Alaska Department of Fish and Game Division of Wildlife Conservation Federal Aid in Wildlife Restoration Research Progress Report

Impacts of Increased Hunting Pressure on the Density, Structure, and Dynamics of Brown Bear Populations in Alaska's Game Management Unit 13



by Sterling Miller Project W-23-4 Study 4.21 January 1992

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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: R. Tobey, C. Gardner

Project No.:	<u>W-23-4</u>	Project Title:	Wildlife Research and Management
Study No.	<u>4.21</u>	Study Title:	Impacts of increased hunting pressure on the density, structure, and dynamic's of brown bear populations in Alaska's Game Management Unit 13

Period covered: <u>1 July 1986-30 June 1991</u>

SUMMARY

Brown bear (Ursus arctos) population estimates were obtained by extrapolation from areas with measured density. Estimates made by a skilled local observer (H. McMahan) were obtained and compared with those made earlier by a team of 3 biologists. These estimates should be considered best guesses on bear population size in the mid 1980s. Subsequent heavy harvests probably have caused a decline from these levels. In Subunit 13A, biologists estimated 232 bears (all ages) compared to 238 for McMahan. In Subunit 13B estimates were 148 and 185: in Subunit 13C estimates were 112 and 185: in Subunit 13D estimates were 371 and 281; and in Subunit 13E they were 364 and 411 for estimates by biologists and McMahan, respectively. For all Game Management Unit (GMU) 13 the population estimate was 1,228 for the biologists and 1,235 for McMahan. Regardless of whether the estimates by biologists or McMahan were used, throughout most of the 1980s, actual harvests exceeded calculated sustainable levels in all 5 subunits in GMU 13. These calculations verified earlier reported empirical results that indicated a significant decline in bear densities in northern Subunit 13E. Estimated sustainable harvest numbers in GMU 13 should not exceed 66-68 bears. Harvests should not exceed 13-14 bears in Subunit 13A, 8-10 in Subunit 13B, 6-7 in Subunit 13C, 15-20 in Subunit 13D, and 19-23 in Subunit 13E.

An analysis of moose (*Alces alces*) calf:cow ratios before and during the period of bear reduction in GMU 13, and in just the northern portion of GMU 13, provided no basis for a conclusion that the regulation changes that caused the reduction in bear density resulted in increased survivorship of moose calves. Recent declines in moose numbers and in calf

survivorship following severe winters suggest that moose numbers may be near appropriate levels for available habitat.

Updated information on black bear (Ursus americanus) reproductive rates in GMU 13 is presented. Mean litter size for 65 litters of cubs-of-year (COY) was 2.2 (range = 1.4), for 43 litters of yearlings it was 1.9 (range = 1-3). Of 91 COY known born, 27% were lost before emerging from dens as yearlings. This mortality rate was higher in the upstream area above Devil's Canyon (34%) than in the downstream area (4%). Mean age of first litter production was 5.9 years. Mean interval between 52 successive successful litters raised to exit from dens as yearlings was 2.6 years (range = 2-5). Of these intervals, 54% were the minimum period of 2 years. The 25 intervals >2 years resulted from skipping year(s) following weaning in 17 cases (68%), from weaning offspring at age 2 in 3 cases (12%), from loss of whole litters in 2 cases (8%), and from combinations of these causes in 3 cases (12%).

Key words: Alaska, brown bear, black bear, Ursus arctos, U. americanus, density estimate, population trends, reproductive rates, litter size, reproductive interval, age of first reproduction.

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BACKGROUND

Little is known about trends in bear populations in Game Management Unit (GMU) 13 before the 1980s. Between 1948 and 1953, the federal government conducted a poisoning campaign directed at wolves in this area which reduced wolf numbers to as few as 12 wolves (Rausch 1969, Ballard et al. 1987). Since this poison was distributed around carcasses of dead animals, mortality to bears that scavenged these carcasses occurred "often" (Rausch 1969:126). After statehood, bears were managed conservatively and populations probably gradually increased over the next 10-20 years.

Research conducted in the late 1970s indicated that brown bears were killing many moose (*Alces alces*) calves and that an experimental reduction in bear densities resulted in increased calf survival (Ballard and Larsen 1987, Ballard and Miller 1989). This research was done when the moose population that had declined during severe winters of the early 1970s was just beginning to increase (Ballard et al. 1991). The calf mortality results led the Alaska Board of Game to liberalize hunting opportunities for brown bears in GMU 13 as well as in many other portions of southcentral Alaska (Miller 1990a). This resulted in increased bear harvest (Miller 1990b) and, at least in northwestern GMU 13, a documented decline in brown bear densities (Miller 1988, 1990b,c). Indirect evidence based on kill densities suggested that harvests exceeded sustainable levels in most portions of GMU 13 (Miller 1990c).

Regulations and harvests in GMU 13 from 1961 to spring 1991 are presented in Table 1.

OBJECTIVES

- 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 brown population subjected to heavy harvest rates.
- 3. Investigate the hypothesis that brown bear cub survival is inversely related to hunting pressure or the proportion of adult males in the population.

RESULTS

Final reports on objective 1 were presented by Miller (1988, 1990c). Progress on objective 2 was presented by Miller (1990b). Data on brown bear reproductive rates accumulate slowly and will be summarized in next year's final report for this project. To assure continuity of reproductive data, radio-transmitters were replaced on 11 bears during this report period. These bears were: 340, 388, 335, 281, 273, 314, 423, 337, 283, 396, and 460. Radio-marked bears were monitored to document changes in reproductive status. Based on data collected on objective 3 during this study, there was no demonstrable effect from reduced bear densities on cub survival (Miller 1990b,f). Reproductive rates are reported for radio-marked black bears (*Ursus americanus*) originally marked in GMU 13 as part of Su-hydro investigations (Miller 1987, 1988).

Publications

During this report period 1 publication was prepared and published (Miller, S. D. 1990. Impact of increased bear hunting on survivorship of young bears. Wildl. Soc. Bull. 18:462-467). Reviewers comments were incorporated and a manuscript was resubmitted that described the absence of demonstrable effects of hunter-induced reductions in bear density on growth of moose populations in GMU 13 (Ballard and Miller in prep.--Appendix B). The first draft was prepared and reviewed by coauthors of a manuscript describing results of all capture-mark-resight bear density estimates in Alaska (Miller et al. in prep.).

Estimated Brown Bear Population in GMU 13 Subunits

Techniques are not available to estimate brown bear population size in large areas (Harris 1986, Miller 1990d). One method that has been used to obtain such estimates is to

subjectively extrapolate from a smaller area where bear density has been empirically estimated (Miller 1990d). In 1987, this was done by a team of 3 biologists (S. D. Miller, W. B. Ballard, and R. D. Tobey) based on the results of bear density estimates obtained in 2 portions of northwestern GMU 13. The resulting population estimates were reported by Miller (1990b:Appendix C). These population estimates were converted to density estimates for each subunit in GMU 13 and compared estimated sustainable harvest densities (Miller 1990b).

The validity of a population estimate obtained by extrapolation from areas of known density depends on our level of knowledge of the bear population in an area. Before a study designed to estimate bear density near Nome, Alaska, biologists were asked to guess the density and rank their level of familiarity with the bear population in the area. Biologists with a high level of familiarity were able to make consistently better guesses about bear density in the area than could persons with less or no familiarity with the area. This was true even when the persons with little familiarity with that specific study area were, otherwise, expert bear biologists (Miller and Nelson, unpublished data).

To derive an independent estimate of bear population size in GMU 13, Mr. Harley McMahan, a highly respected pilot and hunting guide was asked to extrapolate from the 2 study areas where density was known in the same manner as was done by the 3 biologists in 1987. Mr. McMahan has spent most of his life in GMU 13, has participated in both bear density estimates in this unit as well as 2 similar estimates in GMU 9 (Alaska Peninsula), and is widely regarded by ADF&G staff as a keen and expert observer of wildlife. Mr. McMahan was provided with a map of GMU 13 and was asked to draw polygons on the map and to estimate density in each polygon as a function of the density in the northwestern GMU 13 study areas. The area in each of these polygons that overlapped each subunit in GMU 13 was then determined and multiplied by this function to obtain a population estimate for the portion of each polygon in a subunit. These polygon population estimates were summed to obtain a population estimate for each subunit and this population estimate was divided by the area of the subunit to obtain a subunit density estimate. As noted elsewhere (Miller 1990b), population estimates obtained in this way probably have more of an overestimation bias than an underestimation bias under circumstances where population numbers are declining. This is because one's recollection of relative density in an area would probably reflect earlier observations when there were more bears. The results of McMahan's work is presented and contrasted with the biologists' estimates in Appendix A. Both estimates were remarkably similar.

Comparison of Actual and Sustainable Harvest Densities

Based on studies of reproductive and mortality rates of radio-marked bears in GMU 13, the upper limit for sustainable harvest levels was estimated as 8% of the population of bears >2.0 years-old or 5.7% of the population of bears of all ages (Miller 1988, 1990b,d). The upper limit for sustainable harvest density was calculated as 5.7% of

estimated population density (all bears) in each subunit. These values for the estimate for the 3 biologists and for McMahan are illustrated as horizontal lines of symbols in Figures 1-6. Actual harvest density based on reports from successful hunters is compared with this sustainable level for each subunit and for GMU 13 as a whole (Figs. 1-6).

For GMU 13 as a whole and for Subunit 13E, harvest density has exceeded estimated sustainable level for each year between 1978 and 1990, regardless of whether the biologists' or McMahan's estimate is used (Figs. 1 and 6). During 1980-1990, harvest density exceeded sustainable levels for 10 of 11 years in subunits 13A, 13B and 13C, regardless of the population estimate used (Figs. 2, 3, and 4). During this period, harvests in Subunit 13E exceeded sustainable levels for 7 of 11 years based on the biologists' estimate and for 9 of 10 years for the McMahan estimate (in 1988 harvests equaled sustainable levels for this estimate) (Fig. 5).

These analyses indicate that bear densities most probably declined throughout GMU 13 during the 1980s. In the northern portion of Subunit 13E, this decline was documented by contrasting density estimates obtained in 1979 with a significantly lower estimate obtained in 1987 (Miller 1988, 1990c). These analyses support the reduction in bag limit that was instituted in 1988 and a reduction in fall season length in 1990 (except in subunit 13D). These analyses provide no support for maintaining a distinct season in 13D compared to the rest of the unit.

Sustainable harvest numbers in GMU 13 subunits estimated as 8% of the estimated population of bears > 2.0 years-old was 13-14 bears in Subunit 13A, 8-10 bears in Subunit 13B, 6-7 bears in Subunit 13C, 15-20 bears in Subunit 13D, 19-23 bears in Subunit 13E, and 66-68 bears in the unit as a whole. The range in these estimates represents the population estimates made by McMahan and by the group of 3 biologists. These are probably overestimates of sustainable harvest levels since these harvests were exceeded during the 1980s. Populations and sustainable harvest numbers have declined as a result. Also, the estimate of sustainable harvest rate was calculated as an upper limit value using input levels of natural mortality that were best case scenarios.

Effects of Reduced Brown Bear Densities on Moose Calf Survival

In adopting the liberalized brown bear hunting seasons in GMU 13 in 1980, the Board of Game intended to reduce bear densities and thereby improve moose calf survival and moose population growth rates. An analysis has been conducted to determine if this result was obtained. This manuscript is now in review. Based on the reviewer's initial comments, the original manuscript was reduced by about half and analyses pertinent to the management situation in GMU 13 were deleted. The introduction and the section describing the impact on bears of an early draft of this manuscript were presented by Miller (1990b, Appendix A). The portions of the original manuscript dealing with trends in the moose population and conclusions are presented in Appendix B of this report.

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2000

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Figure 1. Comparison of GMU 13 brown bear kill density with estimated sustainable harvest density based on extrapolated population estimates from a group of 3 biologists and H. McMahan.



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Figure 2. Comparison of Subunit 13A brown bear kill density with estimated sustainable harvest density based on extrapolated population estimates from a group of 3 biologists and H. McMahan.



Figure 3. Comparison of Subunit 13B brown bear kill density with estimated sustainable harvest density based on extrapolated population estimates from a group of 3 biologists and H. McMahan.

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Figure 4. Comparison of Subunit 13C brown bear kill density with estimated sustainable harvest density based on extrapolated population estimates from a group of 3 biologists and H. McMahan.



Figure 5. Comparison of Subunit 13D brown bear kill density with estimated sustainable harvest density based on extrapolated population estimates from a group of 3 biologists and H. McMahan.



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Figure 6. Comparison of Subunit 13E brown bear kill density with estimated sustainable harvest density based on extrapolated population estimates from a group of 3 biologists and H. McMahan.

Calendar Year	Bag limit	Spring season	Autumn 7 season	Fotal No. days	Spring kill	Autumn kill	Total kill
1961	1/year	none	9/1-9/30	30	0	42	42
1962	1/year	none	9/1-9/30	30	0	32	32
1963	1/year	none	9/1-9/30	30	• 0	43	43
1964	1/year	none	9/1-9/30	30	0	38	38
1965	1/year	none	9/1-10/15	30	1	47	48
1966	1/year	none	9/1-9/30	3 0 ·	0	63	63
1967	1/year	none	9/1-9/30	30	0	32	32
1968	1/4years ¹	none	9/15-10/15	21	0	39	39
1969	1/4years	none	9/20-10/20	31	0	17	17
1970	1/4years	none	9/15-10/5	21	0	26	26
1971	1/4years	none	9/1-10/5	35	0	70	70 .
1972	1/4years	none	9/10-10/10	31	0	48	48
1973	1/4years	none	9/10-10/10	31	0	45	45
1974	1/4years	none	9/1-10/10	40	0	72	72
1975	1/4years	none	9/1-10/10	40	0	80	80
1976	1/4years	none	9/1-10/10	40	0	59	59
1977	1/4years	none	9/1-10/10	40	1	40	41
1978	1/4years	none	9/1-10/10	40	2	62	64 (continued)

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Table 1. Brown bear regulations and harvests in Alaska's GMU 13, 1961-1990.

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Calendar Year	Bag limit	Spring season	Autumn season	Total No. days	Spring kill	Autumn kill	Total kill	
1979	1/4years	none	9/1-10/10	40	0	73	73	
1980	1/4years	5/10-5/25	9/1-10/31	56	15	69	84	
1981	1/4years	5/10-5/25	9/1-10/31	77	24	58	82	
1982	1/year ¹	4/25-5/25	9/1-12/31	153	23	59	82	
1983	1/year	1/1-5/31	9/1-12/31	273	36	81	117	
1984	1/year	1/1-5/31	9/1-12/31	273	47	77	124	
1985	1/year	1/1-5/31	9/1-12/31	273	54	91	145	
1986	1/year	1/1-5/31	9/1-12/31	273	45	91	136	
1987	1/4years ¹	1/1-5/31	9/1-12/31	273	46	58	104	
1988	1/4years	1/1-5/31	9/1-12/31	273	19	48	67	
1989	1/4year	1/1-5/31	9/1-12/31	273	25	52	77	
1990	1/4year	1/1-5/31	9/10-12/31 ³	263	40	40^{2}	80	
1991	1/4year	1/1-5/31	9/10-12/31 ³	263	50 ⁴	NA	NA	

Table 1. (cont.)

¹ Starting July 1 of year.

² Temporary ungulate season changes caused no overlap with autumn bear seasons for first time.
³ Except for 13D which remained 9/1-12/31.

⁴ Preliminary results.

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APPENDIX A

Appendix A. Memorandum describing results of H. McMahan's brown bear density extrapolation from northwestern GMU 13 to the rest of the unit and comparisons with extrapolations made by biologists.

To:	Bob Tobey Div Wildl Conserv	Date: May 15, 1991
	Glennallen	Phone: 267-2203
From:	Sterling Miller	Subject: Harley McMahan's
	Div. Wildl. Conserv.	GMU 13 brown bear population
	Anchorage	estimate

This memo is designed to document the techniques and results from Harley McMahan's effort to extrapolate from our bear density estimation study areas in GMU 13 to the rest of GMU 13. Harley did this based on my request. For the record I'll state that both you and I know that Harley is an extremely skilled wildlife observer, guide, and pilot with extensive experience throughout GMU 13 and flew one of the aircraft during both the 1985 and 1987 density estimates in GMU 13.

Our 1985 density estimate in the Su-hydro area was 7.02 bears/100 sq. miles (for bears of all ages) or 4.87 for bears ≥ 2.0 . Our 1987 density estimate in the upper Susitna area yielded density estimates of 2.77 and 1.66 bears/100 sq. miles for all bears and bears >2.0, respectively. We also derived separate density estimates for the lowland Monihan and upland Clearwater portions of the 1987 area. The Monihan portion had a density of 3.24 and 2.16 bears/100 sq. miles for all bears and bears >2.0, respectively. The more mountainous Clearwater portion had a density of 1.9 and 1.1 bears/100 sq. miles for all bears and bears >2.0, respectively. Slight differences between these estimates and those reported by Miller (1988, 1990a) reflect differences between the bear-days estimator originally used and the maximum likelihood estimator currently being used for the same data.

Harley's estimates are compared with those derived from a similar exercise conducted by you, Ballard, and myself that was reported in my July 16, 1987 memo to you (reprinted as Appendix C in Miller 1990b:86). This memo will be included as an appendix to my next report on the GMU 13 brown bear project currently in preparation. In the effort the 3 of us made, we classified some areas as a function of the 1985 estimate and others as functions of the 1987 estimate. Harley did not use the 1987 estimate and classified everything as a function of the 1985 estimate. Harley also did not backdate his estimates to a single point in time, as can be seen from the following quote from his March 24, 1991 letter:

The percentage numbers are my impressions of bear densities over a period of years and varying seasons. I know you would have liked me to pin it down to '85 so there could be a direct parallel to that census, but I can't honestly do that. My unit-wide experience has been over an extended time period. However, I think that my estimates are valid for 1985 and wouldn't change much had all my experience been limited to that year alone. In most cases I haven't witnessed big population shifts in short (1-3 year) periods of time and I am drawing from a period that spans '85. The exception I know of where I think numbers did change radically is the upper Gakona River, west across the northern slopes of the Alphabets to Dickie Lake and north to the Denali Highway subsequent to the opening of the April bear season. Snowmachiners with rifles, not necessarily bear hunters, invaded this area and killed bears indiscriminately. There may now be а belated snowmachine-airplane push into the area between Coal Creek and Brushkana.

I hope you can glean something from my estimates, but would sure caution against using them as the basis for any major decisions. They are just too speculative.

Harley did not make an estimate in some areas, mostly in the mountains of western 13E and southern 13D, because he was unfamiliar with these areas; these are listed as "unk" in the attached table. However, some value had to be included for these areas in order to derive a population estimate for each subunit and for the unit as a whole. Because I still have the overlay for the extrapolation we made, I overlaid this on Harley's extrapolation and used our values for the areas Harley listed as "unknown". Values used are listed in the column labeled substitute stratification factor. Also, Harley did not include portions of our census areas in his extrapolation so I put in the "known" values for number of bears in these areas obtained during our census.

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Results from Harley's work are presented in the attached table and compared with our 1987 estimate. As you can see our estimates for bears of all ages are essentially the same for 13A (+2.5%), 13C (+6.8%), 13E (+11.4%), and the whole of GMU 13 (+0.5%). Harley's estimate is less than ours in 13D (-32%) and greater than ours in 13B (+19.9%). Differences are somewhat larger for estimates of bears >2.0 (see attached). These results are much closer to ours than I expected. The biggest difference is in 13D and some of this may result from the large area in the eastern mountains of this subunit (44% of the subunit) with which Harley was "unfamiliar". However, as I've said previously, I believe our 1987 estimate for 13D was overly generous (1-1.2 the MIDSU estimate for most of 13D). As a result, I'm not surprised that Harley's estimate is lower and I think it likely that he is closer than we were. It is interesting that Harley's estimate was higher than ours in 13B since, as he noted-above, he is fully aware of the reduction in bears in the Gakona

River-Alphabet hills area caused by spring snowmachine hunters. I believe this is because Harley used the 1985 area as his yardstick whereas we classified this area as essentially similar to the 1987 census area which we knew had been overhunted during the 1980s.

I believe there is a natural tendency to overestimate in circumstances where impressions of bear density are gained over a period of time during which populations are declining. Under these circumstances, a person would tend to base his estimate on his recollection of having seen more bears in an area than could be seen there currently. As a result, I believe it is more likely that both Harley's and our estimates are overestimates than underestimates.

Harley's cautionary statement listed above notwithstanding, I believe it is clear that a conclusion that the GMU 13 population has been harvested in excess of sustainable levels during the 1980s (Miller 1988, 1990b) is supported by this additional analysis. This analysis also casts doubt on the population estimation that was used to justify a different season in 13D than in the rest of GMU 13. It also supports my contention that the bear population in 13A is more likely to be declining than increasing. This counterdicts the impressions of some of the residents in that area who feel that bears are underexploited and increasing in that area.

Citations:

- Miller, S. D. 1988. Impacts of increased hunting pressure on the density, structure, and dynamics of brown bear populations in Alaska's Game Management Unit 13. Alaska Dep. fish and Game, Fed. Aid in Wildl. Restoration Research Progress Report on Project W-22-6. Sept. 151pp.
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- cc: Craig Gardiner Ken Pitcher Karl Schneider Harley McMahan, PO Box 138, Gakona, Alaska 99586 Warren Ballard

Append-A

Table 2. Estimation of bear population in GMU 13 based on Harley McMahan's extrapolation from the 1985 Su-hydro estimate (7.0 all ages/100 mi2 or 4.9 >2.0/100 mi2).

			HARLEY'S STRATI-	SUBSTITUTE STRATI-	ESTIN NUMBI	ÍATED Er of
			CATION	CATION	BEA	ARS
	sg. in.	sq. mi.	FACTOR	FACTOR*	ALL	>2.0
SUBUNI	T 13A	_				
a3	96.16	1497.0	0.775		81.2	56.8
a2	83.51	1300.1	0.95		86.5	60.5
a1	55.12	858.1	0.875		52.6	36.8
A?	49.62	772.5	unk	1.25(upsu)	17.8	16.1
13A	TOTAL	4428		, <u> </u>	238	170
ACTU	AL AREA	4528				
% diff	. in are	a 2.2				
Tobey,	Ballard	& Miller	1987 estimat	9 =	232	157
% diff	erence i	n Harley's	estimate =		2.5	7.8
SUBUNI	T 13B					
b4	22.25	346.4	0.55		13.3	9.3
b5	11.48	178.7	unk	'87 Clearwater	3.4	2.0
b3	42.67	664.3	0.6		27.9	19.5
bl	94.84	1476.5	0.95		98.2	68.7
b2/87	65.49	1019.5	0.55		39.3	27.5
b6	9.35	145.6	unk	'87 Clearwater	2.8	1.6
13B	TOTAL	3831			185	129
ACTU	AL AREA	3987				
% diff	. in are	a 3.9				
Tobey,	Ballard	& Miller	1987 estimate	e =	148	96
% diff	erence i	n Harley's	estimate =		19.9	25.4
SUBUNI	T 13C					
c2	55.64	866.2	0.8		48.5	34.0
c 1	77.32	1203.7	0.85		71.6	50.1
13C	TOTAL	2070			120	84
ACTU	AL AREA	2044				
% diff	. in are	a -1.3				
Tobey,	Ballard	& Miller	1987 estimat	e =	112	75
% diff	erence i	n Harley's	estimate =		6.8	10.8
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			HARLEY'S STRATI- CATION	SUBSTITUTE STRATI- CATION	ESTIN NUMBI BEZ	MATED ER OF ARS
	sq. 1n.	sq. mi.	FACTOR	FACTOR*	ALL	>2.0
SUBUN.	LL T3D	1461 0	0.05		60.0	
d1	93.86	1461.2	0.85	86.9	60.9	
d2	/0.49	1097.4	0.8	61.5	43.0	
d3	43.71	680.5	0.6	28.6	20.0	
d?1	63.95	995.6	unk	1.5(upsu)	41.4	24.8
d?2	19.64	305.8	unk	1.5(upsu)	12.7	7.6
d?3	18.93	294.7	unk	1.5(upsu)	12.3	7.3
d?4	58.07	904.0	unk 🐭	1:5(upsu)	37.6	22.5
13D	TOTAL	5739	281	186		
ACT	UAL AREA	5771				
% dif	f. in are	ea 0.6				
* "un	familiar"	43.6				
Tobey	, Ballard	l & Miller	1987 estima	te =	371	251
% dif	ference i	In Harley's	estimate =	: ••	-32.0	-34.8
SUBUN	TT 13E					
_1	48 93	761 7	1 1		58 7	41 1
□2	31 16	485.1	1.05		35.7	25 0
<u>حع</u>	39 58	616 2	1.05		34 5	22.0
	26 43	411 5	0.0		25.0	18 1
67 05	20.4J A1 79	411.5	0.9		43 3	30.3
eJ a?1	204 59	2194 0	0.35 10k	0.75(mideu)	167 0	116 2
086	204.30	JI04.9	unk	known	25 7	24 7
007	3/.39	202.1		Mon Improv	22.1	24.7
120		203.0		MOIL KHOWH	9.2	206
120	TOTAL	6975			411	280
ACT ALL P	GAL AREA	6530			/•	
6 QII	r. in are	ea -6.8				
Topey	, Ballard	& Miller	1987 estima	te =	364	243
% aif	ference i	in Harley's	estimate =		11.4	14.9
ALL G	MU 13	23043			1235	855
ACT	UAL AREA	22857				
∦ dif	f. in are	ea -0.8				
Tobey	, Ballard	& Miller	1987 estima	te =	1228	823
∛ dif	ference i	in Harley's	estimate =	:	0.5	3.7

Table 2. (Con't.)

* In areas where Harley McMahan did not estimate a stratification factor, the factor used by Tobey, Miller and Ballard was substituted or the estimated value for the study area was used ("known").

Other reference densities: Clearwater est. = 1.9/100 mi2 (all) or 1.1/100 mi2 (>2.0) Monihan est. = 3.24/100 mi2(all) or 2.16/100 mi2 (>2.0) UPSU est. = 2.77/100 mi2(all) or 1.66/100 mi2 (>2.0)

APPENDIX B

Draft date = Dec. 28, 1990

ANALYSIS OF AN EFFORT TO INCREASE MOOSE CALF SURVIVORSHIP BY INCREASED HUNTING OF BROWN BEARS IN SOUTH-CENTRAL ALASKA

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RESULTS AND DISCUSSION

Bear Population Trends and Harvests (See Miller 1990b:Appendix A)

Moose Population Trends

Moose in GMU 13 increased during the 1940's and 1950's. This increase was attributed to favorable range conditions, mild winters, low numbers of wolves and bears (caused by federal poisoning programs), and low harvests (Bishop and Rausch 1974, Ballard et al. 1991). Based on number of moose observed per hour of survey time, the population apparently peaked about 1963. Subsequently, it declined following severe winters (in 1965-66, 1971-72, and 1974-75) and periods of high predation (Ballard et al. 1991). Record low numbers were reached in 1975 (Ballard et al. 1991). During 1976-1988, moose populations steadily increased although a severe winter in 1978-79 resulted in substantial moose mortality (Ballard et al. 1991, Fig. 7). The increase was attributed to a combination of relatively mild winters, reduced numbers of wolves and bears, and reduced human harvests (Ballard et al. 1991). The winter of 1988-89 may have been more severe in localized areas than average winters and appeared to have caused some decline in moose numbers. The winter of 1989-90 was severe (winter severity index [Ballard et al. 1991] = 28.5), and wolf densities were relatively high. Significant losses of calf and adult moose occurred (R. Tobey and C. Gardner, ADFG, Glennallen, Ak., pers. commun.).

Moose population increases during the 1980's were also indicated by quadrat-sampling techniques (Gasaway et al. 1986) used in CA 3 during autumns of 1980 and 1983. Here, moose densities increased from 688 moose/1,000 km² (90% $CI = \pm 8\%$) to 848/1,000 km² (90% $CI = \pm 10.3\%$) (Ballard et al. 1991). These data suggest an annual compounded growth rate of 7.2%. Assuming the same rate of population growth prior to 1980, moose density at the 1975 low point could have been about 486 moose/1,000 km². Further assuming the same rate of population growth subsequent to 1983, the autumn 1989 moose density would have been 1,287 moose/1,000 km².

The 1989 moose density is similar to that estimated using the 1983 ratio between moose/hr observed during survey flights and quadrat density estimates. In 1983, 417 moose/1,000 km² were counted during autumn trend counts in CA 3. This represents 49% of the density estimated using the quadrat sampling approach. In 1988, 497 moose/1,000 km² were actually counted in this area during fall trend counts. Assuming the same ratio to actual density as obtained in 1983, the actual density would have been 1,010 moose/1,000 km² in 1988, slightly lower than estimated by extending the 1980-1983 growth rate. Trend-count information obtained in 1989 was not used in this comparison because this winter was accompanied by atypical counting conditions that may have inflated moose/hour and sex-age ratios (R. Tobey, pers. commun.).

Within the Susitna River study area which included CA-3 and two adjacent moose count areas (one of which included the Susitna River dam study area where bear numbers were not reduced), trends in moose numbers and composition followed the same pattern as in the rest of GMU 13 (Ballard and Whitman 1988; Ballard et al. Here, 1983 moose densities in a 7.586 km² study area were 600-700 1991). $moose/1,000 \text{ km}^2$ (Ballard and Whitman 1988). The growth rate of this population was estimated at 3-6% by Ballard et al. (1991). Assuming a 1983 population density of 650 moose/1,000 km² and annual compounded growth rates of 3-6%, the 1975 moose density at the 1975 low point was 409-515 moose/1,000 km². Since the last density estimate in 1983, the moose population has continued to increase. During autumn composition and trend counts, moose observed per hour increased from 48 in 1983 to 52, 56, and 76 during 1984, 1985, and 1986, respectively (ADFG unpublished data for CA 7). This area has not been surveyed since 1986. At a 3-6%annual growth rate since 1983, the 1989 moose density would be 776-922 $moose/1,000 \text{ km}^2$.

<u>Proximity to Carrying Capacity for Moose.</u> Little is known about carrying capacity of moose habitat in GMU 13. Recent moose densities in GMU 13 were within the upper 25% of moose densities reported in Alaska using similar techniques (Ballard et al. 1991), but this list includes many areas where carrying capacity is lower. Productivity of ungulate populations should decline when populations are nutritionally stressed (Blood 1974, Albon et al. 1983, Franzmann and Schwartz 1985). Such stress should occur when populations approach carrying capacity of their range.

In the early 1980's, pregnancy rates of GMU 13 cow moose were high (81%) with no indication of a declining trend (Ballard et al. 1991). Twinning rates in a Kenai Peninsula area where habitat had declined in quality was 22% compared to a record high of 70% during 1 year in a highly productive habitat (Franzmann and Schwartz 1985). In GMU 13, the overall twinning rate at parturition was intermediate in this range (38% overall, range = 17-63% in different years) (Ballard et al. 1991). The latter is a relatively high twinning rate and provides little indication of depressed productivity. These data provide no clear indication that the moose population is currently at or above the number that can be supported with minimal mortality through an average winter.

Carrying capacity, however, is a complex concept (McNab 1985). In a management context, the appropriate carrying capacity can be usefully defined as the number of moose that can survive without heavy mortality during a severe winter (here termed moose target density or MTD). It is clear that MTD can be exceeded during a series of mild winters without being indicated by declines in productivity. It is our subjective impression that the 1989 moose population in GMU 13 was near or above MTD for this area which may explain high mortality of calves and adults during the severe winter of 1989-90. Our speculation was supported by the number of moose observed per hour of survey in annual trend counts in GMU 13. This index in the late 1980's was near the level of the mid-1960's, prior to declines correlated with a series of severe winters.

The MTD for moose in GMU 13 appears to be about 1 moose/km² if our analyses and assumptions are correct. At the low point in 1975, moose density was about half of MTD, and in 1979, when the bear transplant was accomplished and calf:cow ratios increased in response to reduced bear numbers, moose density was about 70% of MTD. During the period of increased bear harvests, moose density was >70% of MTD.

Moose Calf Survivorship

Increases in moose calf:cow ratios like that observed following the 1979 bear transplant should have resulted from reductions in bear predation on moose calves if such mortality was additive.

<u>Hypothesis Simulations</u>. We modeled calf:cow (≥ 1) ratios following increases in spring calf survival to determine if increased calf:cow ratios would be expected. Increased survival could be masked in calf:cow ratios by increased numbers of yearling and other young cows which have lower productivity than adults.

When moose calf survivorship increased in 1 year and remained at that level, the simulated autumn calf:cow ratios increased greatly in the first year, declined during the second year in response to increased number of yearling cows, and then stabilized

at a level higher than would have existed if no change had occurred (Fig. 8). When calf survivorship was set at 0.3, calf:cow ratios stabilized at 27.5. When survivorship increased to 0.4 and 0.6, calf:cow ratios stabilized at 34 and 44 calves/100 cows, respectively (Fig. 8). When there was a steady increase in calf survivorship from year-to-year, simulated autumn calf:cow ratios increased steadily over time (Fig. 9). In this scenario, when we simulated progressively later ages of full maturity for cows, calf:cow ratios would initially decline followed by a steady increase (Fig. 9).

We also modeled expected calf:cow ratios within CA 3 with a deterministic moose population model based on moose and predator data collected within the Susitna River Study Area (including CA 3 during 1975 through 1986. The model's assumptions and calculations were described by Ballard et al. (1984, 1986). For the scenario depicted in Fig. 10, we assumed average adult moose productivity of 1.13 calves/adult cow and used survival and mortality estimates derived from studies of radio-collared moose (Ballard et al. 1991). Estimates of moose mortality due to wolf predation were based on estimated spring and autumn wolf densities (Fig.) and assumed, based on results of scat analyses, that 35% of the spring-early summer wolf diet was composed of calf moose (Ballard et al. 1984, 1986, 1987). Estimates of brown bear densities were derived from Miller and Ballard (1982a). We assumed a stable bear population until 1979 when 60% of the bears were transplanted away from the area. After 1979 we assumed the bear population was permanently reduced by 36% as a result of increased bear hunting and residual effects of the transplant experiment. Bear predation rates on calf moose were derived from Ballard et al. (1990). Prior to 1980 we used a predation rate of 0.14 calf moose/bear/day for a 60-day period in late spring and early summer. After 1980 we assumed a compensatory increase in bear predation rates up to 0.16 calves/bear/day. In all simulations all mortality was assumed additive. Based upon these assumptions it was possible that increases in calf survival as a result of reducing bear numbers during the 1980's could have been partially or totally negated by increases in wolf numbers (Fig. 10).

<u>Calf:Cow Ratios</u>. Based on the above scenarios, if bear predation was additive to other sources of calf mortality, an increase in calf:cow ratios following the bear transplant in CA 3 should have occurred as reported by Ballard and Miller (1990) (Fig. 9). If bear and wolf densities and calf survivorship had remained at post-transplant levels, calf:cow ratios should have declined the following year but remained higher than prior to the transplant (Fig. 8). In the year following the transplant, moose calf:cow ratios returned to pre-transplant levels and stayed at that level (Ballard and Larsen 1987) (Fig. 11). This suggests that moose calf survivorship returned to pretransplant conditions during initiation of increased bear seasons and harvests in 1980.

During 1980-1989, calf:cow ratios in CA 3 were not significantly different from stable. If 1989 data were included, the slope in calf:cow ratios since 1980 was negative but not significant (Fig. 11). If 1989 data are excluded, the regression had a positive slope that was also not significant (P = 0.47). If the bear reduction resulted in

increased survivorship of moose calves in an additive fashion as expected, an increase in calf:cow ratios would have been observed (simulation illustrated with Fig. 9); this did not occur. In CA 3, the bear harvest liberalization (1980-1989) had a significantly lower effect on calf:cow ratios than the transplant experiment (t test, $\mathbf{P} = 0.006$). The same conclusion was reached excluding the low ratio observed in 1989 ($\mathbf{P} = 0.002$).

Calf:cow ratios for all of GMU 13 exhibited similar trends as those for CA 3 (Fig. 12). During the period 1980-1989 when high bear harvests occurred, there was no trend in calf:cow ratios. If 1989 data were included, the slope was negative but non-significant (P = 0.53) (Fig. 12). Excluding 1989, the slope was positive but also not significant (P = 0.14).

However, in both CA-3 and in all of GMU 13, wolf densities increased, and improved calf moose survival from bear reductions could have been negated by wolf predation. In addition, annual variation in count data, particularly in CA-3, could have masked smaller increases than those reported in 1979.

In CA 3 and as well as in all GMU 13, better fits to the moose survey data were obtained by plotting the 1976-1988 period of moose population growth (Ballard et al. 1991) instead of the period before and after initiation of bear reductions (Figs. 9 and 10). A regression of calf:cow ratios from 1976-1988 indicated a steady increase in calf:cow ratios as a result of mild winter conditions, low hunter harvests which were largely restricted to bulls only, and relatively low numbers of bears and wolves during portions of this period (Ballard et al. 1991). This contrasts with the flat line obtained during the period of heavy bear hunting and wolf population increases to record levels (Fig. 12).

SUMMARY AND MANAGEMENT IMPLICATIONS

During the 1980's, increased brown bear harvests led to reduced brown bear densities in much of GMU 13. This reduction was especially well documented in a heavily-hunted northern portion of the unit that included CA 3, where a 1979 experiment involving a short-term reduction in bear density resulted in a significant 1-year increase in moose calf survivorship (Ballard and Miller 1990). Bear density in CA 3 in 1987 was estimated to be no more than 60% of that in 1979 and a third of the density in a nearby area with less hunting pressure.

The moose population began to recover from historic low numbers in 1975 (Ballard et al. 1991). This population recovery was underway when liberalized bear hunting regulations began in 1980. In the area where the 1979 bear reduction experiment occurred and where the subsequent decline in bear density was best documented, calf survivorship has not changed since the bear reduction began. In the latter area, calf survivorship remains well below the level that occurred in 1979 following a 60% experimental reduction in bear density.

Available data are inadequate to select between alternative explanations on why reduced bear densities apparently did not improve moose calf survival during 1980-1988. At the higher moose densities that existed during 1980-1988 when bears were being reduced by hunters, bear predation on moose calves may have been less additive than at the lower moose densities that existed in 1979. Compensatory increases in predation on calves by a growing wolf population may also explain the lack of response. Increased predation rates by the remaining bears may also have occurred. It is also clear that sampling variation in annual autumn sex-age composition surveys would make it difficult to detect small to moderate changes in calf survival difficult, particularly in CA-3. All of the above explanations may be correct to some degree.

Our findings are similar to those on Alaska's Kenai Peninsula where black bears were found to kill a large proportion of neonatal moose (Franzmann et al. 1980). The impact of this predation on moose population growth depended on the quality of the moose habitat; in high quality habitat bear predation had much less impact than in lower quality habitat (Schwartz and Franzmann 1989, 1991). In older successional stages where habitat quality is relatively low and winter is a controlling variable, reductions in predators would have relatively less impact (Theberge and Gauthier 1985, Schwartz and Franzmann 1989).

Because it will take decades of reduced hunting for Alaskan brown bear populations to recover (Miller 1990<u>b</u>,c), it appears that the management experiment in GMU 13 will have some unfortunate consequences. These include reduced hunting opportunities for bears and the possibility that the accelerating pace of industrial development and human settlement in this area may prevent bear densities from returning to previous levels. Perhaps one of the more unfortunate consequences is the public's perception that hunter-induced bear density reductions will always increase moose calf survivorship and, by extension, moose populations. Such perceptions, once in place, have proved intransigent to change or modify. For a variety of reasons, public support for fewer bears is usually more compelling than for more bears, in Alaska as elsewhere. We consider it unfortunate that a more cautious approach was not followed in south-central Alaska and that purposefully designed projects were not in place by which to evaluate the results of reduced bear densities on moose.

We are uncertain whether the recent restrictions in bear seasons in GMU 13 will be retained. Currently, a number of individuals residing in GMU 13 and adjacent areas are advocating that bear densities be even further reduced and that the liberal bear hunting regulations of the 1980's be re-implemented. These voices claim that bear populations have not declined or that they are still too high, that local and subsistence needs or preferences for more moose or caribou mandate still lower bear and wolf densities, and/or that problems between bears and increased human presence in formerly remote areas require still lower bear densities for human safety.

It is important not to overgeneralize from our results in GMU 13. Elsewhere, such as in east-central Alaska recovery of low density depressed moose populations may be slowed because of heavy predation on neonatal moose by bears and wolves (Boertje et al. 1987, 1988; Gasaway et al. 1983, 1988, in review). However, in our area, where the low point for the moose population was at a density close to the target range for interior moose populations (i.e. $500-1,000 \text{ moosc}/1,000 \text{ km}^2$ [Gasaway et al. in review]), and where moose and caribou populations were already growing, wolf densities had been greatly reduced, and bear densities were moderate, reductions in bear density appeared to be unnecessary to permit the moose population to recover to desirable levels within a decade. Until biologists design and execute proper studies to address whether hunter-induced declines in bear densities result in significant improvements to calf moose survival, the utility of bear reductions remains unclear and should not be considered as a routine management prescription for increasing moose populations.

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Figure severe (*) winters (based on index developed by Ballard et al. 1991) are depicted squares were not included in trend analyses. Area 3 11. of south-central Alaska during Tends in autumn moose calf:cow (≥ 2 years-of-age) ratios in moose Count 1970-1990. Trends in major predator species and Points illustrated by filled in

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CALVES/100 ADULT COWS



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Figure 12. were not included 13 of southcentral (1991) are depicted. *) or moderately severe (**) winters (based on index developed by Ballard et al Trends in autumn moose calf:cow in trend analyses. Alaska during 1970-1990. Trends in major predator species and severe $(\geq 2 \text{ years-of-age})$ ratios within GMU Points illustrated by filled in squares

Appendix C. Black bear repro (1988).	oductive data u	pdated from that presented by Miller
Table Cl. Summary of black bears with litte	k bear litter s ers of newborn	ize data based on observations of cubs.
MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B289 (10 in spring '81)	3	lost 1 in August, 2 survived
B289 (12 in spring '83)	2	lost l cub in September, other survived to den exit
B289 (14 in spring '85)	2 (in den) [2 at exít]	both survived to yearling age
B289 (16 in spring '87)	1	survived to August at least
B289 (18 in spring '88)	Х	had 1 @ COY in October (earlier?)
B301 (8 in spring '81)	2	both survived to yearling age
B301 (10 in spring '83)	2 (in den) [2 at exit]	survivorship undetermined female shed collar
B317 (7 in summer of '80)	2 (summer)	initial capture in summer, both survived to fall, cubs not seen with bear at initial capture
B317 (10 in '83)	2 (in den) [2 at exit]	lost l in June, other survived to den exit
B317 (12 in spring '85)	2 (in den) [2 at exit]	l sur v ived to den entrance, l lost in July
B317 (13 in spring '87)	2	survived to August, at least
B318 (5 in summer '80)	l (summer)	survived
B318 (8 in '83)	2 (den) [2 at exit]	both lost by 6/6/83 apparently, shed collar
B328 (7 in summer '81)	2 (summer)	bred in 1980. Lost 1 by 7/29/81, shed collar in den (not sure if survived until exit)
B328 (ll in spring '85)	3 (in den) [3 at exit]	lost 6/6 - 7/24
B328 (13 in spring '87)	3	survived to den entrance

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Table Cl. (Con't.)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B326 (5 in summer '80)	2 (summer)	bear shot in 1980, cubs may have been adopted by B317
B321 (11 in spring '81)	2	no cubs in summer 1980, both cubs lost by 8/24/81, no litter in '82, no litter verified in 1983 but may have lost a litter early in 1983, bred in 1983
B321 (1 4 in '84)	2	lost 1 of 2 by 6/29, other survived to den entrance
B 327 (5 in summer '80)	2 (summer)	both survived to yearling age
B32 7 (8 in '83)	2 (den)	cubs survived into June, female
B349 (6 in spring '83)	2 (den) [0 at exit?]	first litter, no cubs in summer '81 or spring '82, cubs apparently lost in May '83, collar shed in July no ylgs on 5/84
B349 (8 in spring '85)	2 (in den) [2 at exit]	one survived to den entrance, l lost in August
B349 (9 in '87)	2	survived to den entrance
B349 (12 in 1990)	2	survival (?)
B354 (5 in '82)	2	both survived to den entrance, at least l ylg at exit in '83
B354 (7 in '84)	2	may have lost 1 by den entrance date
B354 (9 in '86)	2	lost 1 in Sept., other ok to exit
B354 (11 in '88)	3	all survived
B354 (13 in '90)	2	1 lost by 6/30
B361 (8 in '83)	4 (in den) [3 at exit]	lost l in den prior to exit, others survived to den exit in '84
B361 (12 in '87)	2	survived to den entrance, l lost in den
B363 (6 in '84)	2 (in den) [2 at exit]	bear missing after 5/23/83, cubs alive at that time

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Table C1. (Con't.)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B363 (8 in '87)	2	survived to den entrance
B363 (10 in '89)	2	1 lost
B364 (10 in '86)	2	both survived to den exit
B364 (13 in '89)	2	both survived
B369* (6 in '84)	2 (in den) [2 at exit]	none lost to den entrance
B369* (9 in '87)	2	survived
B369* (12 in '90)	x	with at least 2 COY, saw sow 2 next spring
B370 (8 in '83)	2 (in den) [2 at exit]	bear missing after 5/23/83, cubs alive at that time
B372* (10 in '83)	3 (in den) [3 at exit]	lost 1 in early July, others survived to 7/20, female lost in September '83
B374* (7 in '83)	3	think lost 2 in July, bear shot in September '83
B375* (6 in '83)	2	both survived to exit in '84
B376* (5 in '83)	3 (in den) [3 at exit]	all survived to exit in '84
B376 (10 in '88)	2 (survival?)	
B377* (5 in '83)	[1-2??] NOT COUNTED	cubs may have been lost prior to or during capture, cubs not seen during capture but saw at least l cub 9 days earlier on 5/10/83
B377* (6 in '84)	some(in den) [0 at exit]	heard at least 1 cub in den, none seen at exit
B377* (7 in '85)	2 (in den) [2 at exit]	lost l in June, other in August- September
B377* (9 in '87)	3	at least 2 survived
B377* (11 in '89)	2	survival?

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Table Cl. (Con't.)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B378* (7 in '83)	2 (in den) [2 at exit]	both survived to '84 den exit
B378* (9 in '85)	1	survived to den entrance
B378* (11 in '87)	2	survived to den entrance
B379 (9 in '83)	3 (den) [2 at exit]	lost all cubs by 5/23/83, bred again, died in July
B402* (12 in '85)	2 (in den) [2 at exit}	both survived to den entrance
B402* (15 in '88)	2	.survival?
B404* (11 in '83)	1	survived thru 7/20/83 at least, not seen in '84
B405* (17 in '83)	2	both survived to den exit in '84
B406* (11 in '83)	2	both survived to den exit in '84
B409* (?)(6 in '84)	?	not observed in '84
B409* (7 in '85)	2	probable age = cub, survived
B409* (9 in '87)	2	survivorship?
B409* (17 in '89)	2	survival?
B410* (7 in '83)	2	both survived thru June, bear shot in July
B411* (9 in '84)	2	status at entrance into '84 den unknown
B438 (9 in '86)	3	B4 38 probalby shot by 9 /5/86, cub statu <mark>s unknow</mark> n
B441 (11 in '87)	2	survived
B329 (7 in '87)	2	l lost in June-Aug., other ok
B448 (8 in '87)	2	assumed lost when mother died

(continued on next page)

Table C1. (Con't.)

Total number of cubs	Number of litters	Mean litter size (range)	Comments (includes)
138	65	2.2(1-4)	all cub litters counted at earliest observation
123	58	2.12(1-3)	spring observations only (w/o den data or summer litters)
129	59	2.19(1-4)	earliest observation excluding summer litters
44	19	2.3(2-4)	observations in dens only

* Downstream study area

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B288 (10 in 1980)	3	bred in 1980, ylgs with female into August, shed collar in 1980
B289 (9 in 1980)	2	weaned by 5/22/80, bred, 3 cubs in 1981
B289 (13 in 1984)	1	with mon to September bred in June
B289 (11 in 1982)	2 (in den)	weaned by 6/9/82, bred, had 2 cubs in 1983
B289 (15 in 1986)	2	weaned by 7/9/86
B289 (17 in 1988)	1	weaned
B290 (8 in 1980)	2	<pre>weaned by 6/23/80, bred in 1981, collar removed on 8/5/81 (neck scarred)</pre>
B301 (7 in 1980)	1	weaned by 6/12/80, bred, had 2 cubs in 1981
B301 (9 in 1982)	2	weaned by 6/17/82, bred, had 3 cubs in 1983
B317 (8 in 1981)	2	weaned by 6/18/81, bred, 1 ylg returned and was with female until 9/9/81, no cubs in 1982
B317 (11 in 1984)	1	weaned in June, bred
B317 (15 in 1988)	2	weaned
B318 (6 in 1981)	1 (den)	ylg (B330) weaned by 5/29/81, bred, ylg died by 8/24/81, no (reason?) cubs in 1982, bred again, 2 cubs in 1983
B318 (10 in 1985)	2	B318 not located after 6/11/85
B327 (5 in 1981)	2 (den)	ylg B329 and sibling, sibling weaned by 6/5/81, B329 by 6/21, bred, no cubs in 1982, bred again, cubs in 1983
B 329 (8 in 1988)	1	

Summary of black bear litter size data based on observations of

bears with litters of yearlings (age at exit from den).

Table C2.

(continued on next page)

Table C2. (Con't.)

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ANTER

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B349 (9 in 1986)	1	
B349 (11 in 1988)	2	
B354 (6 in 1983)	1 (?)	at least 1 ylg exided den (perhaps) both?), weaned by 6/2/83
B354 (10 in 1987)	1	weaned after 6/7
B354 (12 in 1989)	3	weaned
B361 (13 in 1988)	1	weaned
B363 (8 in 1985)	2	weaned by 9/4/85
B363 (11 in 1988)	2	weaned
B364 (8 in 1984)	3	2 weaned early, bred, still with one in September
B364 (11 in 1987)	2	2 weaned in June
B369* (7 in 1985)	2 (in den) [2 at exit]	
B402* (10 in 1983)	3	weated in early July
B402* (13 in 1986)	2	weaned by September
B409* (8 in 1986)	2	probably age - l
B411* (8 in 1983)	2	weaned after 6/13
B321 (15 in 1986)	1	weaned by 6/27/85
B361 (9 in 1984)	3	entered den w/mom, weaned at age 2
B369 (10 in 1988)	2	weaned at age 2
B375* (11 in 1984)	2	weaned in June
B376* (8 in 1984)	3	weaned 2 in June, 1 with mom in October
B377* (10 in 1988)	2	weaned?
B378* (8 in 1984)	2	not seen after June

(continued on next page)

Table C2. (Con't.)

MOTHER'S ID (age-ye	ar) LIT	TER SIZE COMMENTS
B378* (14 in 1988)	. 3	weaned ?
B404* (12 in 1984)	[?]	'84 status not verified
B405* (18 in 1984)	2	with mon into August
B406* (12 in 1984)	2	weaned by September
B409* (16 in 1988)	2	weaned
B432 (6 in 1985)	1	weaned by 6/3/85
B441 (12 in 1988)	2	weaned
		٠ د
Total Number of ylgs. observed	Number of litters	mean litter size (range) Comments
82	43	1.91 (1-3) all litters with ylgs. counted

radio collar). Bears were in upstream study area unles otherwise indicated 290 (8 in '80) 301 (7 in '80) 317 (7 in '80) 289 (9 in '80) Year 1980 w/2@0 in August w/2@1 weaned in May-bred w/2@1 weaned in June w/l@l weaned in June 1981 w/3@0, 1 lost in Aug. alone, bred, collar w/2@0, w/2@1, weaned in June, removed bred, reunited w/1@1 through September 1982 weaned 2@1, May-June, bred w/2@1, weaned in June, no newborns, possibly - w/1@2 into June bred 1983 w/2@0, 1 lost in Sept. w/2@0, 1 lost in June - w/2@0, shot in Sept. 1984 w/1@1, weaned, June, weaned 1@1 in May, bred, - bred, reunited reunited June-Sept. weaned in Sept. predenning 1985 w/2@0, 1 lost in July, w/2@0, survived - -- other okay through Sept. at least 1986 w/2@1, weaned (date?) alone in June - -. .. 1987 w/1@0, survived w/200, survived - -- -1988 w/1@1, weamed (?) w/2@1, weaned - -÷ --(continued on next page)

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Reproductive histories of radio-marked female black bers. ("Shed" refers to removal by bear of Table C3.

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Table C3. (Con't.)

Year	289 (9 in '80)	290 (8 in '80)	301 (7 in '80)	317 (7 in '80)	
1989	w/1@0 in October			missing	
1990	missing				

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Table C3 Con't.)

Year	318 5 in '80	321 10 in '80	325 11 in '80	327 5 in '80	328 6 in '80	329 l in '81	349 4 in '81	354 5 in '82	361 7 in '82	363 4 in '82
1980	w/100 in Aug.	≜lone in Aug.	alone in Aug,	⊎/2@0 in Aug.	alone in Aug.	with mother 327				
1981	w/1@1, weaned in May, bred	v∕2@0, lost both in Aug.	alone, shed in next den	w/20l in den, 1 weaned in May, other in June, bred	w/2@0, 1 lost in July, other okay thru Sept., collar shed	weaned from 327 in June	alone			
1982	alone	alone		alone, bred	7	alone	alone	w/2@0, to den entrance	alone	alone, bred?
1983	w/2@0, suspect lost both June, shed	think lost litter very early, bred		√/2@0, mother died in July	7	alone, bred?	w/2@0, both lost in den	w/1@1 weaned in May, bred	√/4@0 in den, 1 lost in de	alone, bred en
1984	[must have had at least 2@0 based on 1985]	w/100 (in July)			alone, bred	alone, bred?	alone	w/2@0, 1 lost in Sept.	w/301 not weaned seen in de	w/2@0 survived
1985	w/2@1 in June when reported	w/101 weaned in June			w/3@0, all lost in June- July	alone, bred?	w/2@0 in den, 1 lost in August	alone (June) t	w/302, weaned in June	w/2@1 weaned, date?
1986	7	alone			alone	alone	w/1@1, weaned (date?)	v/2@0 (Sept.) 1 lost in Sept. 2	alone in June	alone, bred
1987		alone, died			w/3@0 survived	w/2c, 1 lost in June-Aug.	w/2c survived	w/1@l, weaned	w/2c, 1 lo≤t in den	w/2c, survived
		·			(continued on ne	XE PAGO)				

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Table C3 Con't.)

Year	318 5 in '80	321 10 in '80	325 11 in '80	327 5 in '80	328 6 in '80	329 1 in '81	349 4 in '81	354 5 in '82	361 7 in '82	363 4 in '82
1988					NOT SEEN	w/101 (7) •	w/2@1	w/3@0, survived	w/1@1, weaned	w/2@1, weaned
1989					shed	fallure	alone	w/ 3@1	failure	w/2@0 1 lost
1990							w/2@0 (survival	w/2coy 7) 1 lost by 6/30		alone?

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Table C3. (Con't.)

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Year	364 6 In '82	Downstream 367 4 in '82	Downstream 369 4 in '82	Downstream 370 7 in '82	Downstream 372 9 in '82	Downstream 374 7 In '82	Downstream 375 9 In '82	Downstream 376 6 in '82	Downstream 377 4 in 'B2	Downstream 378 6 in '82	Downstream 402 10 in '83
1982	alone, bred, collar failed	alone	alone	alone	alone, bred	alone?	v/3@1?	alone?	alone	alone	
1983	[must have had cubs based on 1984]	shot-alone	alone	₩/2@O, falled colla	w/2@0, arfailed coll:	w/3@0, ar2 died in July, shot in fall	₩/2@0, survived	₩/3@0	alone?	w/2@0, survlved	w/3@1, weaned in June
1984	<pre>v/3@1, weaned in June-July bred, reunited v/1 in Sep</pre>	 t.	2@0 in den lost 1 in Sept.				v/2@1 veaned in July	w/3@1, weaned in May, reunite in July and Sept.	alone ed	v/2@1, veaned	alone
1985	₩/1@2 in June		v/l@l weaned in June-July				shot in spring	alone?	w/2@0, 1 lost in June, other in July-Aug.	w/1@0, survived	₩/2@0
1986	w/2@0, survived thru Sept.		alone?				*-	alone	alone	alon e	w/2@1, survived
1987	w/2@1 weaned		w/2c, survived					alone, bred	v/3c, 2+ survived	w/3c, survived	alone

(continued on next page)

Table C3. (Con't.)

Year	364 6 in '82	Downstream 367 4 in '82	Downstream 369 4 in '82	Downstream 370 7 in '82	Downstream 372 9 in '82	Downstream 374 7 in '82	Downstream 375 9 in '82	Downstream 376 6 in '82	Downstream 377 4 in '82	Downstream 378 6 in '82	Downstream 402 10 in '83
1988	alone		w / 2@1					w/2@D survival	w/2@1	v/3@1	v/2@0 survival
1989	w/2c survived		w/2@2 weaned					failure	w/2@0 (survival?)	failure	failure
1990	not seen		w/200 survived to exit						fallure		

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Table D3. (Con't.)

Year 	Downstream 404 11 in 'B3	n Downstream 405 17 in '83	Downstream 406 11 in '83	Downstream 409 5 in '83	Downstream 410 7 in '83	Downstream 411 8 in '83	431 11 in '85	432 6 in '85	438 8 in '85	441 9 in '85	448 6 in '85
1982											
1983	w/1@0 thru July then ??	w/2@0, survived	v/2@0, survived	alone?	w/2@0 shot	w/2@l, weaned June-Aug.					
1984	alone in August	w/2@1, not weaned	w/201, weaned in June-Aug., collar faile	alone?		v/2c, survived	,				
1985	3@0 in den, shot in spring	w/2@2, weaned in June, shot		w/2@O probable age		⊎/2@1,	alone, bred	w/l@l, weaned in June, bred	w/2@27, age??	alone, bred	elone bred
1986		``		w/2@1 probable age		alone	alone in June	alone in June	w/3@0, shot	alone bred	alone
1987				w/2c, survived		ND	ND	alone, shot		v/2c, survived	w/2c, died in summer
1988				w/2@1						w/2@1	
1989	æ.∞			w/2@0 (survival?)				.e		not seen	

Year	Upstream study area	Downstream study area	Both areas
1980	no data	no data	
1981	4 of 9 lost (289, 301, 321, 328	no data	4 of 9 lost
1982	0 of 2 lost (354)	no data	0 of 2 lost
1983 incomplete data*	8 of 13 lost (289, 317, 361, 349	1 of 12 lost (375, 376, 377**, 378, 405, 406	9 of 25 lost
1984 complete data	1 of 4 lost (321, 363)	0 of 2 lost (369)	l of 6 lost
1985 complete data	7 of 11 lost (289, 3 17, 328, 349, 377)	0 of 3 lost (378, 402)	7 of 14 lost
1986 complete data***	0 of 4 lost (354, 364)	0 of 0 lost .	0 of 4 lost
1987 complete data****	3 of 21 lost (289, 317, 328, 349, 354, 361, 363, 377, 441, 329)	0 of 6 lost (369, 378, 409)	3 of 27 lost
1988	0 of 3 lost (354)	no data	0 of 3 lost
1989	1 of 4 lost (363, 364)	no data	l of 4 lost
1990	1 of 2 lost (354)	no data	1 of 2 lost

Table C4. Summary of known losses of black bear cubs-of-the-year. Losses calculated during first season out of den (in dens or at emergence from dens as cubs to entrance into dens as cubs.

* Incomplete data resulted from not observing the family status of the bear before it entered its winter den, shed collars, collar failures, or early hunter kills. Tabulated losses occurred prior to loss of the female to these causes.

24 of 70 = 34% lost 1 of 27 = 4% lost 25 of 91-27% lost

** B377 may have lost 2 of 2 rather than the 1 of 1 tabulated in 1983, the initial litter size was not known with certainty.

*** B438 and B409 had inadequate data.

TOTALS (all years)

**** Not included is B448 (2 of 2 assumed lost when mom died or was killed).

Table C5. Age at first reproduction for GMU 13 (Su-hydro area black bear females. "Adult" means first litter was at indicated age or younger, "open" means had no litter, data indicated with (*) were not included as bear could have had a previous unobserved, litter.

				Ag	re		
Id	Area	3	4	5	6	7	8
289	u	?	?	?	?	?	adult
290	u	?	?	?	?	adult	adult
301	u	?	?	?	cubs	adult	adult
317	u	?	?	?	?	adult	adult
318	u	?	?	cubs	adult	adult	adult
326	u	?	?	cubs	adult	adult	adult
327	u	?	?	cubs	adult	adult	adult
328	u	?	?	?	open*	cubs*	adult
329	u	open	open	open	open	cubs	adult
349	u	?	open	open	cubs	adult	adult
354	u	?	?	cubs	adult	adult	adult
361	u	?	?	?	open*	cubs*	adult
363	u	?	open	open	cubs	adutl	adult
364	u	?	?	?	open*	cubs*	adult
367	d	?	open	open	?	adult	adult
368	d	?	?	?	?	?	?
369	d	?	open	open	cubs	adult	adult
370	d	?	?	?	?	open*	cubs*
374	đ	?	?	?	?	open*	cubs*
375	d	?	?	?	?	?	adult
376	d	?	?	?	open*	cubs*	adult
377	d	?	open	open	open	cubs	adult
37 8	d	?	?	?	open*	cubs	adult
409	d	?	?	open	open	cubs	adult
410	d	?	?	?	?	adult	adult
411	d	?	?	?	?	cubs*	adult
432	u	?	?	cubs	adult	adult	adult
438	· u	?	?	?	?	adult	a du lt
446	u	?	?	open	?	?	?
448	u	?	?	?	open*	open*	cubs*
Both a	areas						
# Suba	adults	. 2	6	8	3	0	0
# lst	litters	0	0	5	4	4	0
#>1st	litter	0	0	0	5	14	25
* "adı	ult" =	0.0	0.0	38.5	75.0	100.0	100.0

Mean age of first reproduction = 5.92 years

* = not included in total as would have had earlier litter

Continued on next page.

Table C5 (Con't.)

	Age									
Id Area	3	4	5	6	7	8				
Upstream only										
# Subadults	1	4	5	1	0	0				
# lst litter	0	0	5	3	1	0				
#>lst litter	0	0	0	5	11	16				
€ "adult" -	0.0	0.0	50.0	72.7	100.0	100.0				
Mean age of fi	rst reprod	luction =	5.56 years							
Downstream onl	y									
# Subadults	1	2	3	2	0	0				
# lst litter	0	0	0	1	3	0				
#>1st litter	0	0	0	0	3	9				
% "adult" =	0.0	0.0	0.0	66.7	100.0	100.0				
Mean age of fi	rst reprod	luction =	6.75 years							

Table C6. Summary of reproductive intervals for black bears by bear ID. (* indicates bear from downstream study area. Year of litter and reason for intervals >2 years are indicated in parentheses - "lost" means lost complete litter).

COMPLETE I	NTERVALS OF:			
2 YE	ARS	3 YEARS	4 YEARS	5 YEARS
289 (81)	363 (84)	317 (83, skippad 1)	318 (83, lost 2)	321 (84, lost 1-2)
289 (83)	363 (89)	361 (83, weaned 82)	349 (85, 1 lost, 1 skip	
289 (85)	364 (86)	361 (87, skipped 1)	328 (87, 1 lost, 1 skip) ³	
289 (87)	369* (84)	363 (87, skipped 1)	369* (87, 1 skip, 1 wean @2)	
301 (81)	375* (83)	364 (83, weaned 62)	376* (87, skipped 2)	
317 (80)	376* (83)	40 2* (85, skipped 1)	377* (87, skipped 2)	
317 (87)	377* (87)	405* (83, weaned 62)		
318 (80)	379* (83)	441 (87, skipped 1)		
327 (80)	378* (85)			
329 (87)	378* (87)			
349 (87)	406 (83)			
354 (82)	409* (85)			
354 (84)	409* (87)			
354 (86)				
354 (88)		·		
2 YEARS		3 YEARS	4 YEARS	5 YEARS
		327 (83. skipped)		
		361 (87, skipped)		
		363 (87, skippeu)		
		364 (89, skipped)		
		431 (87, skipped)		
		432 (87, skipped)		
		441 (87, skipped)		
		448 (87, skipped)		
		411* (87, skipped)		
		349 (90, skipped)		
AVERAGE RE	PRODUCTIVE INTE	RVAL, UPSTREAM AREA ONLY	<u></u>	
COMPLETE INTERVALS ONLY $(N = 2\theta)$			2.54	
INCOMPLETE INTERVALS ONLY $(N = 7)$			3.0	
COMPLETE AND INCOMPLETE $(N = 36)$			2.56	
AVERAGE RE	PRODUCTIVE INTE	RVAL, DOWNSTREAM AREA ONLY		
COMPLETE INTERVALS ONLY $(N = 16)$			2.5	
INCOMPLETE INTERVALS ONLY $(N = 1)$ COMPLETE AND INCOMPLETE $(N = 17)$			3.0 2 <i>.</i> 53	
AVERAGE RE	PRODUCTIVE INTE	RVAL, BOTH AREAS LUMPED		
COMPLETE INTERVALS ONLY $(N = 44)$			2.52	
INCOM	PLETE INTERVALS	ONLY (N = B)	3	
COMPL	ETE AND INCOMPLI	ETE ($N = 52$	2.60	



Projected funded by Federal Aid in Wildlife Restoration