $60,000 in the same area during 1985 (Miller et al. in prep.). In 1985 logistic support was available as part of the Su-hydro project and 8 replications were obtained in contrast to the 5 replications during 1995. Initial costs for the 1995 estimate would have been higher had there not been a number of radiomarked bears present in the study area. Radiomarks on these individuals had been maintained since termination of the Susitna Dam marking studies in 1985.

CALF MORTALITY

Three studies of causes of calf mortality have been conducted and previously reported in Unit 13. These studies were based on intensive monitoring of radiomarked moose calves and inspection of kill sites. Results of these studies have not been previously compiled in a single reference; these data are presented in Table 12. Combining results of these studies indicated 46% of radiomarked calves were killed by brown bears (88 of 193) (Table 12).

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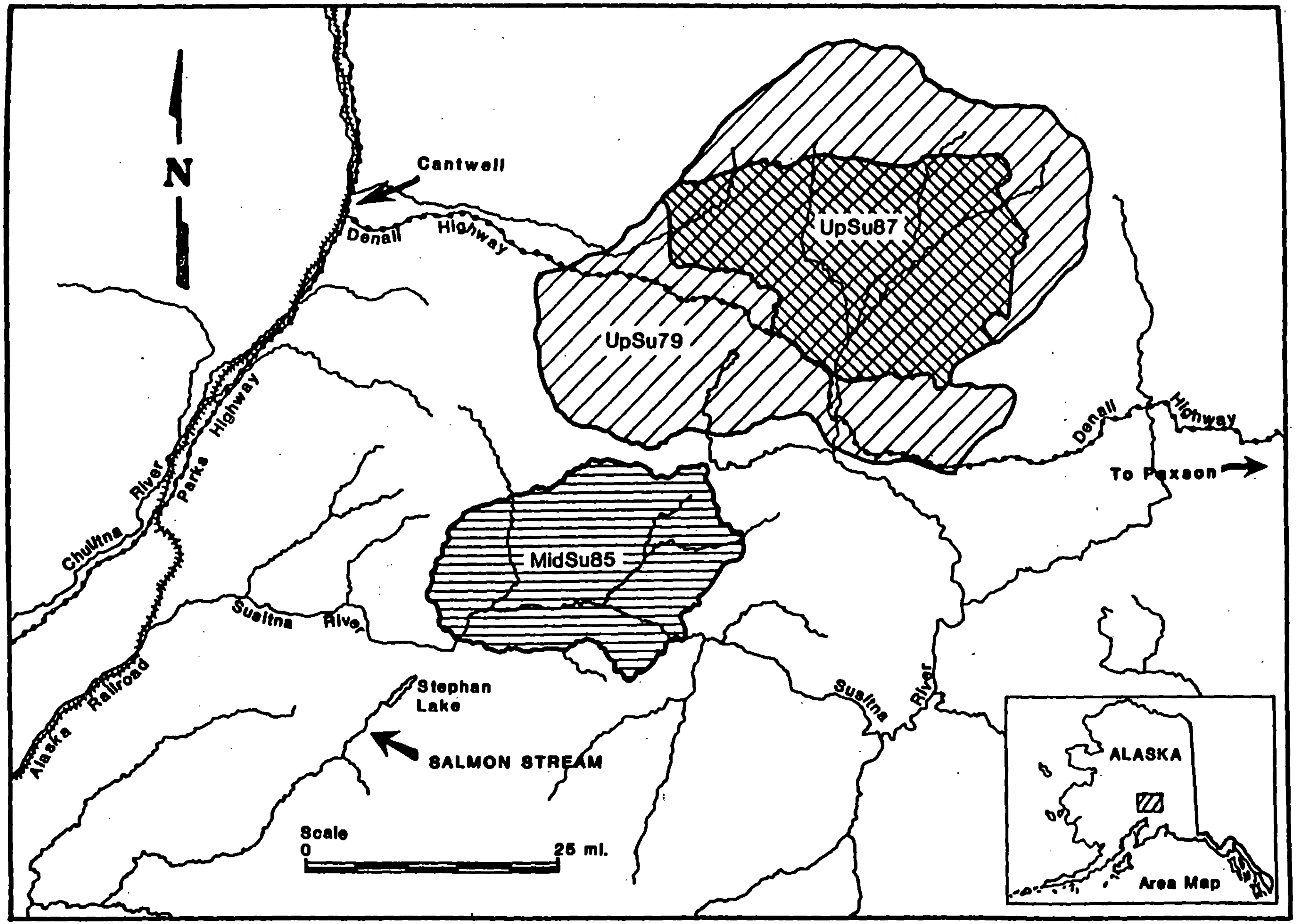


Figure 1. Study area in Unit 13E where density estimates were taken in 1985 and 1995 ("MidSu85," also referred to as the Su-hydro area in this report). Also illustrated are comparison study areas along the Denali Highway where hunter access is relatively easy and where density estimates were taken in 1979 (UpSu79) and 1987 (UpSu87).

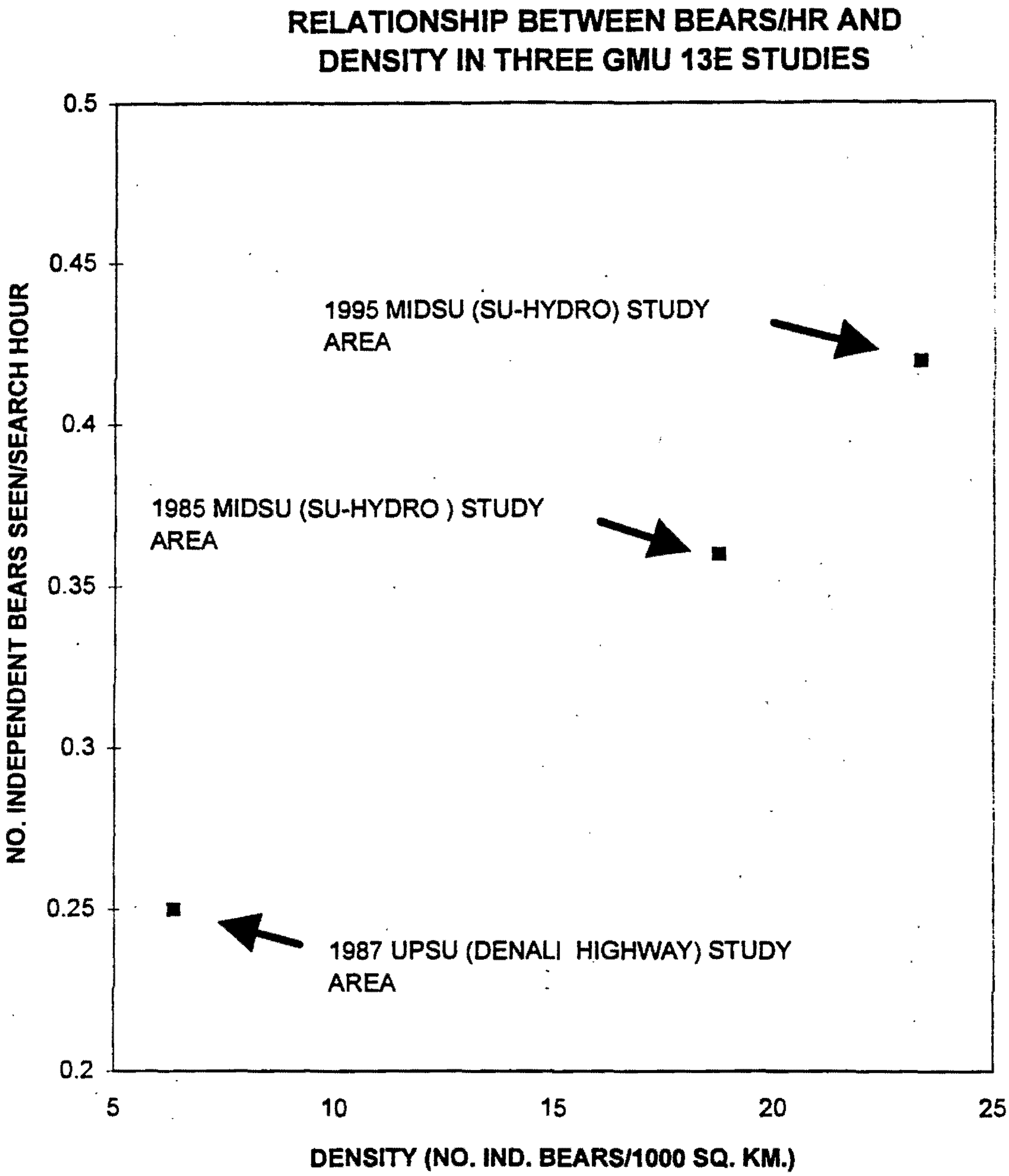


Figure 1. The relationship between independent bears seen per hour of search effort and measured density during 3 capture-mark-resight density estimates in Alaska's Unit 13.

Table 1. Composition of brown bear population in the Su-hydro study portion of southcentral Alaska during spring 1995 based on individuals known to be alive.

Bear ID	Sex	Repro. Status in 1995	Age in 1995	Codes[1]
522	F	w/ siblings	2	2, 3
506	F	alone	4	1, 3
507	F	alone	4	1, 3
491	F	alone	4	2, 3
503	F	alone	4	2, 3
509	F	alone	5	1
518	F	alone	5	1, 3
337	F	alone	27	1, 3
499	F	w/ 2 @0	8	1, 3
314	F	w/ 3 @0	17	1, 3
281	F	w/ 2 @0	18	1, 3
273	F	w/ 2 @0	19	1
484	F	w/ 1 @1	6	1, 3
485	F	w/ 2 @1	7	1
525	F	w/ 2 @1	7	2, 3
486	F	w/ 2 @1	8	1, 3
496	F	w/ 1 @1	9	1, 3
306	F	w/ 3 @1	18	1, 3
283	F	w/ 1 @1	27	1, 3
52	F	w/ 2 @2	9	2, 3
47	F	w/ 2 @2	12	2, 3
335	F	w/ 1 @2	17	1
517	F	w/ 2 @2	19	1
498	F	w/ 2 @2	22	1
521	M	w/ siblings	2	2, 3
519	M	alone	4	1
15	M	alone	5	1
493	M	alone	8	2, 3
523	M	alone	8	2, 3
524	M	alone	15	2, 3
280	M	alone	20	1, 3

[1] Codes: 1= radiomarked and available before start of density estimate on May 15, 1995.
2= captured and marked in density estimation study area during May 1995.
3= Present in the density estimation study area at least once during period May 15-May 19, 1995.

SUMMARY FOR ALL BEARS KNOWN TO BE IN GENERAL AREA (CODES 1, 2, AND 3)

	TOTAL NUMBER	MEAN AGE	S.D. DEVIATION OF MEAN	MEDIAN AGE
No. females	24	11.5	7.44	8
No. males	7	9.14	6.51	6.5
males:100 females	29.2			
No. females >/= 5	19	13.5	7.00	10.5
No. males >/= 5	5	11.6	6.15	8
males:100 females	26.3			
No. females >/= 10	10	19.4	4.45	18
No. males >/= 10	2	18.5	3.50	--
males:100 females	20.0			

SUMMARY FOR ALL BEARS KNOWN TO BE IN DENSITY ESTIMATION AREA AT LEAST ONCE (CODE 3 ONLY)

	TOTAL NUMBER	MEAN AGE	S.D.DEVIATION OF MEAN	MEDIAN AGE
No. females	18	10.5	7.53	8
No. males	5	11.0	6.87	8
males:100 females	27.8			
No. females >/= 5	13	13.1	7.28	9
No. males >/= 5	4	13.2	5.8	11.5
males:100 females	30.8			
No. females >/= 10	6	19.8	5.45	18
No. males >/= 10	2	18.5	3.50	--
males:100 females	33.3			

Table 2. Composition of brown bear population in the Su-hydro study portion of south-central Alaska during May 16-19, 1995 based on marked animals known to be alive plus animals previously captured in the area and not known to be dead.

Bear ID	Sex	Repro. Status in 1995	Age in 1995	Codes[2]	Comments
501	F	unknown	4*	4	Captured in 1993
502	F	unknown	4*	4	Captured in 1993, 1994
495	F	unknown	4*	4	Captured in 1994
501	F	unknown	4*	4	Captured in 1994
504	F	unknown	7*	4	Captured in 1993
508	F	unknown	8*	4	Captured in 1993
488	F	unknown	14*	4	Captured in 1993
522	F	w/ siblings	2	2, 3	
506	F	alone	4	1, 3	
507	F	alone	4	1, 3	
491	F	alone	4	2, 3	
503	F	alone	4	2, 3	
509	F	alone	5	1	
518	F	alone	5	1, 3	
337	F	alone	27	1, 3	
499	F	w/ 2 @0	8	1, 3	
314	F	w/ 3 @0	17	1, 3	
281	F	w/ 2 @0	18	1, 3	
273	F	w/ 2 @0	19	1	
484	F	w/ 1 @1	6*	1, 3	captured 1993
485	F	w/ 2 @1	7*	1	captured 1993
525	F	w/ 2 @1	7	2, 3	
486	F	w/ 2 @1	8*	1, 3	captured 1993
496	F	w/ 1 @1	9	1, 3	
306	F	w/ 3 @1	18	1, 3	
283	F	w/ 1 @1	27	1, 3	
520	F	w/ 2 @2	9	2, 3	
437	F	w/ 2 @2	12	2, 3	
335	F	w/ 1 @2	17	1	
517	F	w/ 2 @2	19	1	
498	F	w/ 2 @2	22	1	
521	M	w/ siblings	2	2, 3	
516	M		4*	4	Captured in 1994
519	M		4	1	

Table 2. Continued

Bear ID	Sex	Repro. Status in 1995	Age in 1995	Codes[2]	Comments
492	M		5*	4	Captured in 1993
500	M		5*	4	Captured in 1993
505	M		5*	4	Captured in 1993
515	M		5*	4	Captured in 1994
515	M		5	1	
514	M		6*	4	Captured in 1994
489	M		6*	4	Captured 1993
487	M		7*	4	Captured 1993
487	M		7*	4	Captured in 1994
493	M		8	2, 3	
523	M		8	2, 3	
483	M		13*	4	Captured in 1993
524	M		15	2, 3	
280	M		20	1, 3	
510	M		22	4	Captd. 1993, Shot 9/95

*Age based on extrapolation from age at capture to 1995. There is no direct evidence these individuals were alive during spring 1995.

[2]Codes: 1 = Radio marked and available prior to start of density estimate on May 15, 1995.
2 = Captured and marked during density estimation study area during May 1995
3 = Present in the density estimation study area at least once during period May 15-May 19, 1995.
4 = Captured prior to 1995 and not known to be dead during spring 1995, could be alive.

SUMMARY FOR ALL BEARS KNOWN TO BE IN GENERAL AREA (CODES 1-4)

	TOTAL NUMBER	MEAN AGE	S. D. MEAN AGE	MEDIAN AGE
No. females	31	10.4	7.15	7.5
No. males	18	8.6	5.45	6
males:100 females	58.1			
No. females >/= 5	22	13.1	6.81	12
No. males >/= 5	15	9.13	5.47	6.5
males:100 females	68.2			
No. females >/= 10	11	19.1	4.48	18
No. males >/= 10	4	17.5	3.64	17.5
males:100 females	36.4			

Table 3. Comparisons of brown bear densities and population composition in 4 studies in 2 study areas in Alaska's Unit 13E. Composition based on individuals in the study area at least once during the density estimation period. The 1987 study in the Denali Highway area occurred in a portion of the 1979 study area.

	Su-hydro Area		Denali Hwy. Area	
	1985	1995	1979*	1987
Days of search	7	5	17*	7
Population estimate (independent bears)	24.7	30.7	--	8.0
Density estimate (independent. bears)				
No./1000 km^2	18.75	23.31	10.5*	6.36
95% CI	15.9-23.8	19.3-30.1	6.0-25.7*	5.4-8.4
Number >/= 2				
Females	17	18	15	10
Males	14	5	19	8
MM:100FF	82.4	27.8	126.7	80.0
Number >/= 5				
Females	13	13	8	8
Males	10	4	9	3
MM:100FF	76.9	30.8	112.5	37.5
Number >/= 10				
Females		6		
Males		2		
MM:100FF		33.3		
Mean age >/= 2				
Females	10.2	10.5	7.0	10.0
Males	9.9	11.0	6.4	4.1
Median age >/= 2				
Females	7	8	5	7
Males	9	8	4	2

Table 3. Continued

	Su-hydro Area		Denali Hwy. Area	
	1985	**1995**	**1979***	**1987**
Mean age >/= 5				
Females		13.1		
Males		13.2		
Median age >/= 5				
Females		9		
Males		11.5		

* Technique used to obtain the 1979 estimate was different from the other studies. Raw CMR estimate was reduced by 28% to compensate for suspected bias based on failure of closure assumption (Miller 1990a). Reported results are for bears >/= 2.0 rather than for "independent" bears.

Table 4. Comparision of brown bear population and density estimates in two study areas in Alaska's Unit 13. Estimates are based on the maximum likelihood estimator (White 1993).

	Su-hydro(1317 km^2)		Denali Hwy. or Upper Susitna, (1257 km^2)
Independent Bears	1985	1995	1987
Population Estimate	24.7	30.7	8.0
95% CI	20.9-31.3	25.4-39.7	6.8-10.6
80% CI	21.9-28.6	26.9-36.0	7.1-9.5
Density Estimate			
Bears/1000km^2	18.75	23.31	6.36
95% CI	15.87-23.77	19.29-30.14	5.41-8.43
80% CI	16.63-21.72	20.43-27.33	5.56-7.56
Bears/100mi^2	4.86	6.04	1.65
95% CI	4.11-6.16	5.00-7.81	1.40-2.19
80% CI	4.31-5.63	5.29-7.08	1.46-1.96
Bears ≥ 2			
Population Estimate	24.7	40.6	8.0
95% CI	20.9-31.3	34.0-51.2	6.8-10.6
80% CI	21.9-28.6	35.9-46.9	7.1-9.5
Density Estimate			
Bears/1000km^2	18.75	30.83	6.36
95% CI	15.87-23.77	25.82-38.88	5.41-8.43
80% CI	16.63-21.72	27.26-35.61	5.56-7.56
Bears/100mi^2	4.86	7.99	1.65
95% CI	4.11-6.16	6.69-10.07	1.40-2.19
80% CI	4.31-5.63	7.06-9.23	1.46-1.96
Bears of All Ages			
Population Estimate	35.6	53.7	13.5
95% CI	33.0-40.1	47.4-63.1	11.3-17.7
80% CI	33.7-38.3	49.3-54.9	11.9-16.0

Table 4. Continued

Bears of All Ages, cont.	Su-hydro(1317 km²) 1985	1995	Denali Hwy. or Upper Susitna, (1257 km²) 1987
Density Estimate			
Bears/1000km^2	27.03	40.77	10.74
95% CI	25.06-30.45	35.99-47.91	8.99-14.08
80% CI	25.59-29.08	37.43-41.69	9.47-12.73
Bears/100mi^2	7.00	10.56	2.78
95% CI	6.49-7.89	9.32-12.41	2.33-3.65
80% CI	6.63-7.53	9.70-10.80	2.45-3.30

Table 5. Comparison of brown bear population and density estimates in 2 study areas in Unit 13. Estimates are based on the bear-days estimator (Miller et. al. 1987).

	Su-hydro ($1317 km^2$)		Upper Susitna ($1257 km^2$
Independent bears	1985	1995	1987
Population Estimate	25.09	29.40	8.37
95% CI	20.76-33.91	23.12-41.64	6.71-12.67
80% CI	21.94-30.58	24.88-36.98	7.01-10.98
Density			
Bears/$100km^2$	19.05	22.32	6.66
95% CI	15.76-25.75	17.55-31.62	5.33-10.08
80% CI	16.66-23.22	18.89-28.08	5.58-8.74
Bears/$100mi^2$	4.93	5.78	1.38
95% CI	4.08-6.67	4.55-8.19	1.35-2.61
80% CI	4.31-6.01	4.89-7.27	1.45-2.26
Bears $\geq$ 2			
Population Estimate	25.09	39.07	8.37
95% CI	20.76-33.91	31.04-53.57	6.71-12.67
80% CI	21.94-30.58	33.35	7.01-10.98
Bears of All Ages			
Population Estimate	36.7	57.13	13.21
95% CI	33.26-42.57	47.9-71.7	10.57-18.45
80% CI	34.23-40.43	50.66-66.35	11.28-16.45
Density			
Bears/$100km^2$	27.87	43.38	10.57
95% CI	25.25-32.32	36.37-54.44	8.41-14.68
80% CI	25.99-30.70	38.46-50.38	8.98-13.08
Bears/$100mi^2$	7.22	11.23	2.24
95% CI	6.54-8.37	9.42-14.10	2.18-3.80
80% CI	6.73-7.95	9.96-13.05	2.33-3.39

Table 6. Estimate of number of brown bear in the middle Susitna (Su-hydro) study area of Alaska using the bear-days estimator in spring 1995 (n1 = number of marked bears present during replicaiton, m2 = number of marked bears seen during replication, n2 = total number of bears seen during replication, and $\hat{N}$ = population estimate).

INDEPENDENT BEARS

DATE	n1	m2	n2	Min. No.	Daily Est.	Sight-ability	$\hat{N}$	Normal 95% CI N*=+/-	Binomial CI 95% Limits Lower	Binomial CI 95% Limits Upper	Binomial CI 80% Limits Lower	Binomial CI 80% Limits Upper
5/15	12	2	6	16	29.3	0.167	29.33	19.709	15.44	277.14	18.00	129.59
5/16	13	6	12	19	25.0	0.462	26.94	9.979	18.05	58.06	20.17	44.77
5/17	14	6	15	23	33.3	0.429	29.89	8.752	21.39	51.02	23.61	42.58
5/18	17	6	9	20	24.7	0.353	28.93	6.931	22.02	43.75	23.90	38.00
5/19	17	6	11	22	29.9	0.353	29.40	6.179	23.12	41.64	24.88	36.98
	Mean =			20								
	Mean =				28.44	0.356						
	SE=				1.44							

BEARS ≥ 2 YEARS OLD

DATE	n1	m2	n2	Min. No.	Daily Est.	Sight-ability	$\hat{N}$	Normal 95% CI N*=+/-	Binomial CI 95% Limits Lower	Binomial CI 95% Limits Upper	Binomial CI 80% Limits Lower	Binomial CI 80% Limits Upper
5/15	12	2	10	20	46.7	0.167	46.67	34.940	21.58	476.19	26.69	220.18
5/16	17	6	15	26	40.1	0.353	42.83	18.170	27.10	96.99	31.03	73.90
5/17	18	8	20	30	43.3	0.444	42.96	12.762	30.59	71.64	33.94	60.33
5/18	21	8	12	25	30.8	0.381	39.77	9.266	30.40	58.34	33.07	51.24
5/19	21	8	14	27	35.7	0.381	39.07	7.732	31.04	53.57	33.35	48.12
	Mean =			25.6								
	Mean =				39.3	0.360						
	SE=			2.51								

BEARS OF ALL AGES

DATE	n1	m2	n2	Min. No.	Daily Est.	Sight-ability	$\hat{N}$	Normal 95% CI N*=+/-	Binomial CI 95% Limits Lower	Binomial CI 95% Limits Upper	Binomial CI 80% Limits Lower	Binomial CI 80% Limits Upper
5/15	26	4	12	34	69.2	0.154	69.20	39.776	39.93	262.10	46.51	168.61
5/16	27	13	22	36	45.0	0.481	52.00	13.433	39.22	81.71	42.61	70.09
5/17	25	11	37	51	81.3	0.440	65.05	14.384	50.24	92.76	54.47	82.25
5/18	31	12	16	35	40.8	0.387	58.77	10.332	47.81	77.35	51.02	70.43
5/19	32	13	21	40	50.9	0.406	57.13	8.472	47.90	71.70	50.66	66.35
	Mean = 39.2											
	Mean =				57.45	0.376						
	SE=	6.88										

Table 7. Capture, sightability, and closure values for 1995 density estimate in the Su-hydro study area of southcentral Alaska.

			Replication Date							
	Age	Assoc.	5/15	5/16	5/17	5/18	5/19	Times Present	Times Available	Times Seen
MALES										
280	20		yes	yes	yes,seen	no	no	3	5	1
493	8		captured	yes	yes	yes	yes	4	4	0
521	2			captured	yes	no	no	1	3	0
523	8			captured	yes	?shed	shed	1	1	0
524	15*				captured	yes	yes	2	2	0
							TOTALS	11	15	1
FEMALES										
337	27	alone	yes	yes, seen	yes	yes	yes	5	5	1
506	4	alone	yes,seen	yes	no	yes	yes	5	4	1
507	4	alone	yes	yes,seen	yes,seen	yes	yes,seen	5	5	3
518	5	alone	no	no	no	yes	no	1	5	0
522	2	w/ 2 sibs?		captured	yes	yes	yes	3	3	0
491	4	alone		captured	yes	yes,seen	yes	3	3	1
503	4	alone			captured	yes	yes	2	2	0
							TOTALS	24	27	6
437	12	w/2@2	captured	yes	yes,seen	yes	yes	4	4	1
520	9	w/2@2	captured	yes	yes,seen	yes	yes	4	4	1
							TOTALS	8	8	2
486	8	w/2@1	yes,seen	yes,seen	yes,seen	yes,seen	yes,seen	5	5	5
484	6	w/1@1	yes	yes,seen	yes,seen	yes,seen	yes,seen	5	5	4
283	27	w/1@1	yes	yes	yes,seen	yes	yes	5	5	1
496	9	w/1@1	yes	no	no	no	yes	2	5	0
306	18	w/3@1	yes	no	no	no	no	1	5	0
525	7	w/2@1			captured	no	no	1	0	0
							TOTALS	18	25	10
281	18	w2@0	yes	yes	yes	yes	yes	5	5	0
499	8	w1@0	yes	yes, seen	yes	yes	yes	5	5	1
314	17	w/3@0	yes	yes, seen	no	yes	yes	4	5	1
							TOTALS	14	15	2
Number of uncaptured bears observed										
Prob. ad. MM			1		1	1	1			
Prob. ad. FF							1			
Female		w/2@1					1			
522's sibs	2			2						
Unknown				1	5	3	3			
501* female	4	alone		yes*						

*Collared bear but treated as unmarked bear when seen because not all planes knew it was radio-marked.

Table 8. Daily value of m_i used in calculation of maximum likelihood estimate (m_i = number of radiomarked bears in the area that were present at least once in the search area during the density estimation period).

	5/15	5/16	5/17	5/18	5/19
Independent bears	13	16	20	21	21
Bears $\geq$ 2	13	20	24	25	25
Bears all ages	26	34	38	39	39

Table 9. Allocation of search effort between quadrats during 1995 density estimate in the Su-hydro search area in Alaska's Unit 13.

QUAD. NO.	REP. 1	REP. 2	REP. 3	REP. 4	REP. 5
1	Jerry	Harley	Chuck	Jerry, Sandy	Harley
2	Jerry	Harley	Chuck	Jerry	Sandy
3	Jerry	Harley	Chuck	Jerry	Harley
4	Chuck, Sandy, Harley	Jerry	Harley	Chuck	Jerry
5	Chuck .	Jerry	Harley	Harley	Chuck
6	Sandy	Chuck	Harley, Chuck	Sandy	Jerry
7	not searched	not searched	not searched	not searched	not searched
8	Sandy, Chuck	Sandy, Jerry	Harley	Chuck	Harley
9	Harley	Sandy	Jerry	Harley	Jerry
10	Harley	Chuck	Jerry	Harley	Chuck

Harley = Harley McMahan (pilot) and Jeff Keay or Ward Testa (biologist)

Jerry = Jerry Lee (pilot) and Howard Golden (biologist)

Chuck = Chuck McMahan (pilot) and John Schoen, Suzan Bowen, Dennis McAllister, or Bill Taylor (biologist)

Sandy = Sandy Hamilton (pilot) and Sterling Miller (biologist). This team also flew the periphery flights.

Table 10. Search effort (minutes) by quadrat during 1995 density estimate in the Su-hydro search area. Quadrat number 7 was not counted during 1995 or during 1985.

QUAD. NO.	KM^2	MI^2	TARGET SEARCH EFFORT	REP. 1	REP. 2	REP. 3	REP. 4	REP. 5	TOTAL MIN.
1	146.38	56.52	144	92	176	160	165	198	791
2	142.89	63.64	144	165	217	145	143	217	887
3	100.02	38.62	102	81	129	120	136	126	592
4	127.67	49.3	126	155	197	162	155	207	876
5	142.89	55.17	144	148	124	109	69	156	606
6	87.42	33.76	90	96	100	106	131	148	581
8	167.63	64.72	168	175	183	248	215	271	1092
9	215.71	83.29	216	277	212	220	273	234	1216
10	194.50	75.10	192	166	210	221	172	230	999
TOTAL	1,325	520.12	1,326	1,355	1,548	1,491	1,459	1,787	7,640

Table 11. Comparison of number of hours spent searching for each independent bear seen in 1985 and 1995 density estimation efforts in the Su-hydro study area (MIDSU) (1,325 km^2 including 8 km^2 above 5,000 feet elevation) and in the 1987 density estimate in the Denali Highway study area (UPSU) (1,309 km^2 including 51.7 km^2 above 5,000 feet elevation). Area above 5,000 feet elevation was searched but was not considered bear habitat for purposes of density calculations. Independent bears are defined as marked or unmarked individuals no longer accompanying their mothers.

	REP. 1	REP. 2	REP. 3	REP. 4	REP. 5	REP. 6	REP. 7	TOTALS
MINUTES OF SEARCH (1995)	1,355	1,548	1,491	1,459	1,787			7,640
NO. INDEPENDENT BEARS SEEN (1995)	6	12	15	9	11			53
HRS/IND. BEAR (1995)	3.76	2.15	1.66	2.70	2.71			2.40
MIN/KM^2	1.02	1.17	1.13	1.10	1.35			1.15
MINUTES OF SEARCH(1985)[1]	870	1067	935	1,083	933	1,232	797	6,917
NO. INDEPENDENT BEARS SEEN (1985)	5	1	7	9	9	6	5	42
HRS/IND. BEAR (1985)	2.9	17.8	2.23	2.01	1.73	3.42	2.66	2.74
MIN/KM^2	0.66	0.81	0.71	0.82	0.70	0.93	0.60	0.75
MINUTES OF SEARCH(1987)[2]	1,097	1,037	1,295	1,333	1,293	1,512	1,419	8,986
NO. INDEPENDENT BEARS SEEN (1987)	5	4	4	3	3	6	3	37
HRS/IND. BEAR (1987)	3.66	4.32	5.40	7.41	7.18	4.20	7.88	4.05
SECONDS/KM^2	50	47	59	61	59	70	65	59

[1] From Miller (1987:227)
[2] From Miller (1988:38)

Table 12. Expenses involved in preparing for and conducting the 1995 density estimate in Alaska's Unit 13E 1995 (in thousands $).

ITEM	1993	1994	1995	TOTALS
CAPTURE & DENSITY ESTIMATES				
HELICOPTER	16.1	9.9	10.3	36.3
FIXED WING	16.9	8.6	29.1	54.6
FUEL	9.1	8.8	4.6	22.5
DRUGS	1.0	1.7	1.2	3.9
TRANSMITTERS	5.3	5.7	8.2	19.2
DART/MISC.	1.1	0.5	0.5	2.1
LODGING & FOOD	5.4	2.3	3.2	10.9
OTHER	0.6	0.3	0.3	1.2
SUBTOTAL	**55.5**	**37.8**	**57.4**	**150.7**
MONITORING	3.2	3.4	2.5	9.1

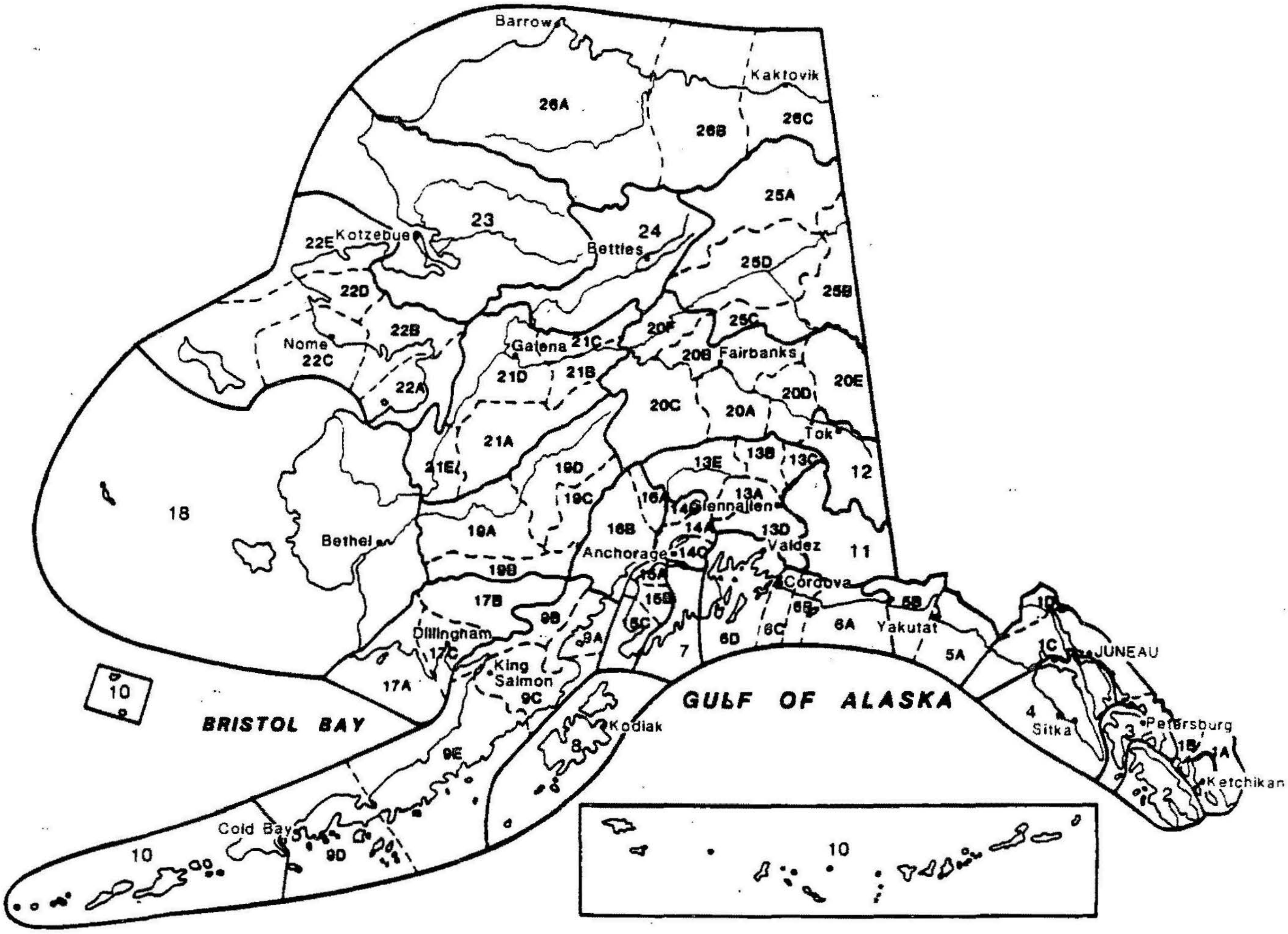
Table 13. Causes of mortality of radiomarked moose calves in 3 studies conducted in Alaska's Unit 13 during 1977-1984.

	1977-78[1]	1979[2]	1984[3]	TOTALS
No. calves collared[4]	120	27	46	193
No. (%) killed by				
Brown bears	52 (43%)	12 (44%)	24 (52%)	88 (46%)
Black bears	0	0	4 (9%)	4 (2%)
Wolves	2 (2%)	NA-see "other"	3 (7%)	5 (3%)
Other	12 (10%)	4 (15%)	7 (18%)	23 (12%)
All causes	66(55%)	15(56%)	38 (83%)	120 (62%)

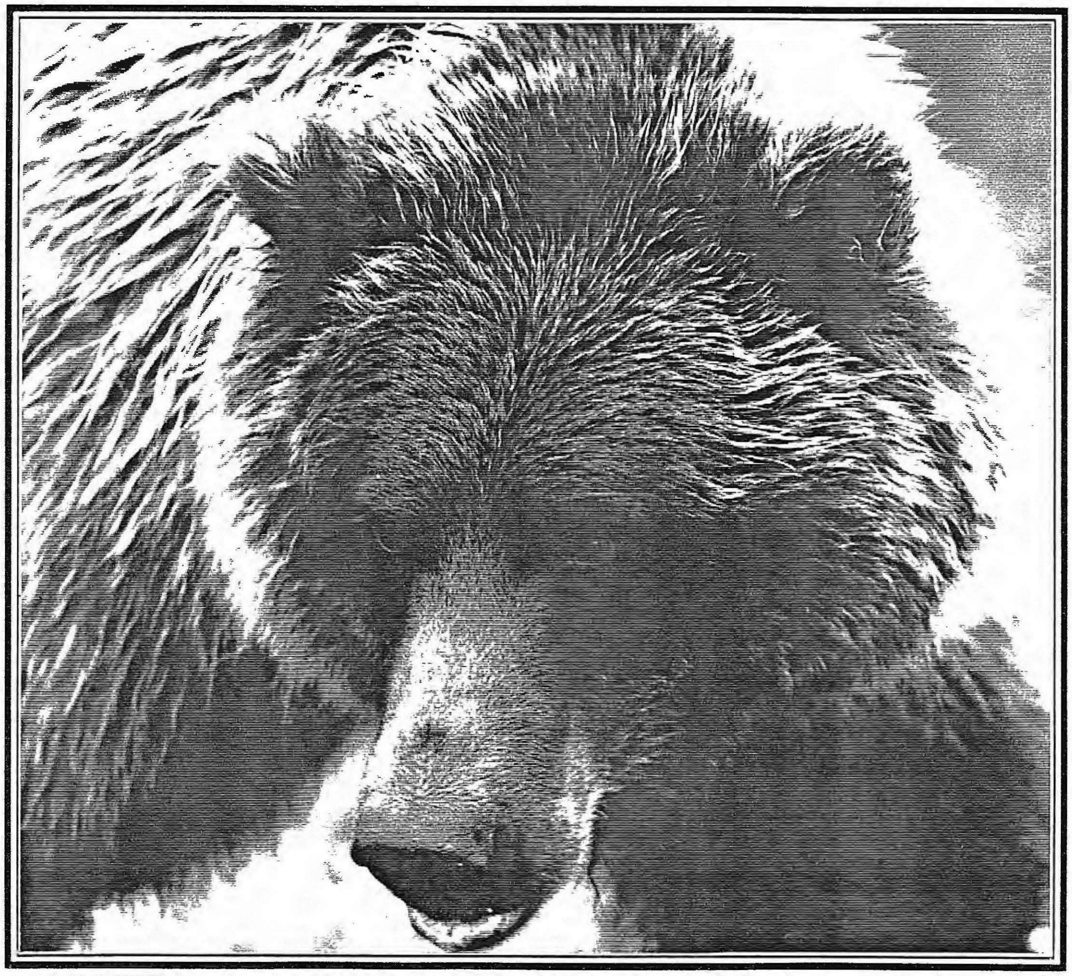
[1] Data from Ballard et al. (1981).
[2] Results obtained during bear transplant operation (Ballard et al. 1980).
[3] Data from Ballard et al. (1990).
[4] Excludes capture-related abandonments and deaths.

NOTES

Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitude for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.



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