

YELLOWSTONE GRIZZLY BEAR INVESTIGATIONS

**ANNUAL REPORT OF THE
INTERAGENCY STUDY TEAM
1987**



**National Park Service
U.S. Forest Service
Montana Fish, Wildlife and Parks Department
U.S. Fish and Wildlife Service
Idaho Fish and Game Department
Wyoming Game and Fish Department**

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INTRODUCTION

The Interagency Grizzly Bear Study Team (IGBST) was initiated in 1973 and is a cooperative effort of the National Park Service, Forest Service, and since 1974 the States of Idaho, Montana, and Wyoming. The IGBST conducts research that provides information needed by various agencies for immediate and long-term management of grizzly bears (*Ursus arctos horribilis*) inhabiting the Yellowstone area. With increasing demands on most resources in the area, current quantitative data on grizzly bears are required for formulation of management decisions that will insure survival of the population.

Objectives of the study are to determine the status and trend of the grizzly bear population, the use of habitats and food items by the bears, and the effects of land management practices on the bear population. Earlier research on grizzlies within Yellowstone National Park provided data for the period 1959-67 (Craighead et al. 1974). However, changes in management operations by the National Park Service since 1967 - mainly the closing of open pit garbage dumps - have markedly changed some food habits (Knight et al 1984), population parameters (Knight and Eberhardt 1985), and growth patterns (Blanchard, 1987). Current research efforts are needed to further define and evaluate grizzly bear population dynamics. Acting upon the recommendation of the Population Review Task Force, the Interagency Grizzly Bear Committee has directed the IGBST to instrument and monitor 10 adult female grizzly bears for a 3-year period beginning in 1986. Those females would be distributed throughout the various habitat conditions within the Yellowstone area.

Distribution of grizzly bears within the study area, movement patterns, and habitat use have been largely determined (Knight et al. 1984) and are now being studied on a monitoring and updating level. Efforts are being concentrated on gathering population parameter data, determining behavior patterns, and assessing the effects of land use practices.

Movement data conclusively indicates that the existence of semi- autonomous population segments is unlikely and that the determination of population size will be difficult due to the average home range sizes of individual bears. Population trend indices appear to be more meaningful and measurable than a number estimate (Eberhardt et al. 1986). Research is ongoing in the attempt to document a sensitive and reliable trend index.

Data analyses and summaries presented in this report supersede all previously published data. Study methods are reported by Blanchard (1985).

RESULTS AND DISCUSSION

MONITORING/POPULATION TREND

Marked Animals

Since 1975, 140 grizzly bears have been fitted with collar transmitters and monitored for varying lengths of time. Of these bears, 29 were known to be alive during 1987, and 61 were known or suspected to be dead at the end of the 1987 field season (Table 1).

During 1987, 21 individual grizzly bears were captured 25 times (Table 2) at 17 locations throughout the study area (Fig. 1). Fourteen bears were involved in research captures and released on site, while 7 were captured as a result of management actions and transported 8 times to various sites throughout the study area. Captures included 11 females (8 adult) and 10 males (5 adult).

Thirty radio-telemetered grizzly bears were monitored for varying lengths of time during the year, including 14 adult females (Table 3). Fourteen adult females were also monitored during 1986, 10 of which also provided data for 1987. During 1987, a maximum of 10 adult females were monitored at one time for a 7-week period from late June through early August (Fig. 2).

Unduplicated Females

Since 1983 the IGBST has attempted to develop a method for monitoring population trend in the Yellowstone ecosystem without trapping or marking bears. The most reliable system attempted appears to be counting the number of females with cubs-of-the-year.

Procedures.--All female grizzly bears with cubs-of-the-year reported by personnel of the participating agencies are considered. Observations by private citizens are considered when verified by agency personnel. Reports include both aerial and ground observations. Bases for distinguishing different females with cubs-of-the-year include both temporal and physical descriptions. Descriptions of family groups are compared with others previously reported in the general vicinity. Time of observation combined with distance between observations are used to distinguish whether look-alike observations are indeed different. Movement histories of radio-telemetered females during the study (1975- 86) are used as a basis to make these decisions. Physical characteristics that have proved to be most reliable in distinguishing different family groups include, but are not limited to: number of cubs per litter, striking coloration (e.g., "white" face, "VI" chest markings, extremely blond or black in direct sunlight), extremes in body size, and extreme aggressiveness by the female. Those that can be separated as individuals following these criteria are added to the unduplicated sample. Separations of family groups are usually.

Table 1. Status of instrumented grizzly bears, 1975-87 ($n = 140$).

Known dead			Suspected dead		Off-air		Active
Human-caused	Natural	Unknown	Human-caused	Natural			
3	12	77	7	54	1	104 ^c	109
4	56	108	11	55	2	106 ^c	110
5	63		24		13 ^c	107 ^c	118
6			31		16	111 ^a	123
8			32		19	112	124
9			75		21	114 ^a	125
10			102		23	115 ^a	126
14					33	116 ^b	128
15					34	117 ^a	135
17					35	119 ^a	136
18					36	129 ^b	137
20					37	130 ^b	138
22					40	131 ^c	139
25					41	132 ^c	140
26					42	133 ^b	141
27					43 ^b	134 ^c	142
28					44		143
29					48		
30					50 ^c		
38					51		
39					57		
45					61		
46					64		
47					68		
49					70 ^a		
58					71		
59					72 ^c		
60					73		
62					74		
63					78		
67					79 ^c		
69					80		
76					82		
81					84		
83					85		
88					86 ^b		
90					87		
93					89 ^a		
94					91		
95					92 ^c		
105					96		
113					97 ^a		
120					98		
121					99		
122					100		
121					101 ^c		
127					103		
47 total	3 total	2 total	7 total	2 total	63 total		17 total

^a Known alive in 1985.

^b Known alive in 1986.

^c Known alive in 1987

Table 2. Grizzly bears captured during 1987.

Bear	Sex	Age	Date	Location ^a	Release site	Trapper
123	M	3	5/9	Kitty Cr/SNF	On-site	IGBST
135	F	6	5/13	Elk Fork/SNF	On-site	IGBST
Unm	M	Cub	5/13	Elk Fork/SNF	On-site	IGBST
Unm	F	Cub	5/13	Elk Fork/SNF	On-site	IGBST
136	F	4	5/15	Kitty Cr/SNF	On site	IGBST
104	F	5	5/14 6/28	Middle Cr/SNF (mgt) Mt Washburn/YNP (mgt)	Blacktail Plateau Crooked Cr/YNP	WY/YNP/IGBST YNP
134	F	5	5/20	Lake/YNP (mgt)	Flat Mountain Arm/YNP	YNP
109	F	6	6/11	Cap & Ball Park/SNF	On-site	IGBST
137	F	7	6/19	Flat Mountain Arm/YNP	On-site	IGBST
118	F	4	7/7	Pelican Cr/YNP	On-site	IGBST
138	M	9	7/21	Pelican Cr/YNP	On-site	IGBST
139	M	8	8/7 9/25	Richards Pond/YNP Island Park/ID (mgt)	On-site Open Cr/BTNF	IGBST ID
140	M	8	8/8	Mesa Pit/YNP	Open Cr/BTNF	IGBST
92	M	8	8/24	Deep Well Ranch/MT (mgt)	Turbid Lake/YNP	MT
110	M	4	9/3 10/21	Duck Cr/MT (mgt) Richards Pond/YNP	Lewis Lake divide/YNP On-site	MT IGBST
20	M	14	9/22	West Yellowstone/MT (mgt)	Management kill	MT
79	F	13	10/13	Stephens Cr/YNP	On-site	IGBST
83	F	19	10/16 10/21	Canyon/YNP (mgt) Canyon/YNP (mgt)	Blacktail/YNP Management kill	IGBST/YNP IGBST/YNP
141	M	1	10/16	Canyon/YNP (mgt)	Big Horn Pass trailhead/YNP	IGBST/YNP

Table 2. Continued.

Bear	Sex	Age	Date	Location ^a	Release site	Trapper	
142	M	6	10/21	Indian Cr/YNP	On-site	IGBST	
143	F	8	11/3	Indian Cr/YNP	On-site	IGBST	
		<u>Females</u>	<u>Males</u>		<u>Traps</u>	<u>Retraps</u>	<u>Transports</u>
Adults		8	5	Research	14	1	-
Subadults		3	5	Management	7	3	8
Total		11	10	Total	21	4	8

^a BTNF = Bridger-Teton National Forest, SNF = Shoshone National Forest, YNP = Yellowstone National Park.

Table 3. Grizzly bears monitored during 1987 ($n = 30$).

Bear	Sex	Age	Number of locations	Interval monitored (days)	Last location	Status
13	F	18	4	22	5/5	Off air
20	M	14	1	-	-	Management kill
72	F	10	25	161	10/2	Off air – cast collar
79	F	13	5	47	11/29	On air
83	F	19	30	287	10/22	Management kill
92	M	8	6	28	9/21	On air – lost
101	F	5	1	-	4/13	Of air – cast collar
104	F	5	44	181	9/21	Of air – cast collar
106	F	11	6	104	8/6	Of air
107	M	8	4	72	6/4	Of air
109	F	6	14	171	11/29	On air
110	M	4	15	114	12/26	On air
118	F	4	24	219	11/29	On air
123	M	3	24	231	12/26	On air
124	F	7	25	250	11/29	On air
125	F	4	35	277	12/26	On air
126	R	15	35	221	11/20	On air
128	F	2	23	323	11/27	On air
131	M	2	12	109	7/31	Off air
134	F	5	31	125	8/16	Off air
135	F	6	15	200	11/29	On air
136	F	4	20	198	11/29	On air
137	F	7	19	154	11/20	On air
138	M	9	16	131	11/29	On air
139	M	8	17	141	12/26	On air
140	M	8	18	140	12/26	On air
141	M	1	8	71	12/26	On air
142	M	6	6	66	12/26	On air
143	F	8	4	26	11/29	On air
Adult female		14	Adult male		7	
Subadult female		5	Subadult male		4	
Total		19	Total		11	

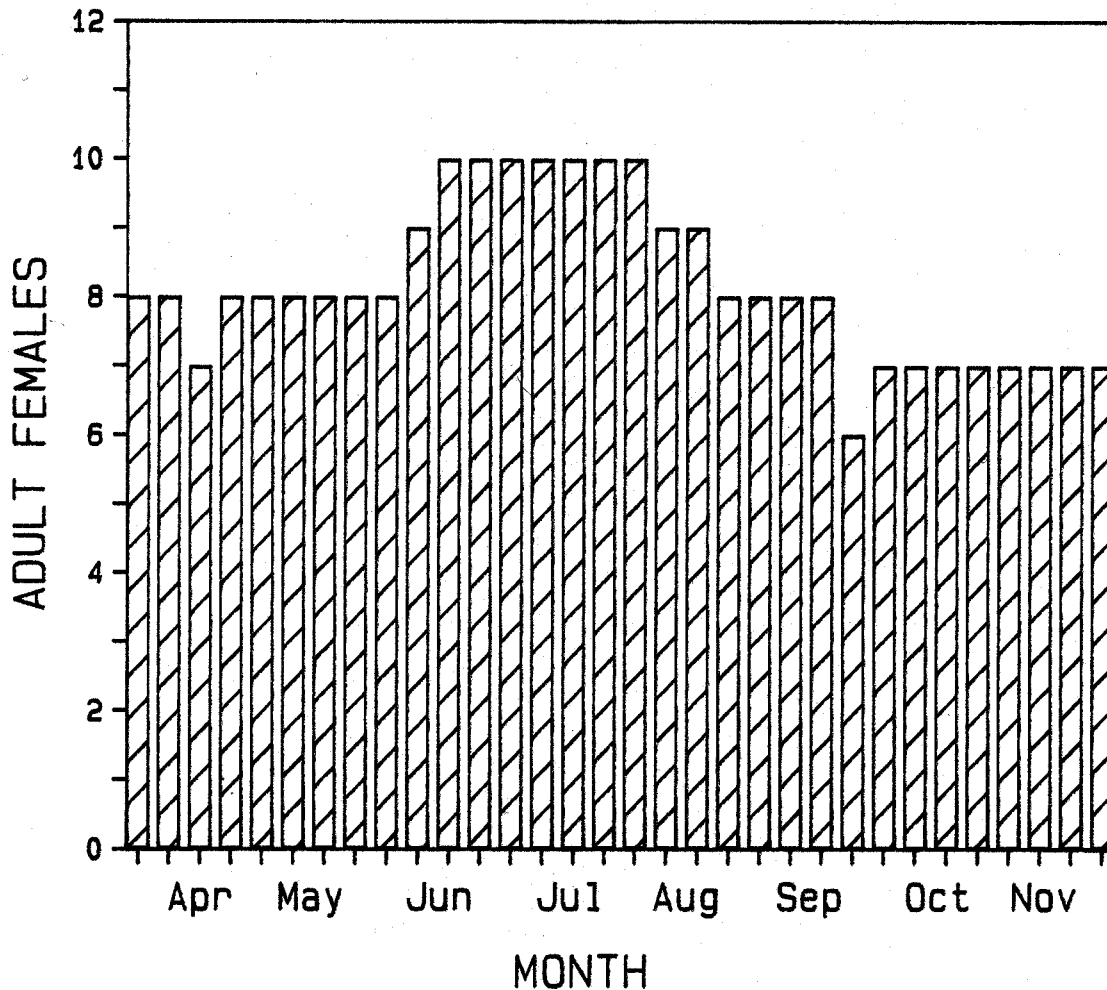


Fig. 2. Adult females monitored during 1-week periods of 1987.

easier using flight data compared to ground data since the same experienced personnel make most of the aerial observations

Types of flights and patterns have varied during the course of the study reflecting annual research priorities. Different aerial monitoring techniques, specifically for observation purposes, have been attempted since 1983. Efforts were made to coordinate flights by different observers on the same day and in a predetermined random sequence. Variable weather patterns within the study area made this impractical. Beginning in 1986, segments were flown when possible and sequence was determined by weather conditions. Experienced dictated 2 hours as the optimum time period for aerial observation based on observer fatigue. Experience also indicated flights over timbered terrain were not cost effective. During the course of the study, females with cubs-of-the-year were most

frequently observed from the air during June-August, with some allowance made for annual variance in observability due to weather, primarily amount of precipitation.

During 1986 the study area was divided into 11 areas that could be flown during a 2-hour observation period (Fig. 1). Flight areas varied in size depending upon topography and proportion of nontimbered area. Observation flights were concentrated over open terrain, specifically open/timber edges. Each flight segment was flown when opportune, beginning 1 June and continuing through August. The same procedure was followed during 1987. Several flight areas could not be effectively searched within the optimum 2-hour observing period. Adjustments to area boundaries will be made prior to the 1988 observation flights.

Results.--A strong correlation was evident between annual number of unduplicated females with cubs-of-the-year seen on observation flights and numbers seen by other methods ($r = 0.90$, $P < 0.05$) from 1983-87. During that period an average of 37% of the unduplicated females were recorded on IGBST observation flights, ranging from 22-41%; during the last 2 years when methodology was similar, observation flights accounted for 38%. Annual average observation flight hours flown was 57 hours, and an average flight was 2.5 hours. Unduplicated observations not recorded on observation flights included an average of 4% recorded incidentally on observation flights made by other researchers over the study area, 43% from ground sightings not duplicated on any type of observation flights, and 17% from IGBST radio-tracking flights only.

Observation flights were made during June, July, and August. Total monthly hours flown were similar for all 3 months; however females with cubs-of-the-year were most frequently observed during July (Table 4). Similarly, all classes of unmarked bears recorded on observation flights were seen most frequently during July, while unmarked bears were most often seen on radio-tracking flights during May.

POPULATION PARAMETERS

Sex and Age Structure

Marked bears known to be alive during 1987 ($n = 46$) included 54% subadults (cub - 4 years) with a sex ratio of .36M:.64F. The adult sex ratio was .33M:.67F. Data from all bears trapped since 1975 indicated a slightly male-dominated age structure (Table 5). However, inspection by 6- or 7-year periods revealed a strong male dominance during the first part of the study period compared to a sex ratio closer to 50:50 in the last years. Particularly noticeable was the change in the subadult sex ratio from male dominance to female dominance. This sex ratio change was also evident in litters of cubs-of-the-year (Table 6). Male dominance in the earlier years could not be explained by a larger proportion of first litters in that sample. First litters tend to be composed of more males than subsequent litters. (See narrative after Table 11, page 18.)

Table 4. Flight data summary for 1987.

Month	Flight type ^a	Number flights	Total hours ^b	Radio locations (seen)	Unmarked grizzly bears		Grizzly bears/hour	
					Total ^c	With cubs	Total	With cubs
Jan	*	1	-	2 (0)				
Mar	rl	1	1.78	5 (0)				
Apr	rl	3	12.00	32 (6)	4		0.33	
	*	1	-	1 (1)	4		-	
May	rl	4	14.75	28 (6)	12		0.81	
	*	2	-	0	7	1 w/ 2	-	-
Jun	rl	11	27.47	67 (14)	2		0.07	
	obs	6	13.67	-	6		0.44	
	*	3	-	0	5		-	
Jul	rl	7	13.74	41 (13)	5		0.36	
	obs	7	17.16	-	24	3 w/ 2 1 w/ 3	1.40	0.23
	*	3	-	9 (3)	3		-	
Aug	rl	10	20.16	53 (3)	10		0.50	
	obs	7	16.34	-	5	1 w/ 2	0.31	0.06
Sep	rl	8	21.83	54 (6)				
	*	1	-	13 (0)				
Oct	rl	14	26.75	61 (3)				
Nov	rl	5	11.20	41 (0)				
Dec	rl	1	2.00	7 (0)				
Total	rl	64	151.76	389 (51)	33	0	0.22	0
	obs	20	47.17	-	35	4 w/ 2 1 w/ 3	0.74	0.11
	*	11	-	25 (4)	19	1 w/ 2	-	-

^a rl = flights made to locate radio-telemetered bears; obs = flights made to observe unmarked bears; * = flights made by other researchers over IGBST study area, grizzly bear observations were made incidentally.

^b Hours do not include ferry time.

^c Total unmarked grizzly bears include young of adult females.

Table 5. Yellowstone grizzly bear sex and age ratios taken from all trapped bears – a composite of all years, and age is that recorded when first trapped.

	Sample size					Sex ratios (M:F)				
	Adult		Subadult		All	Adult	Subadult	All	Ad:SAd	Ad F:SAd F
	M	F	M	F						
All years	31	25	58	51	165	55:45	53:47	54:46	33:67	34:66
1975-1980	17	10	24	15	66	63:37	62:38	61:39	41:59	40:60
1981-1987	14	15	34	36	99	48:52	49:51	48:52	30:70	30:70
1975-1981	20	16	36	21	93	56:44	63:37	60:40	39:61	43:57
1982-1987	11	9	22	30	72	55:45	42:58	46:54	28:72	30:70

Table 6. Sex ratios of cubs-of-the-year litters.

	Litters (n)	Male	Female	Sex ratio (M:F)	No. of first litters
1975-79	6	11	4	.73:.27	2
1980-83	7	7	8	.46:.54	2
1984-87	7	6	9	.40:.60	3
All years	20	24	21	.53:.47	7
<hr/>					
1 st litters	7	11	4	.73:.27	
2 nd + litters	11	12	14	.46:.54	
Unknown sequence	2	1	3	.67:.33	

Survivorship

Survivorship is listed by sex and age class in Table 7. The sample included marked bears and unmarked young of a marked female while accompanying that female. Females had a 20% chance of surviving to 15 years compared to 7% for males. In 1981 a Yellowstone grizzly had 29% chance of surviving to 5 years ($n = 114$) compared to 37% chance in 1987 ($n = 266$).

Production

Thirteen unduplicated females with 29 cubs-of-the-year (COY) were recorded during 1987 (Table 8). From 1973-87 an average of 13 females with COY were recorded each year, ranging from 4 in 1975 to 25 in 1986. Mean litter size was 2.2 in 1987, the largest recorded during this study and duplicated only in 1979.

Numbers of unduplicated females with COY tallied for running 3-year periods have gradually increased from 33 (1973-75) to 46 (1985-87)(Fig. 3). The average number for any running 3-year period was 38.

Reproductive rates were calculated using only data from marked females. Complete cycles were recorded for 12 bears for which COY litter size was known (Table 9). Two additional females were considered in calculations. Both produced and weaned litters, followed by 3 barren years each, prior to next cub production. Cycles were not complete for these 2 females because: (1) litter size as COY was not recorded (Bear 13), or (2) no litter was produced following barren years due to death (Bear 26). Mean cycle length was 2.88 years for the 14 marked females. Reproductive rate for these females was 0.696. Two of the 14 females were known to forage at garbage and they had a reproductive rate of 0.833 (Bears 8 and 10), while the remaining 12 bears produced at a rate of 0.647.

Mean litter size for 50 litters of 42 marked females was 2.12 cubs compared with 1.89 calculated from observations of 196 litters of both marked and unmarked unduplicated females with 370 COY. Mean litter size appeared to increase with age of the female until approximately 14 years (Fig. 4). On the average, largest litters were produced between the ages of 8 and 13 years, with a mean of 2.32 cubs per litter (Table 10). After 13 years of age, females produced litters averaging 2.00 cubs until after 21 years of age, when production dropped to 1 cub per litter ($n = 2$).

First litters were produced at the mean age of 5.84 years ($n = 19$). Extremes in ages at first production included 3 first litters produced at 4 years and 1 at 8 years. Average litter size was smaller for first litters compared with subsequent litters (Table 11). Average litter size increased from 1.94 cubs in first litters ($n = 19$), to 2.00 cubs in second litters ($n = 8$), and to 2.24 cubs in third and later litters ($n = 24$). First litters were less frequently

Table 7. Grizzly bear survivorship rates by sex and age class ($n = 490$).

Age	Sample size			Survivorship		
	Male	All	Female	Male	All	Female
Cub	24	81	17	0.88	0.85	0.94
1	24	68	20	0.83	0.82	0.80
2	24	43	16	0.63	0.72	0.81
3	23	39	16	0.83	0.85	0.88
4	17	35	18	0.76	0.86	0.94
5	14	29	15	0.93	0.90	0.87
6	15	29	14	0.87	0.86	0.86
7	10	24	14	0.90	0.92	0.93
8	11	24	13	1.00	0.91	0.85
9	7	17	10	0.86	0.88	0.90
10	7	18	11	1.00	1.00	1.00
11	7	15	8	1.00	1.00	1.00
12	6	14	8	0.67	0.79	0.88
13	5	11	6	1.00	0.91	0.83
14	5	10	5	0.60	0.10	1.00
15	3	8	5	1.00	1.00	1.00
16	2	6	4	1.00	0.67	0.50
17	2	4	2	0.50	0.75	1.00
18	1	3	2	1.00	1.00	1.00
19	1	3	2	1.00	0.67	0.50
20	1	3	2	1.00	1.00	1.00
21	1	3	2	1.00	1.00	1.00
22	1	3	2	1.00	0.67	0.50

Table 8. Annual numbers of unduplicated female grizzly bears with cubs-of-the-year in relation to mean litter size and deaths of adult females (known and probable), 1973-1987.

Year	Females	Cubs	Mean litter size	Adult female deaths
1973	14	26	1.86	4
1974	15	26	1.73	4
1975	4	6	1.50	1
1976	16	30	1.88	1
1977	13	25	1.92	6
1978	9	18	2.00	1
1979	13	29	2.23	2
1980	12	23	1.92	1
1981	13	24	1.85	5
1982	11	20	1.82	4
1983	13	22	1.69	2
1984	17	30	1.76	2
1985	9	16	1.78	2
1986	24	46	1.92	2
1987	13	29	2.23	2
Total	196	370		
<i>n</i> =	15			39
Mean	13.07	24.67	1.89	2.60

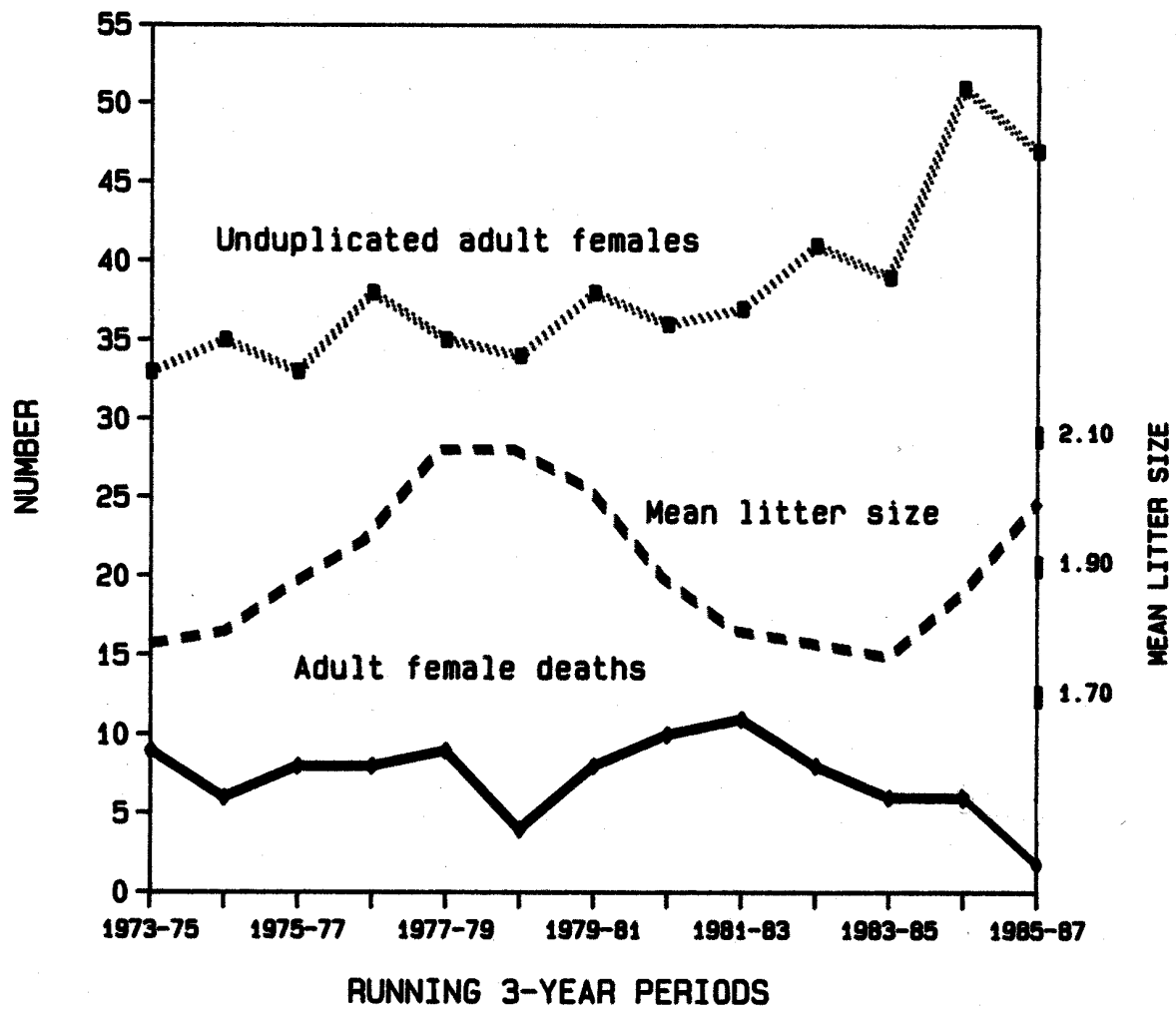


Fig. 3. Running 3-year period tallies of numbers of unduplicated females with cubs-of-the-year, mean litter size, and adult female deaths, 1973-87.

Table 9. Completed reproductive cycles of adult females for which complete cub litter size was known.

Bear	Number cubs/litter	Cycle length (years)	Number cubs dying before weaned	Bear	Number cubs/litter	Cycle length (years)	Number cubs dying before weaned
6	1	1	1	38	3	3	0
8	1	2	0	43	2	3	0
	3	3	0				
	2	2	0	50	2	3	1
10	2	3	?	59	1	1	1
	2	2	0				
12	2	3	0	116	3	3	1
	1	1	1	G36	2	3	
16	2	3	1	13 ^a	0	3	-
21	2	3	0	26 ^b	0	3	-

^a Female producing no cubs for 3 years following weaning of previous litter and prior to next cub production, but litters seen only as yearlings, not cubs.

^b Female producing no cubs for 3 years following weaning of litter; died before producing next litter.

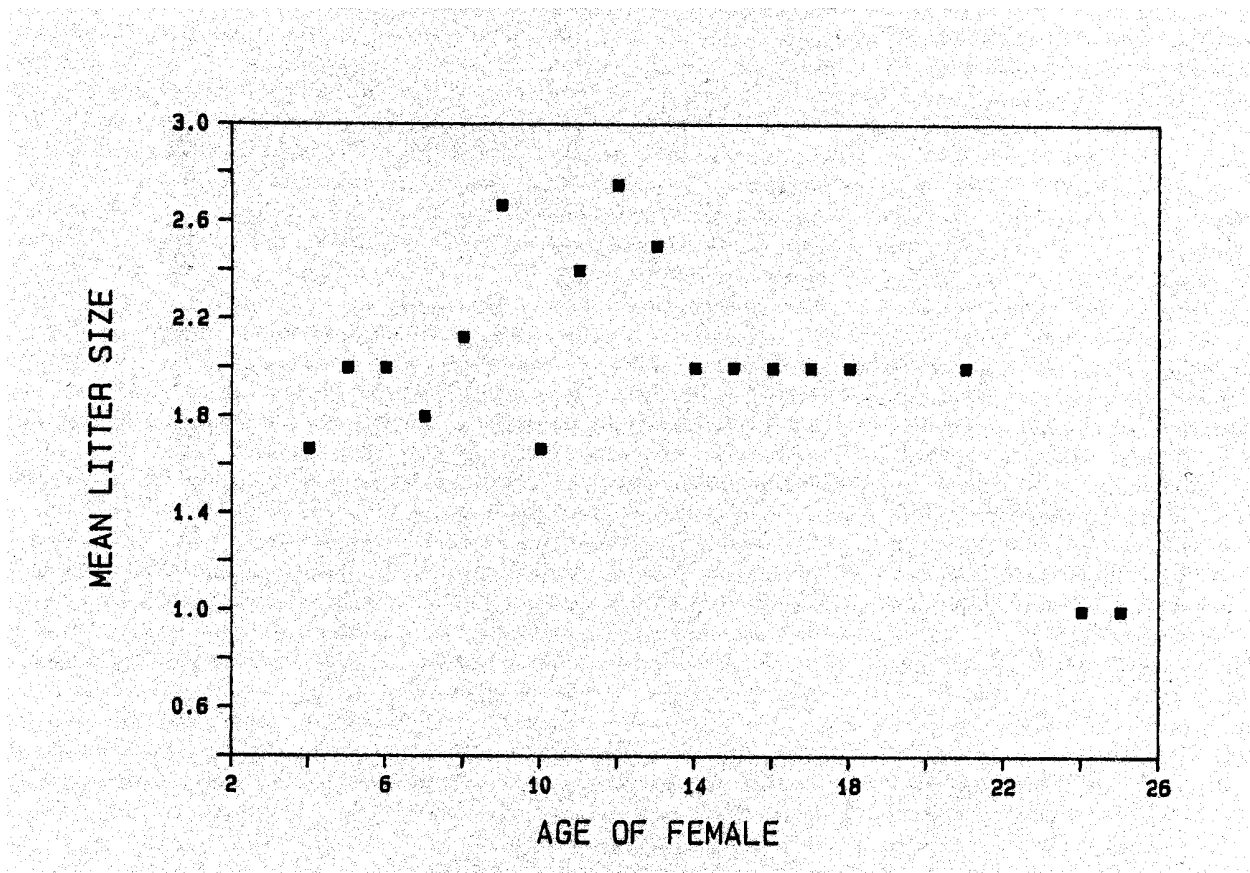


Fig. 4. Relationship between mean litter size and age of the female.

Table 10. Litter size in relation to age of female.

Age	Litters first seen as cubs only			Litters first seen as cubs or yearlings		
	Sample size			Sample size		
	Females	Cubs	Ratio	Females	Cubs	Ratio
4-7	16	30	1.875	21	37	1.762
8-13	25	58	2.320	28	65	2.321
14-21	6	12	2.000	9	16	1.778
22-25	2	2	1.000	2	2	1.000
Total	49	104	2.123	60	120	2.000

Table 11. Comparison of first and subsequent litters, 1975-87.

	<i>n</i>	Mean litter size	Litter size frequency						Mean age of F (range)			
			1	(n)	2	(n)	3	(n)	Unk	(n)		
First litters	19	1.94	0.11	(2)	0.63	(12)	0.05	(1)	0.21	(4)	5.84	(4-8 yrs)
> First litters	32	2.17	0.13	(4)	0.50	(16)	0.28	(9)	0.09	(3)	13.00	(8-25 yrs)
Unknown sequence	6	2.60	-	(0)	0.33	(2)	0.50	(3)	0.17	(1)	7.8	(7-8 yrs)

composed of 3 cubs compared to subsequent litters, and produced a greater frequency of male cubs (73%) than subsequent litters (46%).

Mortalities

Categories of grizzly bear mortalities included known, probable, and possible deaths. A mortality involving a retrieved carcass, parts of a carcass, or adequate radio-telemetry evidence was a known mortality. Reports of a death by a reliable source (as determined by the Team Leader) with no physical evidence retrieved or suspicious radio-telemetry evidence were counted as probable mortalities. Persistent and repeated rumors of a death were recorded as possible mortalities. A single report by an unverified source was not included. Grizzly bear mortality rates were probably underestimated due to the difficulty involved in obtaining volunteer information concerning illegal deaths of a Federally "protected" species. Mortalities were frequently not reported until several years after the death occurred.

Three known deaths were recorded during 1987 - 1 adult male and 2 adult females (Table 12). During the study, mortalities have been characterized by extreme shifts from high to low numbers (Fig. 5). Eberhardt et al. (1988) attributed these extremes to annual natural food availability and many deaths during "poor" food years. The few deaths in 1987 can be attributed to both (1) high level of management agency effort to prevent man-caused deaths, and (2) adequate natural food availability - primarily succulent vegetation and whitebark pine nuts (see Food Habits section).

Table 12. Known grizzly bear mortalities during 1987.

Bear	Sex	Age	Date	Location ^a	Cause
20	M	14	9/22	West Yellowstone, MT	Management control; personal property destruction
83	F	19	10/21	Canyon, YNP	Management control
Unmarked	F	Ad	Oct	East fork Pilgrim Cr, BTNF	Illegal kill by hunter

^a BTNF = Bridger-Teton National Forest, YNP = Yellowstone National Park.

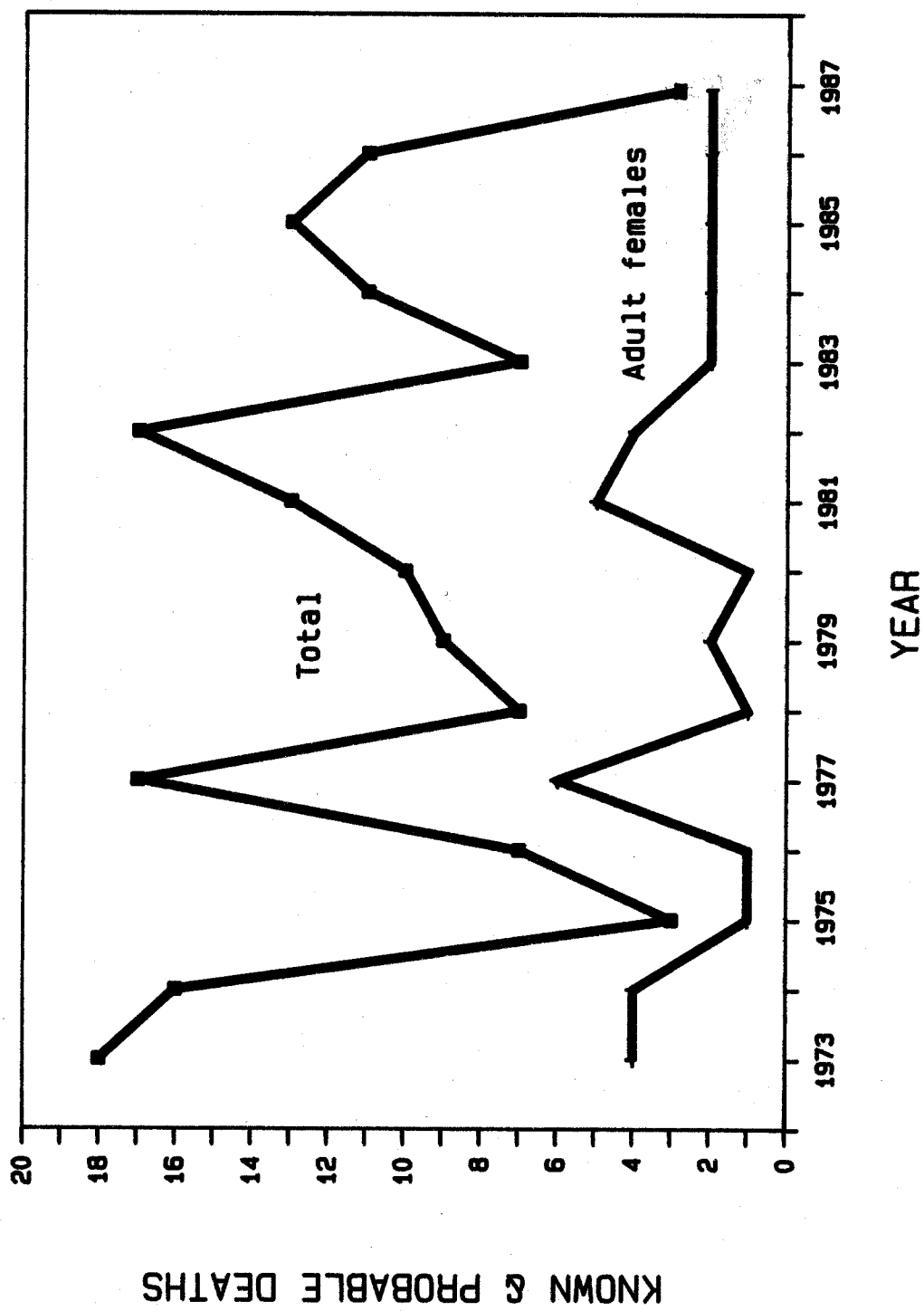


Fig. 5. Known and probable grizzly bear deaths, 1973-87.

FOOD HABITS

Procedures

Yellowstone grizzly bear food habits were determined from scat analysis and ground investigation of feeding sites. Seats were collected whenever encountered during investigation of aerial and ground radio locations of instrumented bears, and during conduct of other field work.

All bear seats collected and classified as grizzly and species unknown were included in the analysis. Dried seats were soaked in water to soften them and washed through 2 screens. Coarse material was retained in the large screen (holes 0.125 in.) and fine material, including seeds, was collected in the small screen (holes 0.0328 in.). All items were identified to species when possible, and the percent volume of each item was visually estimated.

Procedures used in the ground investigation of feeding sites are described by Blanchard (1985). Because feeding activities produce evidence of varying observability and longevity, site examinations were not used alone to determine food habits. Site examinations provide data on habitat use and preference; these examinations also provide data on feeding behavior which produces long lasting sign. Easily digestible food items which are rarely revealed through scat analysis (such as mushrooms) are evident at the feeding site. The more digestible items are probably under-represented in scat contents and, therefore, in the food habits analysis.

Whitebark pine (*Pinus albicaulis*) cone production was monitored to determine annual variation in the amount of pine nuts available to bears. Nine 90-m transects were established in whitebark pine stands in the study area during 1980 (Fig. 6). During 1987, 8 additional transects of 10 trees each were established to assess production in areas and habitat previously unmonitored. Ten whitebark pine trees were selected along each transect and marked with a blaze and an aluminum identification tag. The crown of selected trees could be viewed from the ground from at least 2 angles. Cones were usually counted in July and early August when they had reached mature size, but few had been harvested by squirrels. All trunks joined at the base were considered one tree.

Results

Scat analysis.--Food habits presented here represent results of fecal analysis. These data often do not accurately reflect relative proportions of ingested diet items primarily because different diet item types are subject to different digestibilities. For this reason, more easily digested items such as meat and berries are especially under-represented in scats relative to the vegetal grazing resource.

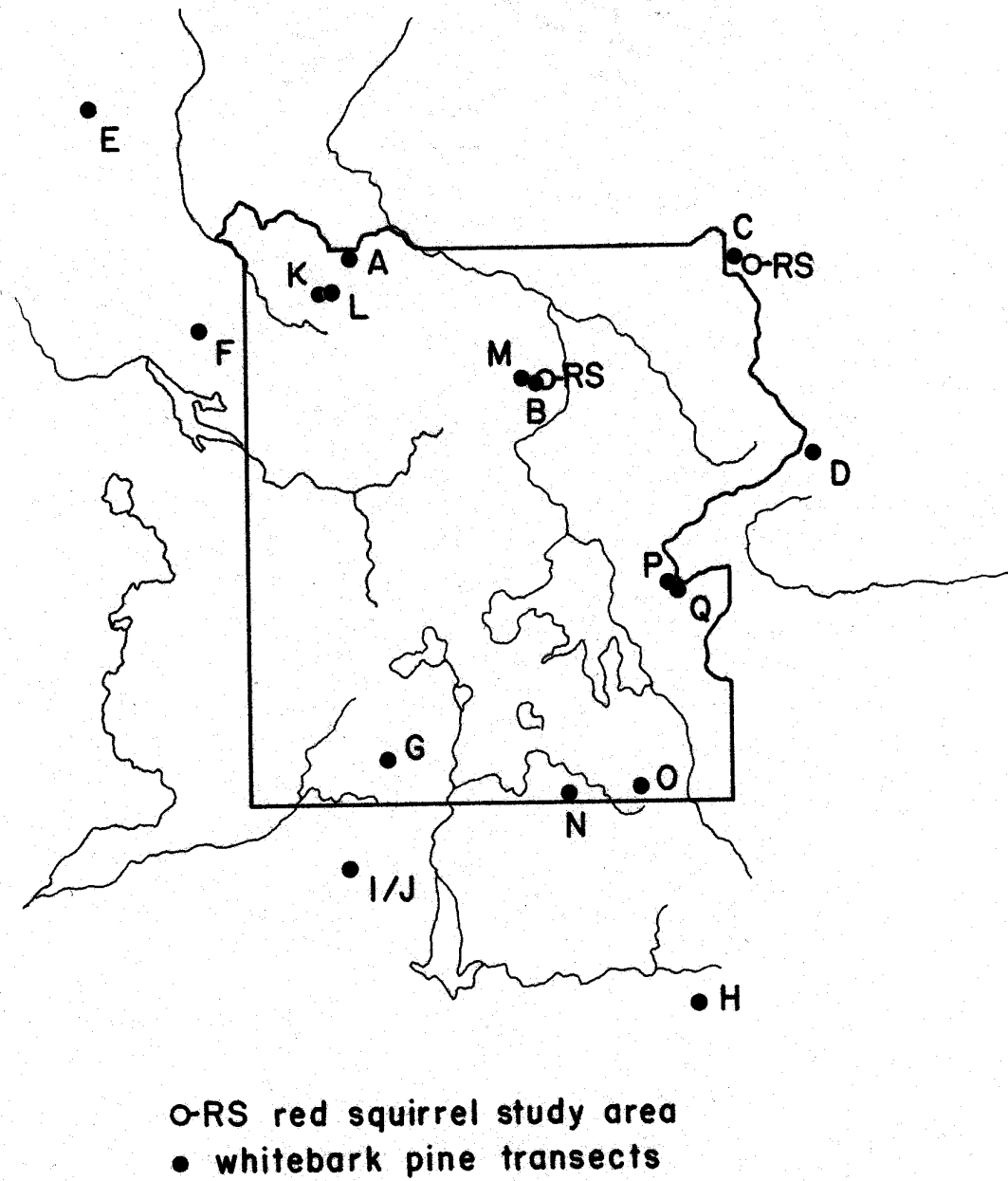


Fig. 6. Locations of whitebark pine cone production transects and red squirrel study subunits.

During 1987, 982 seats were collected and analyzed for content, including 837 grizzly bear and 145 black bear seats (Table 13). Forty- four percent of the grizzly bear seats were collected during 2 site- specific studies: (1) a study of relationships between Yellowstone Lake spawning cutthroat trout and bears (Study 02), and (2) feeding site examinations in Pelican Valley where bears were observed grazing (Study 03). Unless otherwise stated, the following food habits discussion refers to results derived from analysis of scats collected randomly throughout the study area (Study 01).

Spring:

Graminoid and forb foliage was the most frequently observed fecal item during spring and also constituted the greatest scat volume (Table 14). Mammals decreased in percent frequency/volume from 100/100 in March to 55/49 in April and 14/2 in May. Elk contributed the bulk of mammals evident in spring scats. Roots consumed during spring included *Melica spectabilis* corms taken from food caches of pocket gophers (*Thomomys* spp.) during April and May; *Heracleum* spp. roots consumed during April and May; and *Lomatium* *cous* tubers dug during May. Cutthroat trout first appeared in fecal contents during May. Ninety-six percent of the scats containing fish parts were collected during the Yellowstone Lake spawning study. With respect to overall food habits, occurrence of cutthroat trout in the diet of the Yellowstone grizzly population was under-represented in the random study area sample, and over-represented in the Lake study.

Table 13. Seasonal scat sample sizes for 1987.

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Grizzly bear:									
Study 01 ^a	2	22	42	73	96	123	78	7	472
Study 02 ^b			101	166	43				311
Study 03 ^c					21	33			54
Black bear ^d		9	91	20	20	4			145

^a Grizzly bear scats collected randomly throughout the study area.

^b Grizzly bear scats collected during a study of Yellowstone Lake spawning cutthroat trout/grizzly bear relationships.

^c Grizzly bear scats collected during feed site examinations in Pelican Valley where bears were observed grazing.

^d Black bear scats collected randomly throughout the study area.

Table 14. Seasonal scat contents for grizzly and black bears during 1987.

	Study 01 ^a				Study 02 ^a				Study 03 ^a			
	Spring		Summer		Fall		Spring		Summer		Spring	
	$\frac{(n=72)^b}{\%}$	Vol.	$\frac{(n=307)^c}{\%}$	Vol.	$\frac{(n=85)^d}{\%}$	Vol.	$\frac{(n=101)^e}{\%}$	Vol.	$\frac{(n=209)^f}{\%}$	Vol.	$\frac{(n=100)^h}{\%}$	Vol.
Pine nuts			26.71	23.76	61.18	59.18						
Berries			0.98	0.24								
<i>Equisetum</i>	4.17	0.49	6.19	2.65			3.96	1.88	19.14	8.68	5.00	2.75
Mushrooms ⁱ			1.30	0.37	15.29	7.82			1.44	0.60		
Foliage:												
Graminoids	68.05	56.80	55.04	32.10	21.17	9.00	89.11	70.40	65.07	36.61	84.00	69.75
Forbs	13.90	5.63	33.85	18.79	9.40	3.48	11.88	4.95	44.02	27.14	5.00	0.80
<i>Cirsium</i>	1.39	0.69	9.44	5.50	1.18	0.88			28.23	17.75		
<i>Taraxacum</i>	2.78	1.18	6.18	3.94			2.98	1.44	12.92	6.22	3.00	0.35
<i>Trifolium</i>	2.78	0.90	16.61	5.78	5.89	1.70	4.95	1.93	8.13	2.01	2.00	0.45
Roots	20.85	10.07	9.80	6.32	3.54	1.93			0.48	0.38		
Lomatium	6.95	4.93	3.25	2.88								
Melica	4.17	2.50	0.33	0.13	1.18	0.71						
Mammals	30.56	20.21	9.77	3.19	12.94	5.53	12.87	7.28	10.53	4.98	21.00	7.40
Elk	16.67	13.89	3.26	1.22	5.88	2.00	1.98	1.09	3.83	1.99	6.00	2.70
Bison	6.94	4.51	1.95	0.49	1.18	0.71	7.92	4.46	2.39	1.32	12.00	2.70
Cutthroat trout	2.78	0.63	0.98	0.26			28.71	11.09	43.06	15.86	24.00	7.20
Birds			0.33	0.07					1.44	0.17	1.00	0.10
Ants	6.94	0.76	14.34	2.54	3.53	0.47	3.96	1.04			5.00	0.80
Other insects			6.18	3.65							11.00	7.10
Garbage			0.33	0.05			0.99	0.15				2.27
Debris	29.17	7.43	25.73	5.99	28.24	11.94	12.87	3.22	22.49	4.50	13.00	4.10

^a See Table 13 for study definitions.^b March, April, May.^c June, July, August.^d September, October.^e May.^f June, July.^g July, August.^h April, May.ⁱ Includes miscellaneous sporophytes.

Summer:

Graminoid and forb foliage comprised the greatest fecal frequency and volume during summer. Individual species of note included *Trifolium* spp. which increased in percent frequency/volume from 8/3 in June, to 21/6 in July, and 20/8 in August. Use of *Cirsium scariosum* peaked in July at 14/8, whereas *Taraxacum* spp. steadily declined from 16/12 in June to 0/0 in August. Occurrence of roots in fecal contents was less during summer than spring. *Lomatium* spp. was the most commonly consumed root.

Cutthroat trout appeared in fecal contents through July in similar frequency and volume to that recorded in May. Mammals appeared in constant percent frequency/volume levels throughout the summer at approximately 10/4. Pine nuts first appeared in fecal contents during June, and increased in percent frequency/volume to 27/23 by August.

Several grizzlies were observed during August digging on scree slopes above timberline and over 10,000-ft elevations. Feedsite examination and fecal analysis revealed they were feeding on colonies of estivating army cutworm moths (*Chorizagrotis auxiliaris*). This was the first such incidence recorded for Yellowstone grizzlies during this study. Grizzly bears in other study areas have been known to feed on these moths (Servheen 1983, Chapman et al. 1955).

Fall:

Pine nuts were the most important fall food item, occurring in fecal contents at percent frequency/volume levels of 65/64 in September, but falling to 14/14 in October. In addition to graminoid and forb foliage, mushrooms were commonly consumed during September, and mammals were commonly consumed during October; 86% of October's scats were comprised of mammals (mainly elk, deer, and red squirrel). Only minor amounts of root crops such as *Osmorhiza chilensis*, *Perideridia gairdneri*, and *Melica spectabilis* were consumed in the fall of 1987, a contrast with the previous year when these roots appeared in fecal contents in relatively high proportions. During 1986 pine nut production was very low and roots were consumed as an alternate fall food. In 1987 more pine nuts were available, and this was reflected in higher proportions of pine nuts and lower proportions of roots in fecal contents during fall.

Black Bears:

Fecal analysis of black bear scats revealed that 1987 food habits of Yellowstone black bears were very similar to those of Yellowstone grizzly bears, with one major exception. There were noticeably no roots in the scat contents of black bears. This should be no surprise as black bears are not physically adapted to digging. Side-benefit food items acquired while root-digging were also notably absent - e.g. pocket gophers, *Microtus*

spp., and ground squirrels. Concurrently, less debris was recorded in black bear scats as a direct result of the absence of underground food items.

Whitebark pine cone production.--Production of pine nuts in 1987 was the second lowest recorded during this study (Table 15). However, scat content analysis revealed that cone production was greater than indicated by the transect counts. Generally a significant relationship exists between cone production on transects and percent frequency of whitebark pine cones in fall scats when the fall scat sample is >15 scats ($r^2 = 0.90$, $P < 0.05$, $Y = -0.886 + 0.15 (10^{-7} \times X^4)$). Grizzly bears consume greater amounts of pine nuts as the mean number of cones/transect increases (Fig. 7). Theoretically the amount of pine nuts consumed would increase with increased production until a level is reached when bears have maximized consumption and any extra nuts produced would not be used that fall.

Similarly, a significant negative correlation exists between mean numbers of cones produced per transect and numbers of grizzly bears trapped in management actions after 1 August ($r = -0.71$, $P < 0.05$) (Fig 8). This correlation increased to $r = -0.91$ when 1987 data were omitted.

There were 2 primary reasons why the 1987 cone transects failed to accurately reflect actual cone availability. First and most important was the date the transects were read. On the average, in 1987, transects were read approximately 5 August; only 1 was done before 15 July. However, bears were feeding on cones by 15 July, as indicated by individual scat volumes of 100% whitebark pine on that date. Pine nut production is apparently affected by spring weather conditions, with unseasonably warm temperatures in March-May creating conditions favorable for earlier maturation of the current-year crop and increased production of cone primordia. A warm, early spring in 1987 probably resulted in maturation of the cone crop approximately 2 weeks earlier than normal. However, in any year, transects should be read before 15 July to accurately reflect production prior to squirrel and nutcracker harvesting. The second reason was that in 1987, cone production was apparently poorest in xeric, pure to nearly pure whitebark pine stands; whereas mesic, mixed species stand production was often moderate to good. Production was spotty, and numerous cones were often noted on trees outside the transects.

Mean cone production in the Yellowstone ecosystem has decreased since 1980 for all transects combined ($r = -0.40$, $P < 0.05$). Area variation is apparent, however, when individual transect trends are examined. Transects on the Shoshone National Forest have consistently produced above the total mean of 131 cones/year, as have all transects within Yellowstone Park except for the Pitchstone Plateau site (Table 16). Transects on the Gallatin and Targhee National Forests have consistently produced below the mean. Mean cone production for each transect over running 3-year periods reveals 5 of the original 9 transects have steadily declined in productivity (B, F, G, H, I/J). Two have remained fairly stable (A, E) and 2 have increased (C, D) (Fig. 9).

Table 15. Annual whitebark pine cone production, 1980-87.

Year	Sample size		Cones/transect				% Freq. WBP in fall scats
	Trees	Transects	Mean	SD	Sum	Range	
1980	90	9	256.89	130.45	2,312	139-562	55.7
1981	90	9	132.33	157.71	1,191	8-489	0.0
1982	85	9	160.33	163.53	1,443	0-463	2.2
1983	88	9	170.11	94.16	1,531	78-372	6.3
1984	56	6	60.00	43.36	360	14-124	50.0
1985	85	9	256.89	203.93	2,312	17-625	80.8
1986	69	8	12.88	14.09	103	0-38	10.0
1987	158	16	34.38	50.08	550	0-156	61.2
Total	721	75	135.48	147.03	9,802	0-625	-

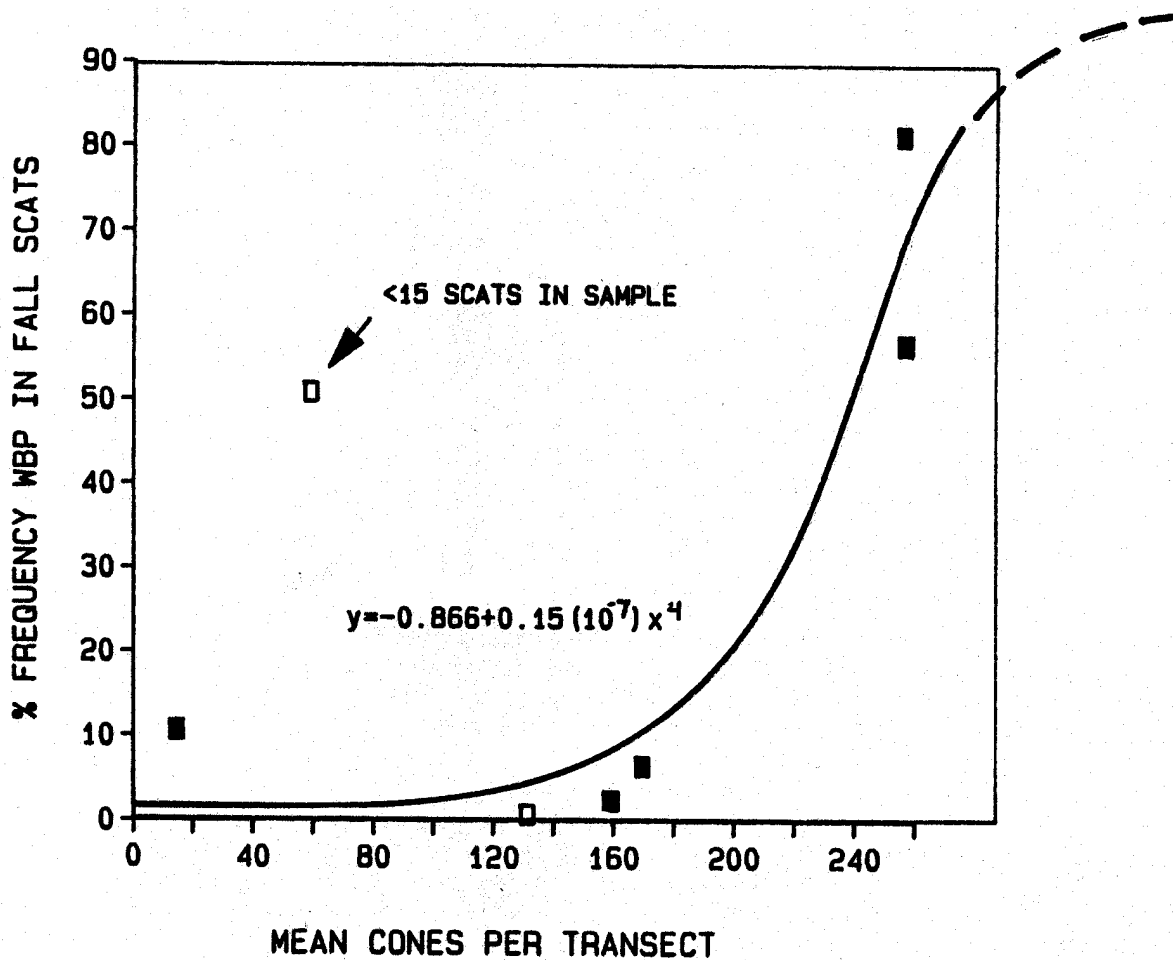


Fig. 7. Relationship between percent frequency of whitebark pine nuts in fall scats and the mean number of cones per transect.

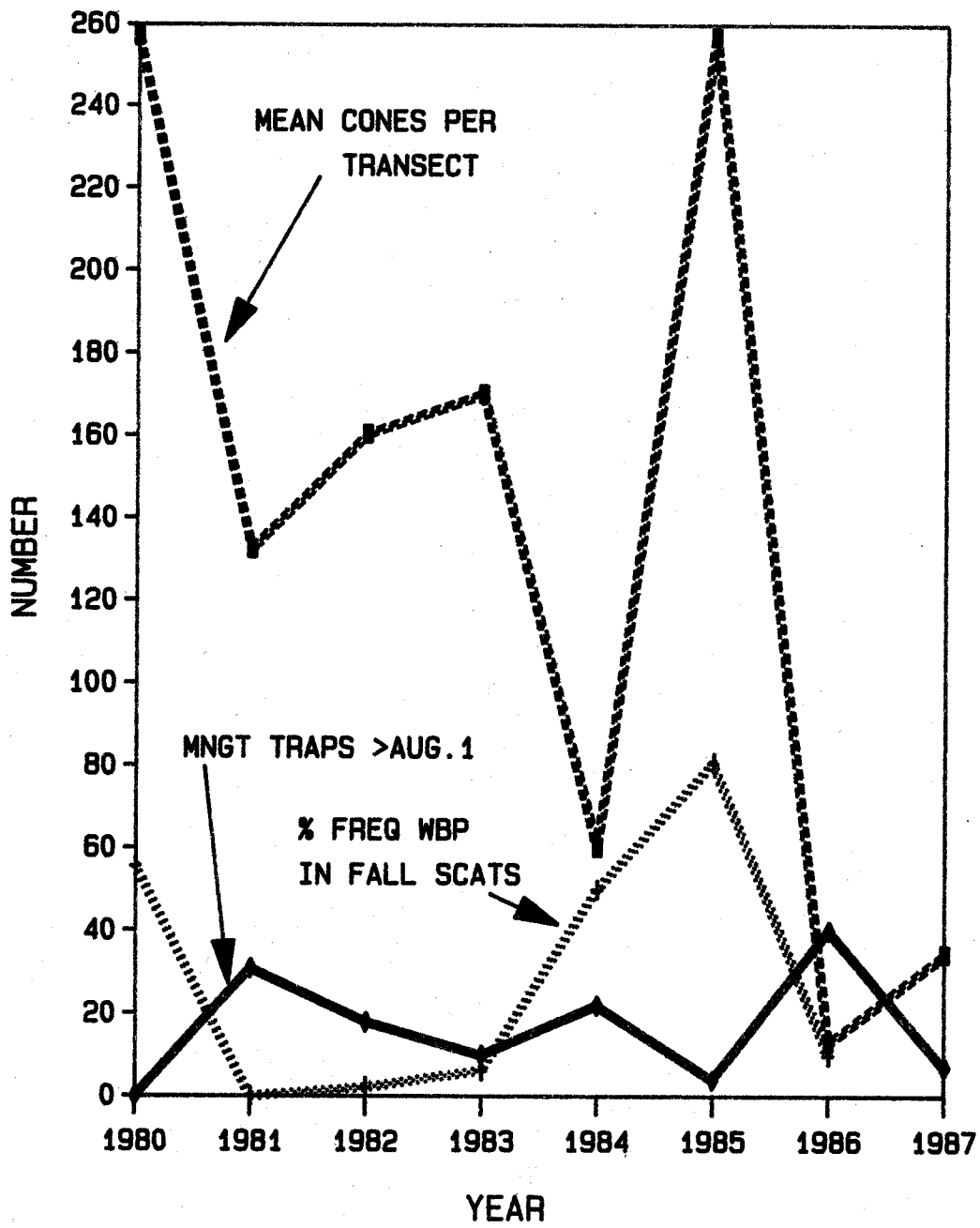


Fig. 8. Annual correlation between numbers of grizzly bears captured in management actions after 1 August and mean numbers of whitebark pine cones produced per transect.

Table 16. Individual whitebark pine transect production and transect characteristics, 1980-87.

			Cones/transect		Years	Elevation	Habitat type
			Mean	SD			
A	Deaf Jim	YNP ^a	168.00	128.11	8	84	Pial/Vasc ^b
B	Mt. Washburn	YNP	165.75	153.03	8	87	Alba/Vasc-Pial
C	Woody Cr	SNF	158.86	150.63	7	89	Alba/Vasc-Pial
D	Sunlight Cr	SNF	197.00	214.40	6	90	Pial/Vasc ^b
E	Lone Mtn	GNF	61.50	77.50	8	89	Pial/Vasc
F	Cabin Cr	GNF	129.86	213.20	7	95	Pial/Feid
G	Pitchstone	YNP	87.63	116.85	8	86	Abla/Vasc-Pial
H	Moccasin	BTNF	231.50	177.50	8	93	Abla/Vasc-Pial
I	Hominy Pk	TNF	109.00	95.97	3	86	Abla/Vasc-Pial
J	Hominy Pk	TNF	66.40	49.33	5	86	Abla/Vasc-Pial
K	Fawn Pass	YNP	0	-	1	90	Pial/Vasc
L	Fawn Pass	YNP	156.00	-	1	-	Abla/Thoc-Pial
M	Mt. Washburn	YNP	2.00	-	1	90	Pial/Juco
N	Big Game Ridge	YNP	19.00	-	1	95	Abla/Vasc-Pial
O	Two Ocean	YNP	12.00	-	1	92	Abla/Vasc-Pial
P	Avalanche	YNP	35.00	-	1	88	Abla/Vagl-Vasc
Q	Avalanche	YNP	1.00	-	1	96	Abla/Vasc-Pial
Total			130.69	147.05	8		

^a BTNF = Bridger-Teton National Forest, GNF = Gallatin National Forest, SNF = Shoshone National Forest, TNF = Targhee National Forest, YNP = Yellowstone National Park.

^b Marginal classification.

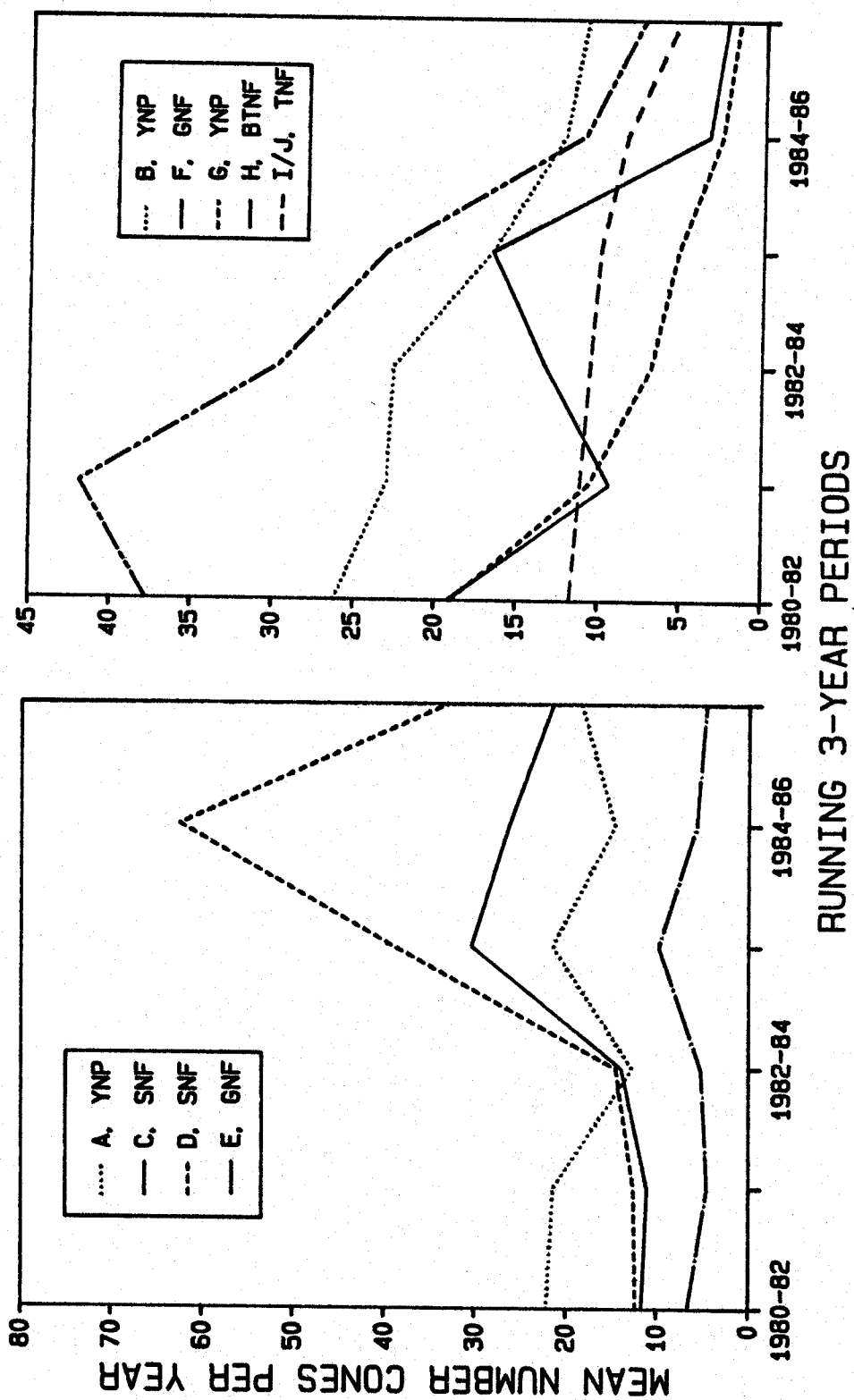


Fig. 9. Whitebark pine transect production during running 3-year periods.

Declines in productivity are probably due to (1) infestations of the pine beetle which were first noted in 1982 by the appearance of beetle-killed trees in transects; (2) the inherent cyclic nature of whitebark pine cone production which results in extremes approximately every 7 to 10 years; and (3) the effects of persistent adverse climatic conditions.

Whitebark pine nuts are still by far the most important fall food of Yellowstone grizzly bears, and availability of nuts influences annual feeding strategies and rates of movement. During years of low availability, numbers of grizzly/human interactions are greater and resulting management actions more numerous. As a consequence, mortality rates are generally higher when cone crops are poor. When nut production is assessed during July, potential intensity and locality of grizzly/human conflicts later that year can be assessed. General ecology of whitebark pine and causes of inconsistent nut production are poorly understood. Research in this area may lead to possible amelioration of inconsistent production and thereby lower or at least anticipate intensities of grizzly/human conflicts in years of low productivity.

DYNAMICS OF UNGULATE CARCASS AVAILABILITY AND USE BY BEARS ON THE NORTHERN WINTER RANGE:

1987 Progress Report

by

Gerald I. Green
David J. Mattson

INTRODUCTION

Yellowstone's grizzly bears (*Ursus arctos horribilis*) are known to make extensive use of ungulate carrion during spring (Knight et al. 1984). However, little documentation is available concerning spatial and temporal distribution of carrion. Reintroduction of wolves into the Yellowstone ecosystem is being considered, and if carried out, patterns of carrion availability will undoubtedly be altered, with unknown impacts on grizzly bears. For these reasons the Interagency Grizzly Bear Study Team (IGBST) instituted studies on ungulate winter ranges in Yellowstone Park: in 1985 in the Firehole area, and in 1987 on the northern ungulate winter range. These studies were designed to characterize the spatial and temporal distribution of ungulate carcasses and their use by bears. Preliminary analysis of the Northern Range data is presented in this report.

Ungulate winter ranges in Yellowstone are of 4 basic types: (1) geothermally influenced areas, which include portions of the Firehole, Madison, and Gibbon Rivers and the Heart Lake area (Craighead & Craighead 1973; Meagher 1973); (2) low-lying valleys represented by the Lamar, Yellowstone, and Gallatin valleys (Meagher 1973; Houston 1979; Craighead, Atwell, and O'Gara 1972); (3) expansive high elevation valleys represented by Pelican and Hayden Valleys (Meagher 1973); and (4) high-elevation, wind-swept ridges such as Specimen Ridge, Prospect Peak, and Quadrant Mountain (Houston 1982; Craighead et al. 1972). The Northern Range study area encompasses winter range types 2 and 4.

STUDY AREA AND FIELD METHODS

The study area consisted mainly of lower elevation portions of the Northern Range but also included higher elevations of Specimen Ridge. The study area was wholly within Yellowstone Park, within the Lamar and Yellowstone river drainages (Fig. 10).

Survey routes were used for data collection. Routes were laid out to coincide with historical spring concentrations of ungulate mortalities (Houston 1978) and grizzly bears (IGBST data on file). Each survey route was traveled more or less biweekly. Areas in the immediate vicinity of routes were thoroughly examined; short side trips were also made

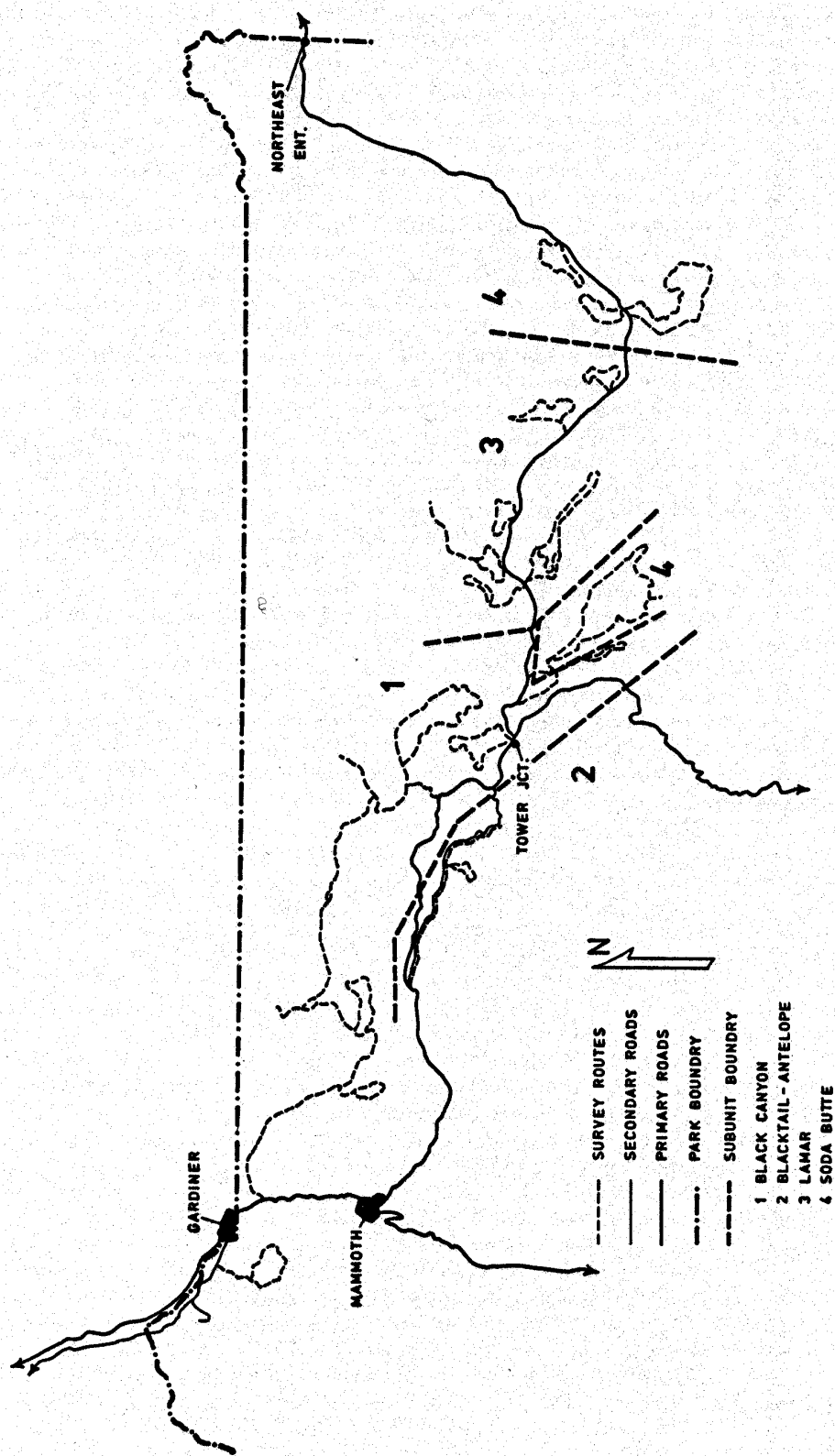


Fig. 10. Survey routes and subunit boundaries of the Northern Range ungulate carcass study.

to explore promising microsites. Travel routes were repeated as closely as possible each time period, after a workable route had been established.

Ungulate carcasses were examined for condition and history, including age of animal at death, condition of animal at death, cause of death, age of carcass, percent of carcass remaining, and estimated percent of carcass consumed by bears and other scavengers. Animal condition at time of death was determined by color and consistency of bone marrow, as described by Greer (1969). Cause of death was deduced by considering condition of animal at death and evidence indicating accident or predation. Habitat characteristics at each carcass location were also recorded.

All encountered bear sign was recorded. Front and rear pad width and stride and straddle were measured from tracks. Where possible, several measurements of each were taken to obtain an average and range. Features of track location such as topographic position, habitat type, direction of travel, distance from road and/or development, and visibility from road and/or development were recorded. The Palmisciano method (Blanchard 1985) was used to determine bear species from tracks. All encountered bear feeding sign was described according to standard procedures (Blanchard 1985).

Sightings of both ungulates and bears were recorded. Sex, age class(es), condition and location were noted for ungulates within 1 km of the study route. Species, size, coloration, age class, sex (when possible) and location were recorded for bears.

ANALYSIS

The study area was subdivided into 4 subunits: Soda Butte, Lamar, Black Canyon, and Blacktail-Antelope (Fig. 10). We segregated ungulate carcasses into 3 age classes--short yearlings, 1-112 to 10 year olds, and >10 year olds. We considered animals that died after date of first bear sign to be potentially available to bears.

We used both bear sightings and track analysis to estimate number of bears within the study area. Front foot pad width was used to, in part, identify individual bears; Klein (1959) suggested that front pad width was the single most discriminating track measurement. Front pad widths were plotted for each of the study area subunits. Criteria for discriminating among individuals included clustering of front pad width measurements, and the ratio of front to rear straddle taken along a straight line. The ratio of front-to-rear straddle varied among but not within a single set of tracks; the rear straddle was consistently either larger or smaller than the front straddle. Free interchange among study area subunits was assumed.

RESULTS

Survey Routes

Survey routes covered 668 km between 10 March and 8 May 1987. Fifty-six percent of the survey routes were within 2 km of a road; remaining portions were decreasingly spread out to 6 km. A large portion (33%) of survey routes were located on southwest aspects (Table 17).

Table 17. Distribution of survey routes among aspect classes and distances from road.

Survey routes	Aspects							
	N	NE	E	SE	S	SW	W	NW
km	68	82	12	92	90	222	54	46
%	10	12	2	14	13	33	8	7
	Kilometers from road							
	1	2	3	4	5	6		
km	183	190	134	96	53	12		
%	27	29	20	14	8	2		

Distances covered in each of the 3 major subunits varied according to the size of the subunit. Black Canyon, the largest subunit, had a total of 247 km of survey routes. The Lamar and Soda Butte subunits contained 219 km and 188 km of survey routes, respectively. The Antelope-Blacktail subunit was more cursorily surveyed along 13 km of survey routes.

Bear Activity

The greatest amount of bear sign was found during the last 2 weeks of April (Fig. 11). We estimated there to be a minimum of 5 to 8 grizzlies and 5 to 7 black bears in the study area at that time. Two to 3 grizzlies occupied each the Soda Butte and Black Canyon subunits; 2 grizzlies utilized the Lamar subunit. The Antelope-Blacktail subunit was not surveyed on a regular basis; however, tracks of 1 to 2 grizzlies were recorded in this area (Fig. 12).

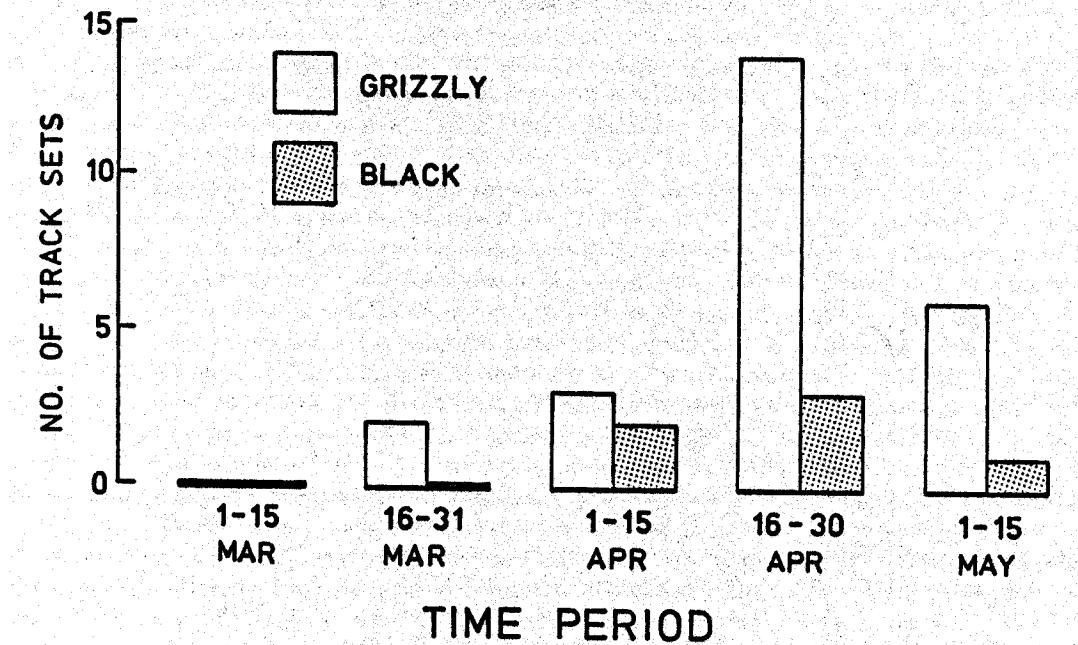


Fig. 11. Number of grizzly and black bear track sets found, by biweekly time period. Tracks were comparatively more difficult to find in the period-1-15 May.

Black bear activity was located mainly in the Black Canyon subunit. Seventy-one percent of black bear sightings reported within survey areas prior to 9 May were within this subunit (Fig. 12). By integrating track analysis and sightings, we estimated there to be at least 3 black bears in the Black Canyon subunit.

Disproportionately little bear sign was found along active roads (Fig. 13). Little grizzly bear sign was found within 1 km and none within 0.5 km of a road. Black bear tracks found within 0.5 km of a road resulted from activity of a small black bear habituated to human presence. If the tracks of this single habituated black bear are discounted, there were no black bear tracks found within 1 km of active roads.

Black bears constituted virtually all bear sightings by IGBST personnel. This contrasts with a number of grizzly tracks equal to or greater than the number of black bear tracks found in all study area subunits (Fig. 12). A reasonable inference is that activity of grizzlies was more nocturnal and that of black bears was more crepuscular and diurnal in lower elevations of the Northern Range.

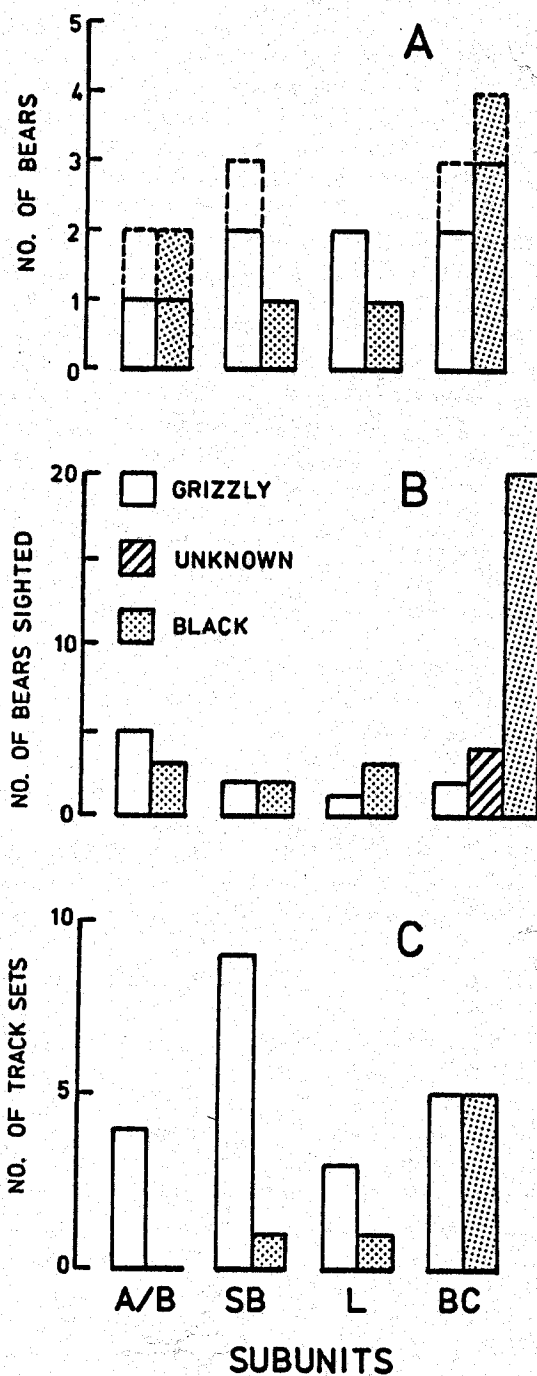


Fig. 12. Estimated number of bears (A), number of bear sightings (B), and number of track sets (C) in study area subunits: (A/B) Antelope/Blacktail, (SB) Soda Butte, (L) Lamar, and (BC) Black Canyon.

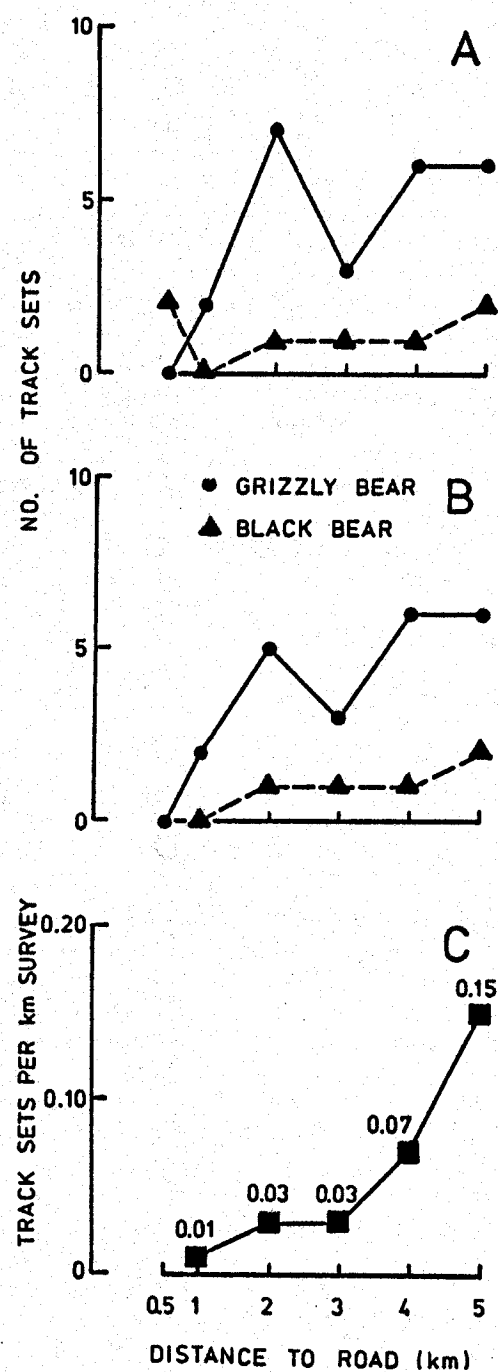


Fig. 13. Number of grizzly and black bear track sets found, by distance to road; (A) total and (B) along transects only. (C) number of tracks found, all bears, per km of survey route. Zone designations correspond to outer zone boundary.

Ungulate Sightings

A total of 9,026 ungulates were sighted along survey routes, including 7,541 elk, 980 bison, 344 antelope, 132 bighorn, and 29 mule deer. Ungulates sighted per kilometer varied little among the 4 subunits: 14.2 ungulates per kilometer in Black Canyon, 13.1 ungulates per kilometer in Lamar, 13.2 ungulates per kilometer in Soda Butte, and 12.6 ungulates per kilometer in Antelope-Blacktail.

Among elk sighted, 4.5 percent (342 individuals) were males >1 year old. There were 6,969 individuals in herds of cows and short yearlings. Using a ratio of 21 short yearlings per 100 cows (Singer, pers. comm.), these herds were estimated to consist of 1,463 short yearlings and 5,506 cows. After adding in sightings of individual cows and yearlings, we estimated total observed animals to consist of 1,491 short yearlings and 5,708 cows (19.8 and 75.7 percent, respectively, of total herd).

Ungulate Carcasses

We examined a total of 83 ungulate carcasses between 10 March and 8 May 1987. Of the total, 5 carcasses were bison, 3 were mule deer, and 75 were elk. Forty-nine percent of the elk carcasses examined were short yearlings, 24 percent were males in their second year or older, and 27 percent were females in their second year or older.

All bison and mule deer carcasses, as well as 73 percent of the elk carcasses, were found along survey routes. Among total elk carcasses, 73 percent of the short yearlings and 74 percent of the adults were located along surveys; we therefore concluded that no disparity in percent of carcasses found on survey routes existed among these gross age classes of elk.

The percent distribution of individuals among short yearling and adult (>1 year old) female and male classes varied significantly between carcasses and sightings of live animals ($\chi^2 = 198.2$, $df = 2$, $P < 0.001$) (Fig. 14). Adult males and short yearlings comprised a much greater proportion of carcasses than sighted live animals while adult females comprised a much smaller portion. Adult males were observed to spend more time in the timber, and comparatively fewer live individuals of this class may have been sighted, creating a bias in the comparison of carcasses and live animals.

The 3 age classes of elk died at different rates during the course of winter and spring (Fig. 15). Short yearlings died at a generally lower rate as the season progressed; this was apparent despite the difficulty in finding remains of this class from the earliest time period (Nov. through Feb.). Death rate of 2- to 10-year-olds also declined but not to the low rate of short yearlings. In contrast, animals older than 10 years died at an increasing rate as the season progressed.

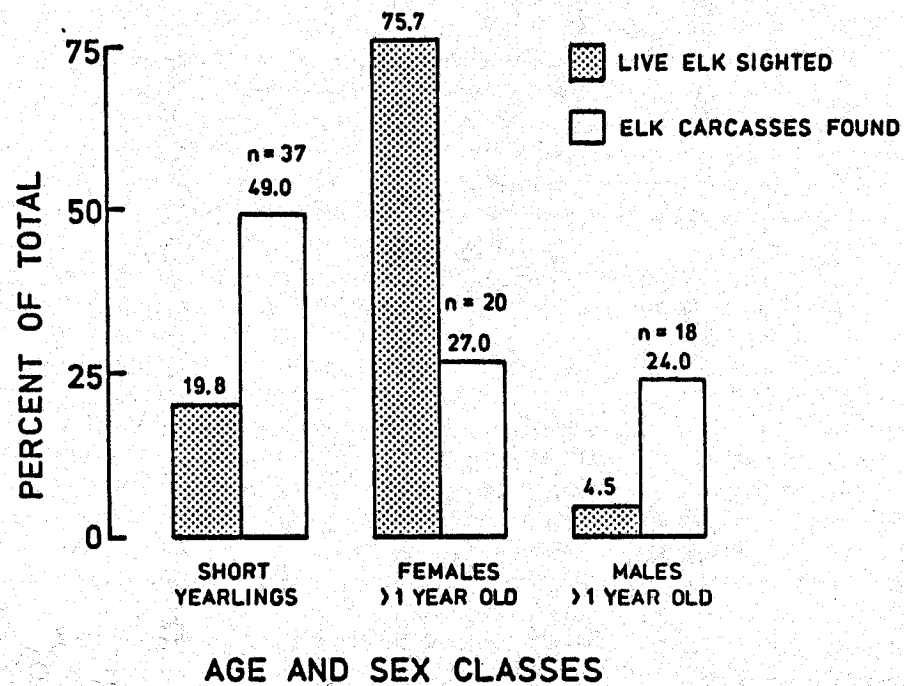


Fig. 14. Percent distribution of live elk sighted and elk carcasses found among 3 age and sex classes.

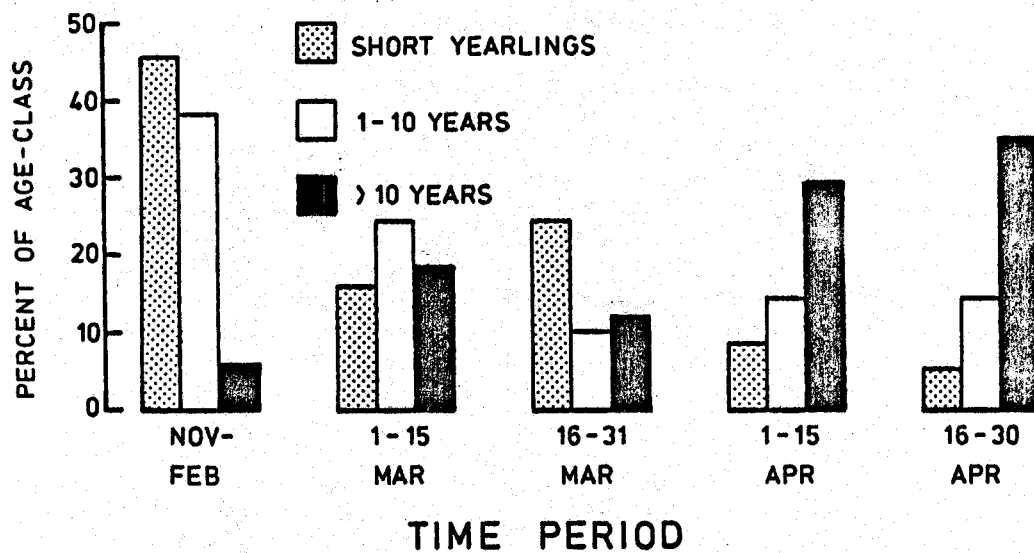


Fig. 15. Percent distribution of elk carcass age classes among time periods.

Among adult elk, a significantly greater percentage of males died during the first 2 weeks of March ($P = 0.023$) (Fig. 16). The highest percentage of females died during the month of April, although the difference was not statistically significant. Death rates during November-February did not significantly vary between sexes.

Sickness and malnutrition was the major cause of death among 2- to 10-year-olds and animals older than 10 years (Table 18). However, a disparity between the number of females and males dying of sickness and malnutrition was evident in these 2 age classes. Virtually all (91%) of the 2- to 10-year-olds dying of sickness were males, whereas virtually all (90%) of the older animals dying of sickness were females.

Table 18. Cause of death among adult age and sex (F = female, M = male) classes; number (n) and percent distribution of class among causes (%).

Age class		Cause of death									
		<u>Sickness/ malnutrition</u>		<u>Predation</u>		<u>Accident</u>		<u>Unknown</u>		<u>Total</u>	
		F	M	F	M	F	M	F	M	F	M
2-10 years old	<i>n</i>	1	10	1	0	3	2	1	3	6	15
	%	17	67	17	0	50	13	17	20	29	71
>10 years old	<i>n</i>	9	1	2	0	1	0	2	2	14	3
	%	64	(33)	14	(0)	7	(0)	14	(67)	82	18

A large portion (47%) of carcasses found on survey routes were found in the Black Canyon subunit. Decreasing percentages of carcasses were found on Lamar and Soda Butte survey routes – 34% and 19%, respectively. The ratio of carcasses per kilometer declined similarly among the subunits: 0.101 carcasses per kilometer in the Black Canyon subunit, 0.082 carcasses per kilometer in the Lamar subunit, and 0.053 carcasses per kilometer in the Soda Butte subunit.

We found carcasses more often at certain aspects and topographic positions. Carcasses were located more often in bottoms or on midslopes than other topographic positions. Most elk carcasses were located on southwest aspects; significantly fewer carcasses than expected by chance were located on northeast and southeast aspects (Figs. 17 and 18).

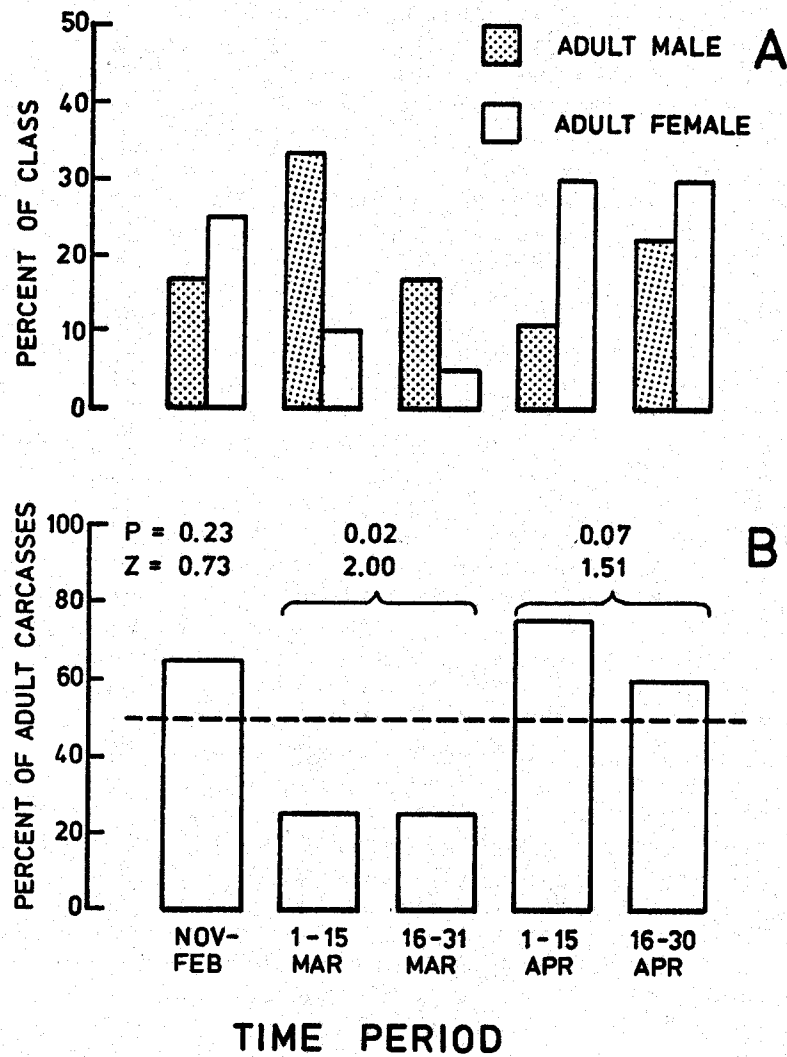


Fig. 16. (A) Percent distribution of adult elk sex classes among time periods and (B) females as percent of total adult carcasses by time period. Z-scores and P-values were calculated to test hypotheses that adult males and females were equally represented among carcasses.

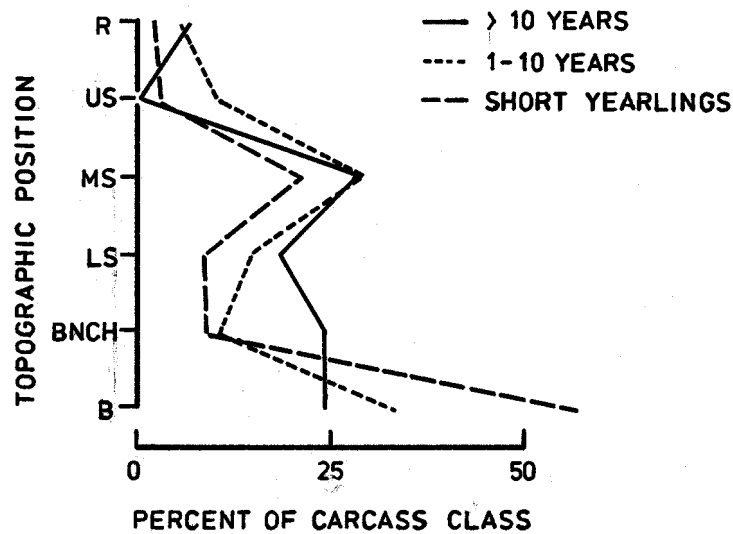


Fig. 17. Distribution of elk carcass age classes among topographic positions: R – ridge, US – upslope, MS – midslope, LS – lowslope, BNCH – bench, and B – bottom.

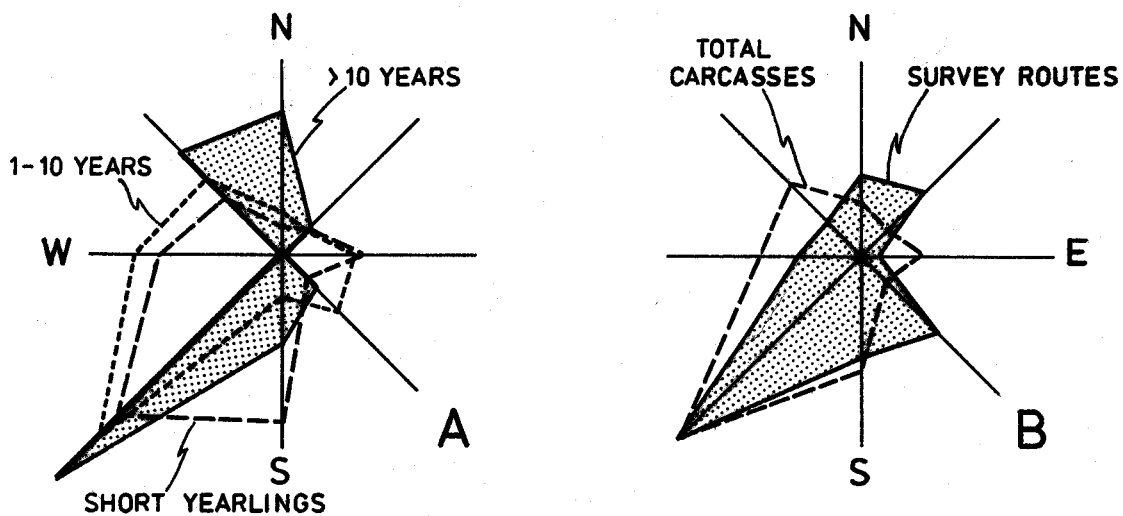


Fig. 18. (A) Percent distribution of elk carcass age classes by aspect. (B) Percent distribution of all carcasses and survey routes by aspect; distributions significantly differed ($\chi^2 = 28.4$, $df = 7$, $P < 0.00$).

Short yearling elk carcasses were found more frequently in the open, especially after February, whereas adult elk carcasses were more often found in timbered areas (Fig. 19). Diversity index of habitat types associated with different age classes was lowest for short yearlings (8.2) and highest for 2- to 10-year-olds (13.64). A diversity index of 11.17 was calculated for habitat types associated with carcasses of >10-years-old animals. Those carcasses found in the timber were mostly in Douglas fir cover types and in the Douglas fir/snowberry and Douglas fir/Oregon grape habitat types.

Bear Use of Carcasses

Bear use of carcasses began in the latter part of March and peaked in the latter part of April (Fig. 20). Carcasses 1.5 km away from active roads were used significantly more often by bears ($P < 0.001$) than were carcasses within 1.5 km of roads (Fig. 21).

Bears more often used available carcasses that were located in the timber ($P < 0.001$). Ten of the 13 carcasses (78%) visited by bears were found in timbered areas. Only 2 of the 9 carcasses (22%) available to bears but not visited were in timber.

We estimated that a total of 3,441 kg of biomass (wet weight) was available from carcasses found during our study after first sign of bear activity (FBS). Of this, we estimated 681 kg (20% of the total) was consumed by bears. Black bears consumed a greater amount of biomass than did grizzlies – 62% of that consumed by bears. We estimated that, on the average, consumption of adult elk carcasses by all scavengers initiated at 0.7 days and progressed at a rate of 15% per day (Fig. 22).

Bears derived a significantly greater amount of food ($P = 0.017$) from carcasses of old adult female elk compared to other carcass classes. Eleven of the 21 carcasses (52%) available to bears in the study area were female elk over the age of 10. These carcasses provided the majority (68%) of biomass consumed by bears.

Virtually none of the short yearlings were available to or utilized by bears. Only 34% of short yearlings found died after FBS. Consumption of short yearlings by all scavengers was initiated the same day they died, and carcass depletion occurred at an average rate of 54% per day (Fig. 22). Maximum probability of encounter (ca. 95%) between a bear and carcass did not occur until 32 days after the ungulate's death in the Firehole area (Mattson and Henry 1987). Time to maximum probability of encounter on the Northern Range was probably at least 32 days, given the Northern Range's much greater expanse and habitat variation. As a result, a short yearling dying post-FBS was likely completely consumed long before it could be found by a bear.

In large part, immediate initiation of consumption of short yearlings after FBS resulted from coyote predation. Of the short yearling carcasses that were found within 8 days of death, 45% resulted from coyote predation (Table 19). We were not able to determine

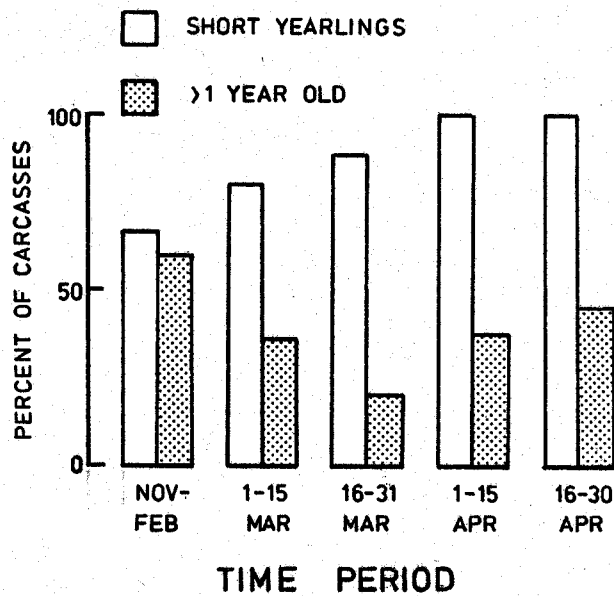


Fig. 19. Percent of elk carcass age classes located in the open, by time period.

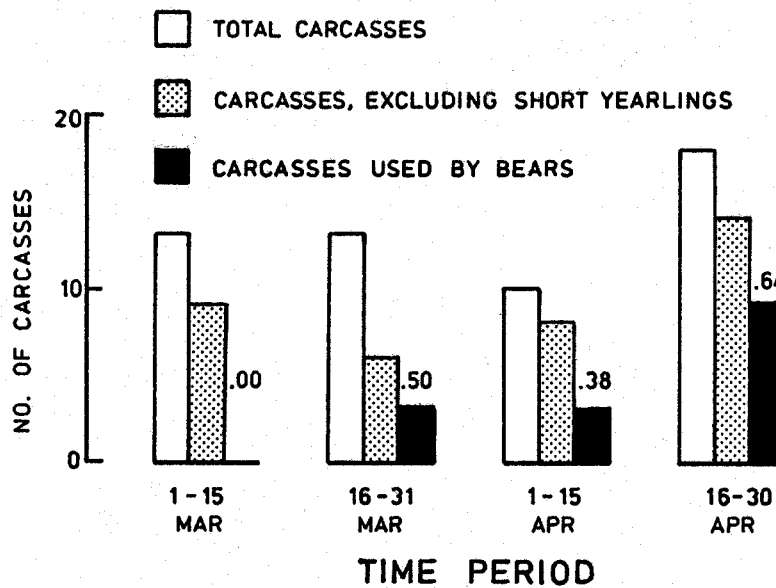


Fig. 20. Total carcasses, total carcasses excluding short yearlings, and carcasses used by bears, by time period. Proportion of carcasses, excluding short yearlings, used by bears is also given.

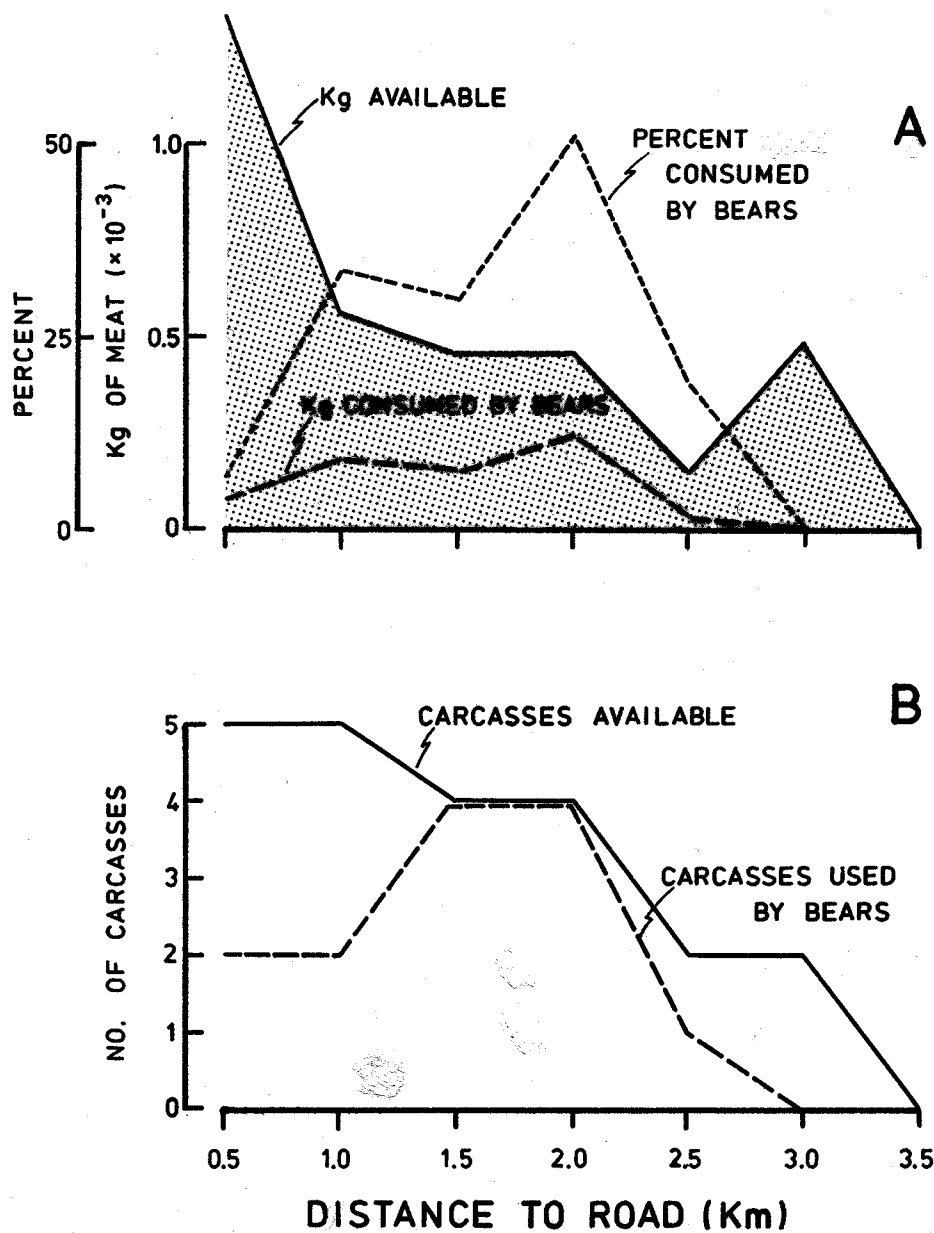


Fig. 21. Availability and use of carrion by bears, by km distance from road; (A) as kg of utilizable tissue (meat), (B) as individual carcasses. Carcasses considered to be effectively not available to bears by virtue of date of death (prior to date of first bear sign) or age class (short yearlings) were not included.

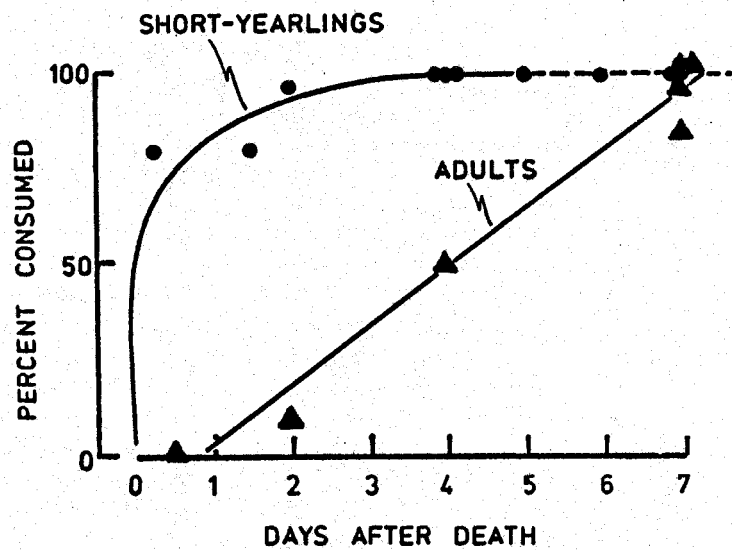


Fig. 22. Carcass consumption relative to days after elk death, for short yearlings and animals >1 year old.

cause of death in the remaining 55%. IGBST personnel also witnessed an attempted predation by 3 coyotes on what appeared to be a healthy short yearling at 0830 hours, 17 March. The predation attempt occurred along the forest edge on the south side of Little America Flats.

Table 19. Cause of death for short-yearling elk, as able to be determined, by estimated days after death (number (*n*) and percent of class by days after death (xxx)).

Cause of death	Days after death						
	0-2	2-4	4-8	8-16	16-30	30-60	60-90
Sickness/ Malnutrition	0	0	0	0	0	0	0
Predation	2 (100)	1 (33)	2 (33)	0	0	0	0
Accident	0	0	0	0	1 (17)	1 (17)	0
Unknown	0	2 (67)	4 (67)	1 (100)	5 (83)	5 (83)	16 (100)

DISCUSSION

Ungulates very likely entered the winter of 1986-87 in good condition due to the unusually wet growing season of 1986. Unseasonably mild winter and spring conditions also probably resulted in little stress on the ungulate populations. Spring of 1987 was warm and dry. March, April and May temperatures were well above normal and ranged from 2.2 above normal at Cooke City during March to 80 above normal at Mammoth during April. March and April precipitation was well below normal. May precipitation was higher than normal; however, virtually all of it fell after mid-month in the form of rain (NOAA, climatological data). These climatic conditions favored survival of ungulates and undoubtedly resulted in low carrion availability, March through May of 1987. Many more carcasses were found during winter-spring of 1974-75 and 1975-76 (538 and 277, respectively) (Houston 1978) than the 83 found by our team during spring of 1987. Weather data indicate that severe winter conditions during 1974-1975 extended well into spring. The 1975-1976 weather data reflect moderate winter-spring conditions more comparable to those of the 1986-87 season. (Table 20). We have no well founded hypothesis to explain the difference in number of carcasses found, especially between 1975-76 and our study period; however, we do not think that search effort alone would explain the disparity.

Not only numbers but also age and sex classes of elk carcasses found by Houston differed from those found during our study (Table 21). During 1974-75, proportionate representation of short yearlings among carcasses was comparable to that of 1986-87; however, adult males comprised a substantially greater portion of carcasses during 1974-75 compared to 1986-87. This suggests that adult males were more vulnerable to the effects of a dry growing season (as was the summer of 1974) and a cold, snowy winter. Near equal percentages of adult males and females among carcasses during 1975-76 corresponded to our findings during 1986-87. However, proportionately many fewer short yearling carcasses were found during 1975-76 compared to our study period, possibly a consequence of differential success in finding these remains or differences in predatory activity of coyotes between the 2 study periods. Nowhere does Houston remark on predatory activities of coyotes. On the other hand, we hypothesize that a major portion of short yearlings were killed by coyotes during spring of 1987. Conceivably, sustained high elk densities may have favored an increase in predatory behavior in coyotes, noticeable between 1975-76 and 1986-87.

Female elk over 10 years old were an important source of food for bears during 1986-87. Peak die-off of older females occurred in April, later in the winter-spring season than adult males and during the period of peak carrion use by bears. Thus, older females comprised the greatest amount of carrion available to and used by bears in 1987. Earlier die-off of adult males was probably a-consequence of stress attributable to the rut; fat reserves of vulnerable adult males were very likely depleted earlier in the winter-spring

Table 20. Monthly average temperature and precipitation and departures from normal, for Mammoth and Cooke City, for 1974-75, 1975-76, and 1986-87.

Average monthly temperature and departure from normal																
Station & years	November		December		January		February		March		April		May		June	
	Avg temp	Depa- ture	Avg temp	Depa- ture	Avg temp	Depa- ture	Avg temp	Depa- ture	Avg temp	Depa- ture	Avg temp	Depa- ture	Avg temp	Depa- ture	Avg temp	Depa- ture
Mammoth																
1974-75	29.6	0.1	19.9	-2.2	16.3	-2.6	17.6	-5.7	24.2	-2.5	28.3	-9.2	42.8	-4.2	52.8	-1.3
1975-76	26.7	-2.8	26.1	4.0	22.9	4.0	25.0	1.7	25.5	-1.2	40.0	2.5	49.9	2.9	53.5	-0.6
1986-87	28.0	-1.5	21.9	0.1	18.9	-0.2	26.7	2.7	30.9	3.7	45.1	8.0	51.3	3.9	57.8	2.4
Cooke City																
1974-75	22.9	-0.5	12.3	-3.3	10.7	-2.8	14.5	-3.3	20.2	-1.2	25.3	-6.3	36.5	-4.9	44.6	-4.1
1975-76	18.9	-4.5	18.3	2.7	13.6	0.1	17.4	-0.4	17.5	-3.9	32.0	0.4	42.1	0.7	46.8	-1.9
1986-87	20.0	-2.8	10.0	-4.9	10.8	-2.7	18.7	0.5	23.8	2.2	37.1	6.0	46.0	5.1	M	
Total precipitation and departure from normal																
Station & years	November		December		January		February		March		April		May		June	
	Total precip	Depa- ture	Total precip	Depa- ture	Total precip	Depa- ture	Total precip	Depa- ture	Total precip	Depa- ture	Total precip	Depa- ture	Total precip	Depa- ture	Total precip	Depa- ture
Mammoth																
1974-75	0.30	-0.96	1.04	-0.19	1.04	-0.31	0.52	-0.39	1.52	0.37	1.76	0.51	1.34	-0.65	1.44	-1.03
1975-67	1.25	-0.01	0.87	-0.36	0.21	-1.14	0.53	-0.38	1.31	0.16	0.79	-0.46	2.68	0.69	3.83	1.36
1986-87	0.96	-0.1	0.02	-1.17	0.32	-1.00	0.35	-0.48	0.63	-0.49	0.53	-0.64	2.87	0.99	1.78	-0.32
Cooke City																
1974-75	0.71	-1.53	1.88	-0.40	4.09	1.62	1.94	0.10	1.98	0.05	1.79	-0.18	2.58	-0.14	3.40	0.08
1975-76	3.09	0.85	2.43	0.15	3.31	0.84	3.29	1.49	2.12	0.19	2.53	0.56	1.13	-1.59	3.58	0.26
1986-87	2.03	-0.07	0.25	-2.22	1.13	-1.66	0.67	-1.43	1.16	-0.92	0.67	-1.26	3.74	1.23	1.52	-1/38

Table 21. Proportionate distribution of elk carcasses among sex and age classes; winter-spring of 1974-75, 1975-76 and 1986-87. 1974-75 and 1975-76 data are extracted from Houston (1978).

Winter-Spring	<i>n</i>	Adults		Short yearlings
		Females	Males	
1974-75	299	0.19	0.35	0.46
1975-76	152	0.36	0.35	0.29
1986-87	83	0.24	0.27	0.49

season. On the other hand, a generally younger bull in marginal condition may have been able to recoup more quickly than a typically much older, undernourished female once green-up had started. This could simply have been a function of differences in tooth wear and resulting ability to use shorter and sparser spring growth. The system of older females may also, in general, be much less resilient.

The mild winter-spring weather of 1986-87 apparently affected distribution of elk among our study area subunits. The comparable rates of encounter with live elk along transect routes in all subunits suggests a more or less even distribution of animals within the Northern Range covered by our survey during spring 1987. This contrasts with a tendency for animals to concentrate at lower elevations during severe winters (Houston 1979).

Highway proximity affected bear use of carrion as well as level of activity during spring 1987. We found significantly less use of carcasses within 1.5 km and encountered many fewer tracks per kilometer of travel within 3 km of an active highway. This may be partly a consequence of lack of cover along much of the Mammoth to Cooke City highway (Fig. 23) (IGBST data). The disproportionately high use of carrion in timber by bears indicates that bears may be highly security conscious.

We hypothesize that niche separation of black and grizzly bears on the Northern Range during spring of 1987 took at least 2 forms. Black bears tended to be more day active and grizzly bears more night active. In addition, black and grizzly bears were differentially distributed among study area subunits. Except for the single black bear track on Mt. Norris, all black bear sign and sightings recorded by IGBST personnel were either in the Black Canyon subunit or in areas closely bordering the subunit. Grizzly sign, although more evenly dispersed throughout the subunits, was more frequently found in the Soda Butte subunit.

Fig. 23. Percent nonforest area by km distance from roads, Mammoth to Northeast Entrance; zone designation corresponds to outer zone boundary in km from road.

We found comparatively little grizzly bear sign, especially in lower elevations of our study area, during spring of 1987. Our 1987 study area was distinguished by very little available carrion compared to the large majority of years. Intense scavenger activity, especially by coyotes, resulted in rapid consumption of all classes of carrion; maximum time to near 100% consumption averaged 7.2 days. Using a minimum of 32 days to maximum probability of any given bear encountering any given carcass (Mattson and Henry 1987), many carcasses were probably completely consumed 3 weeks prior to discovery by a bear.

SPRING GRIZZLY BEAR USE OF UNGULATE CARCASSES IN THE FIREHOLE RIVER DRAINAGE:

Third Year Progress Report

By

Jeff Henry
David J. Mattson

INTRODUCTION

A study was initiated in 1985 by the Interagency Grizzly Bear Study Team (IGBST) to investigate dynamics of ungulate carcass availability and use by bears in the Firehole River drainage. This study has continued through the spring of 1987. During 1987, the Norris geyser basin, Elk Park, and Gibbon Meadows were also surveyed for carcasses and bear sign. The study area and methods are described by Mattson and Henry (1987), and Green and Mattson (this volume).

This progress report presents preliminary findings, including study results that pertain to human-bear interactions, and effects of highway traffic on bear use of ungulate carcasses. Effects of humans using and in residence at the Old Faithful development on grizzly bear use of ungulate carcasses are presented in Mattson and Henry (1987).

RESULTS

Ungulate Carcasses

There were major differences in number of observed carcasses among the 3 study years (Table 22). The largest number of carcasses (85) was found during 1986 and the least number (17) during 1987. During 1985 and 1986 we found more elk than bison carcasses; during 1987 we found more bison carcasses.

Differences in representation of species, sex, and age classes among carcasses and among years were apparent. Adult female elk carcasses comprised a large proportion of carcasses during all 3 years, while adult male elk were underrepresented in the carcass samples. Short yearlings comprised a large proportion of bison and elk carcasses found during 1986 compared to 1985 and 1987. Finally, compared to elk and to bison short yearlings, deaths of adult bison were remarkably constant (between 9 and 11 individuals) among the 3 study years.

We also noted differences in timing of ungulate deaths among the study years (Fig. 24). A prominent peak occurred from early March through early April (Julian dates 60-104).

Table 22. Number of elk and bison found that died during 1985, 1986, and 1987; and proportion of dead animals that were short yearlings or, among adults, male or female.

Year	Bison					Elk				
	<i>n</i>		Short		Adults		Short		Adults	
			yearlings	yearlings	Female	Male	yearlings	yearlings	Female	Male
	Total	Adults					Total	Adults		Unknown
1985	25	11	0.56	0.64	0.36	0.36	29	15	0.48	0.20
1986	30	9	0.69	0.33	0.76	0.76	54	19	0.65	0.05
1987	12	10	0.17	0.60	0.40	0.40	5	3	1.00	0

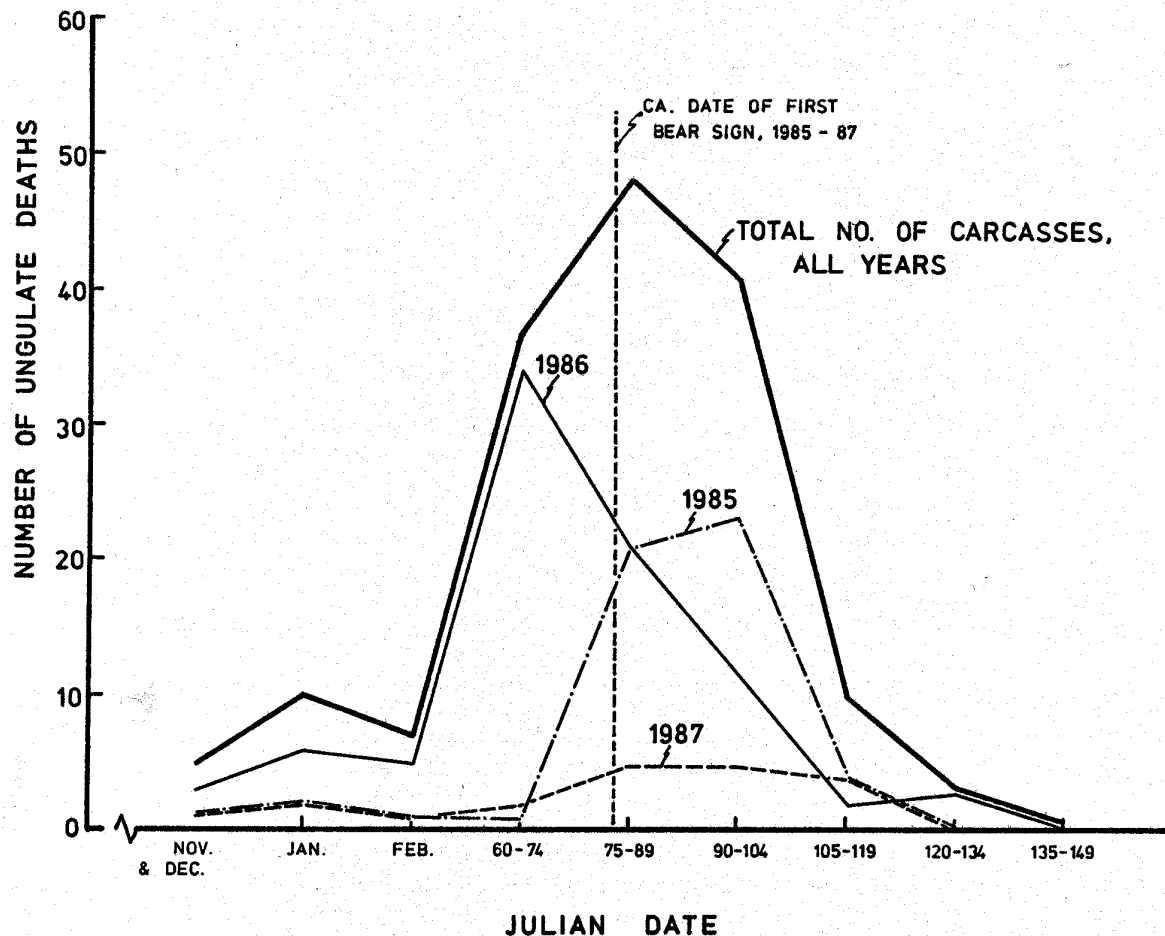


Fig. 24. Number of ungulate deaths by time periods and year.

Individual year peaks varied from early April in 1985 to March in 1986; no prominent peak was evident during 1987. Differences among years could be attributed to weather conditions. The later die-off in 1985 followed some severe March storms. During 1986, more severe early to mid-winter weather apparently stressed ungulates and we anticipated a large die-off. This potential was dissipated by early mild spring conditions. The winter of 1986-87 was unusually mild, and followed a wetter than normal growing season, resulting in relatively low levels of die-off.

Time-specific deaths varied between bison and elk and among sex and age classes (Fig. 25). Distribution of elk and bison deaths among time periods differed significantly ($G = 19.5$, $df = 7$, $P = 0.007$). Elk tended to die during a shorter time period, especially during late March and early April. Among both bison and elk, short yearlings tended to die earlier than the majority of adults. This was also evident for elk on the Northern Winter Range in Yellowstone National Park (Green and Mattson, this volume). Adult

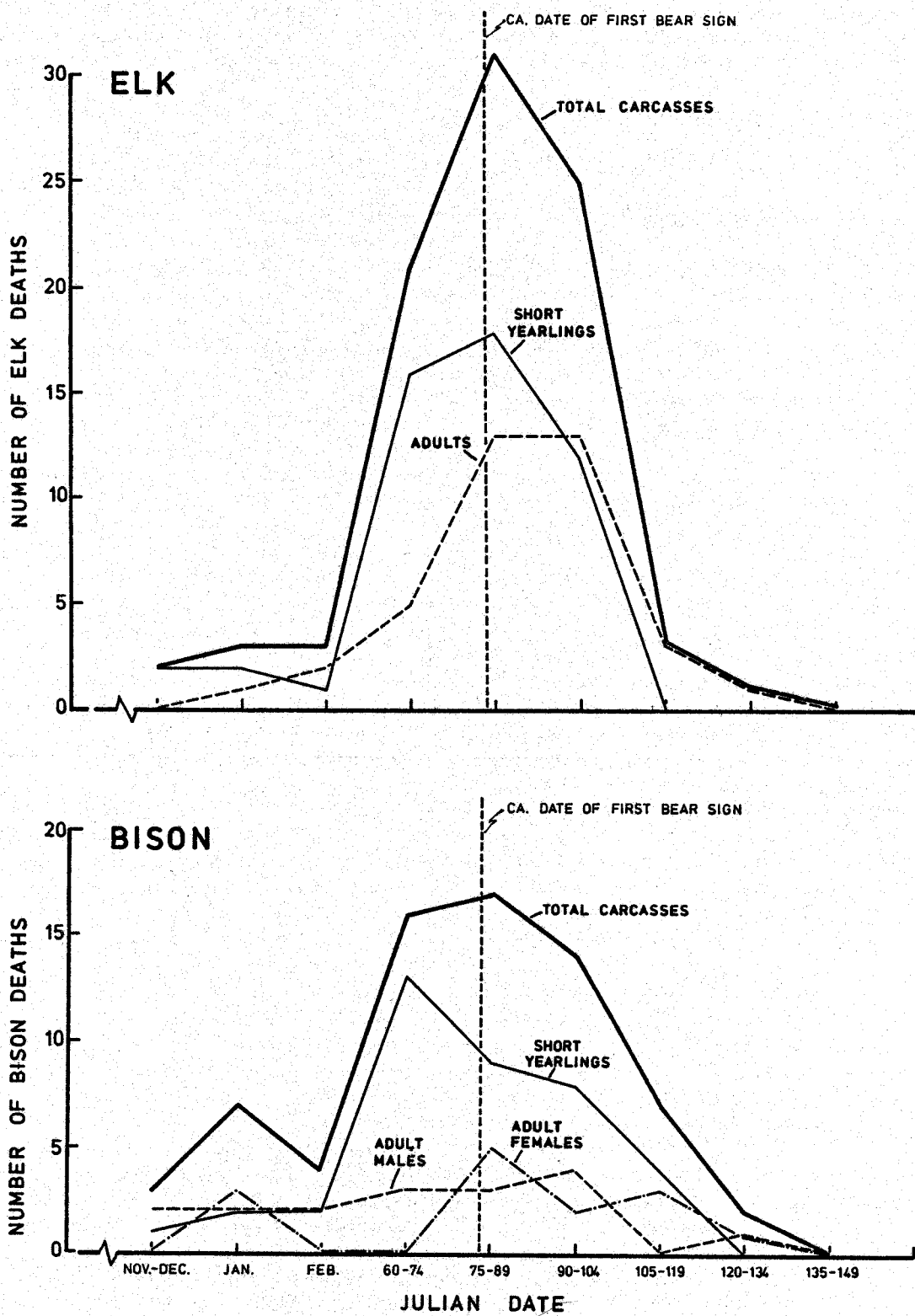


Fig. 25. Number of deaths by time period for elk and bison; total and for sex and age classes.

female bison tended to die in disproportionately large numbers, later in the spring. This was probably due to stresses associated with calving.

Bear Activity and Use of Carcasses

From track analysis (see Green and Mattson, this volume) and observation of individuals, we estimated that at least 9 grizzly bears and 1 black bear used the Firehole study area during spring 1987. An additional 2 grizzlies and 1 black bear were also probably present. Of the 9 known grizzlies, 3 were lone adult females, 1 was a female with cubs-of-the-year, and 2 were adult males (sex was determined by examining urinations). Fresh tracks of the 3 cubs-of-the-year, without accompanying tracks of a larger bear, were later observed and followed a considerable distance over expansive barren geothermal deposits. We also estimated that 1 black bear and between 6 and 7 grizzlies used the Norris geyser basin area, primarily between the first week of April and the first week of May.

The first date of bear sign did not vary among years: Julian date 83 in 1987, 85 in 1986, and 84 in 1985. First date of bear sign coincided with the aggregate peak of ungulate deaths, and preceded peak of adult ungulate deaths (see Figs. 24 and 25). This coincidence very likely reflects investigation of ungulate winter ranges by bears at a time when the greatest amount of carrion is available. The consistency of dates among years also suggests that timing may be cued by day length.

Bear activity peaked twice during the spring of 1987 in the Firehole area, first in the last week of March and second during the last half of April (Fig. 26). Width of right front pad averaged larger ($t = 2.62$, $df = 28$, $P = 0.007$) for track sets measured during the second compared to the first period. Width of left front pad also tended to be larger ($t = 1.56$, $df = 29$, $P = 0.068$) during the second time period. If size of foot is assumed to be positively correlated with overall body size, then average larger animals may have been responsible for the late April activity. Black bear tracks were not observed in the Firehole study area until late April, after grizzly bear activity had substantially declined. A black bear was observed earlier in the spring, in the near vicinity of Old Faithful. These observations tend to corroborate our earlier assessment that black bears avoid grizzlies in the Firehole area during the spring, and when present more often range closer to the Old Faithful development.

Bear use of carcasses was apparently affected by proximity to the Old Faithful-Madison Junction highway. Within 400 m of the highway bears made substantial use of only 35% of the carcasses, compared to 65% of carcasses beyond 400 m (Fig. 27); the difference was significant ($G = 5.13$, $df = 1$, $P = 0.024$). We only used carcasses of animals that had died after 15 March and were located greater than 5 km from Old Faithful ($n = 72$) for our analysis. Bear use of short yearling carcasses was most affected by proximity to the

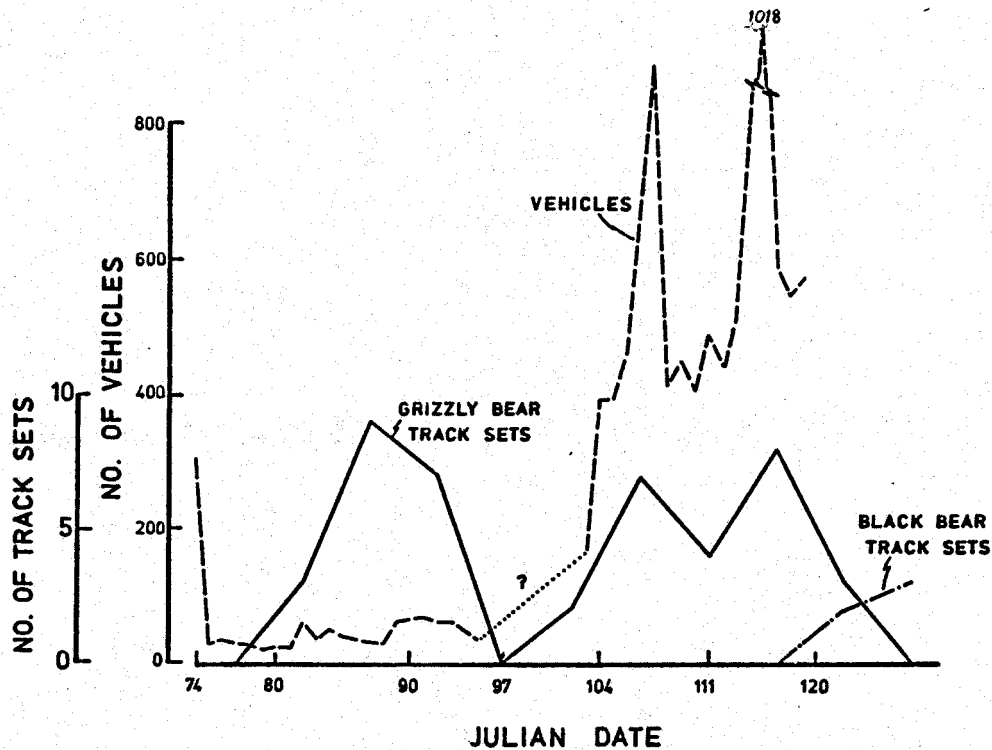


Fig. 26. Number of vehicles counted on the Old Faithful-Madison Junction highway and number of bear track sets measured in the Firehole study area, by time period.

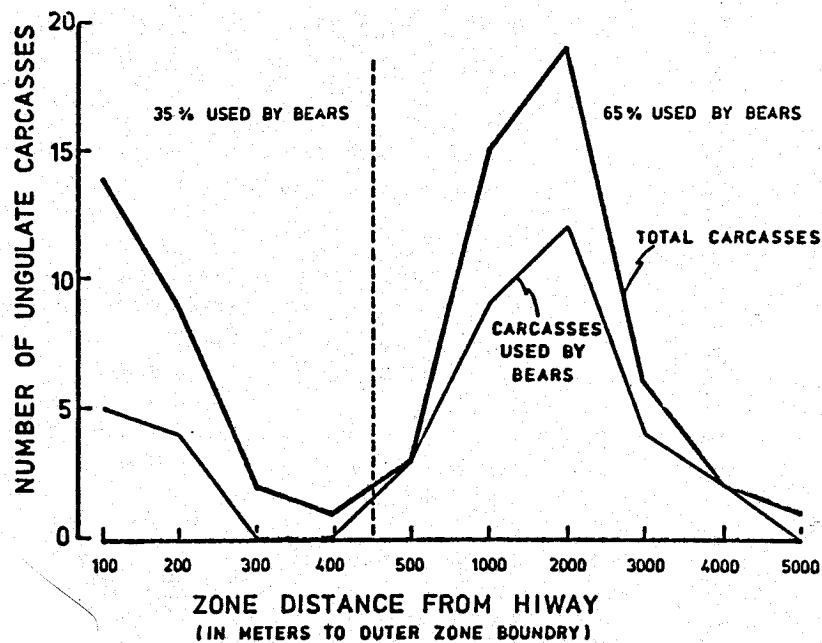


Fig. 27. Number of ungulate carcasses available to and used by bears, by zone distance from the Old Faithful-Madison Junction highway; zones are designated by distance in meters to outer zone boundary from highway.

road. Within 400 m of the Old Faithful highway, bears made use of only 10% of available short yearling carcasses; beyond 400 m they used 54% of this class. The difference was significant ($G_c = 4.44$, $df = 1$, $P = 0.037$). Probability of adult carcass use was somewhat but not significantly less closer to the road ($G_c = 0.95$, $df = 1$, $P = 0.357$).

Human Activities

Records of 1987 vehicle traffic were available from a traffic counter at Madison Junction. We derived estimates of traffic on the Old Faithful- Madison Junction highway from vehicles in lanes inbound from and outbound to Old Faithful (lanes 3 and 5) (see Fig. 26). High levels of traffic ended on 15 March. Low levels continued from then until sometime between 5-13 April. This period of low use coincided with the first peak of bear activity. High levels of vehicular traffic characterized the remainder of the 1987 study period. This later period coincided with the second peak of bear activity.

Hourly records of traffic were also available from the counter. Traffic was concentrated between 0900 and 2000 hours (Fig. 28). Early season traffic was characterized by 2 minor peaks at 1300 and 1800 hours, respectively. Late season traffic was characterized by a broader peak between 1500 and 1700 hours. We compared these traffic patterns with average daily activity patterns documented by Schleyer (1983) for grizzly bears during spring in the Yellowstone area. This comparison suggests that bears are most active during the spring in hours prior to and following peak traffic. Bears would probably make greatest use of carcasses along roads during early morning hours (0630-1000) when they are most likely to be active and when traffic levels are still low.

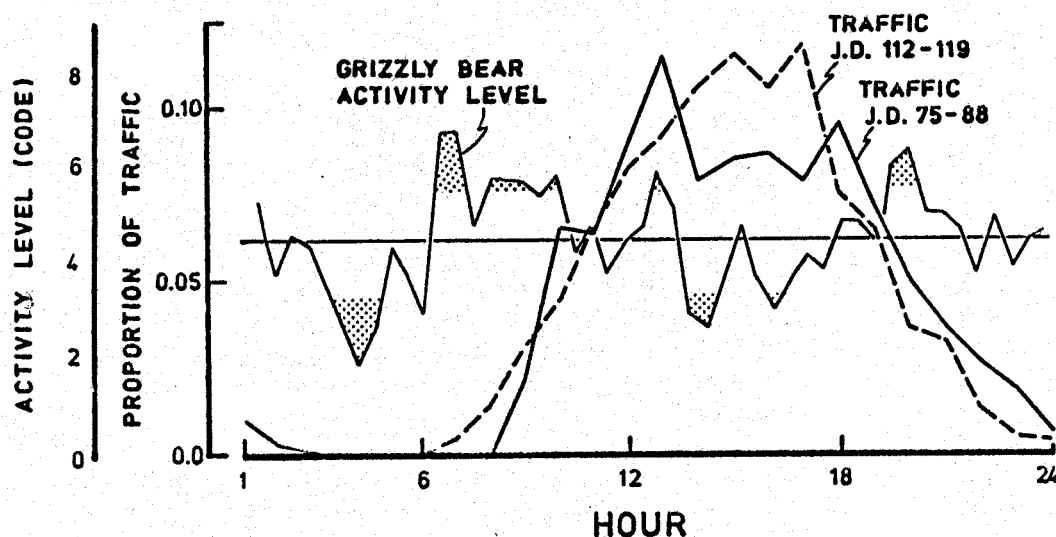


Fig. 28. Proportionate distribution of Old Faithful-Madison Junction vehicle traffic among hours, for Julian dates 112-119 and 75-88; hourly activity level of grizzly bears measured during spring in the Yellowstone area (from Schleyer 1983).

DISCUSSION

Timing of first observed bear sign in the spring was consistent among years. Also, we first observed grizzly bear sign during 2 consecutive springs (1987 and 1988) during the same 7-day period on the Northern Ungulate Winter Range. These observations suggest that movement of grizzly bears to most ungulate winter ranges during the spring is cued by day length. Also, given the correspondence of first date of bear sign with peak effective carrion availability, we suspect there has been feedback so that bears initiate more active foraging strategies at a time when probability of encounter with utilizable carrion is highest.

Dates of first observed bear sign only relate to time at which bears were active in our study areas. However, the mean date at which telemetered bears emerged from their dens in 1975-80 (Julian date 87) (Judd et al. 1986) falls within the same timeframe as our dates of first observed bear sign. Only adult males were likely to emerge at a significantly earlier date.

Our observations suggest that different individual bears were responsible for much of the early and late peaks of activity during spring of 1987. Given that different cohorts of bears tend to emerge from their dens at different dates (Judd et al. 1986), the 2 peaks could be attributable to arrival of different cohorts on the winter range. Black bear(s) apparently started using the winter range only after use by grizzly bears dropped off markedly.

Our data suggest that grizzly bear use of carcasses was negatively affected by proximity to the Old Faithful-Madison Junction highway, and that the effect extended out to an average 400 m. Within this zone virtually no short yearling carcasses were used by bears, and adult ungulate carcasses were used somewhat less often. Bears would probably benefit by lower levels of early morning (0600-1000 hours) and late afternoon (1800-2100 hours) human traffic on the Old Faithful highway.

Our carcass use study coincided with the season of least human presence in the Firehole-Old Faithful area; therefore avoidance of the Old Faithful development and the Old Faithful-Madison Junction highway by bears might not be expected. However, avoidance was observed. Either the avoidance was an artifact and the bears were avoiding these facilities per se, or there was enough human presence even during the low use season to affect bears. Traffic levels were quite high (between 400 and 1,000 vehicles/day) during half the period that bears were using carcasses in the Firehole drainage during 1987, and it logically follows that bears would avoid the highway at least during daylight hours. There are no data readily available that document the level of human activity around the Old Faithful development during our study period. Our impression from working around Old Faithful during the spring was that human activity levels were not trivial. We recommend that in coming years some record of day and

overnight human use of the Old Faithful development be kept. These records would necessarily include employees and dependents of contractors, concessionaires, and the Park Service working or in residence at the Old Faithful development.

YELLOWSTONE LAKE TRIBUTARY STUDY

Third Year Progress Report

by

Daniel P. Reinhart

INTRODUCTION

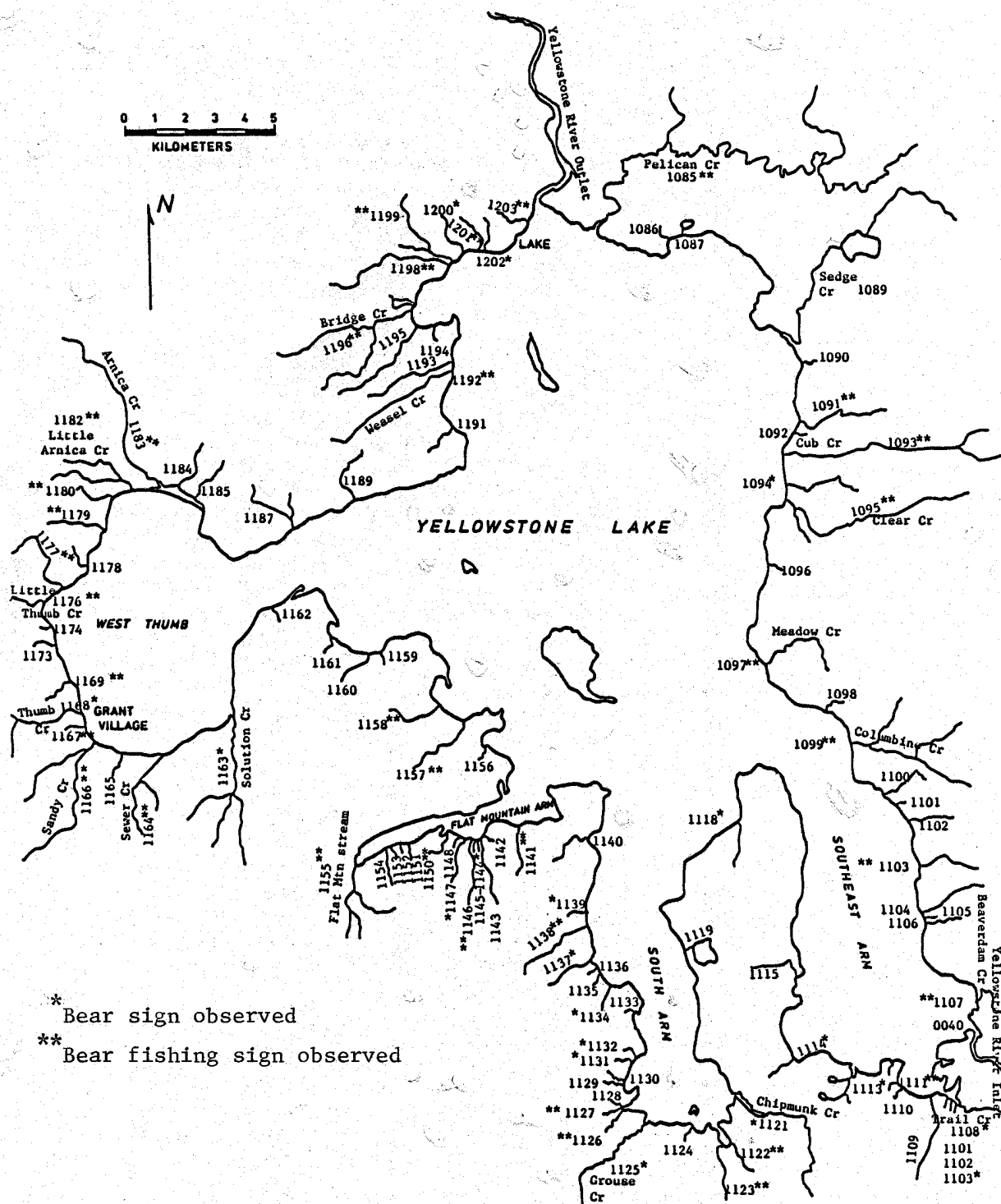
Grizzly bears (*Ursus arctos*) and black bears (*Ursus americanus*) prey on spawning cutthroat trout (*Salmo clarki*) in tributary streams of Yellowstone Lake. Brown bears are also known to use spawning salmonids as a food source in coastal systems of Alaska (Erickson 1965), British Columbia (Hamilton and Archibald 1985), and the Soviet Union (Bromlei 1965). Bear use of cutthroat trout in Yellowstone National Park is unique since, unlike anadromous coastal salmon (*Oncorhynchus* spp.) that spawn once and die, Yellowstone Lake cutthroat trout are repeat spawners (Ball and Cope 1961) and are an adfluvial inland population.

Bear use of spawning cutthroat trout was studied in 1974 and 1975 by the Interagency Grizzly Bear Study Team (IGBST) (Hoskins 1975). Since then, regulation of the Yellowstone Lake fishery has resulted in an increased proportion of older and larger cutthroat trout (Gresswell and Varley 1986). Spawning cutthroat trout may constitute an increasingly abundant high quality food source for a major segment of the Yellowstone grizzly bear population.

A new study was conducted from 1985 through 1987 by the IGBST to investigate grizzly bear use of cutthroat trout spawning streams in Yellowstone Park. Objectives were to (1) appraise the relative value of spawning cutthroat trout as a food source for Yellowstone grizzlies, (2) quantify bear use of streams and stream attributes, and (3) identify changes in bear use of streams since Hoskins' 1974-75 study. First- and second-year progress reports were presented by Reinhart and Mattson (1986, 1987). Jones et al. (1986, 1987) reported information obtained by the U. S. Fish and Wildlife Service from Yellowstone Lake cutthroat trout spawning streams. Results and discussion of the IGBST survey for 1985, 1986, and 1987 are presented here.

STUDY AREA

Yellowstone Lake is a subalpine oligotrophic lake located in the east-central portion of Yellowstone National Park (Benson 1961). There are 124 known tributaries to Yellowstone Lake in addition to the Yellowstone inlet and outlet (Fig. 29). The 1985 study area comprised the backcountry streams including those of the east shore, Southeast, South and Flat Mountain Arms, and west shore north to Grant Village. The 1986 study area included front-country streams from Grant Village to Sedge Bay as well as selected backcountry streams. Front-country streams were characterized by close proximity of primary roads and developments. In 1987, all 1985-86 study area streams around Yellowstone Lake were surveyed.



METHODS

Field work was conducted from May through August in 1985, 1986, and 1987. Field methods are described in detail by Reinhart and Mattson (1986). Briefly, all streams were periodically surveyed to determine the presence and level of trout spawning activity and bear use. Stream physical parameters, length of spawning run, fish numbers, vegetation community types, and bear activity (from seats, fish parts, tracks, and trail use) were measured or identified. Tracks found along the stream were measured to determine the number and species of bears on each stream.

Indices were developed to enumerate spawner density and levels of bear use. Seats were analyzed to determine volumetric representation of major bear foods. Track measurements were analyzed to estimate the number of bears utilizing Yellowstone Lake spawning streams.

RESULTS

One hundred-nineteen streams were surveyed at least 2 of the 3 field seasons at 1- to 2-week intervals. Four previously known streams were not found by the study team (1117, 1112 in the Southeast Arm and 1171, 1172 in the West Thumb). The Yellowstone inlet and outlet were omitted from the stream survey due to their large size. Bear fishing information for Pelican Creek was gathered by the IGBST from radio telemetry relocations of collared bears and by observations from Pelican Cone lookout (Gunther 1986).

Of 124 known tributaries of Yellowstone Lake, 59 (48%) were found to have a spawning run. Of these, 56 (95%) had associated bear activity, and 36 (61%) had evidence of bear fishing (Table 23, Fig. 29). Five other streams had incidental sign of bear activity but no evidence of a spawning run. This was probably due to close proximity of other spawning streams and bear use of vegetation along the streams.

Discrepancies between evidence of bear use and fishing is explained by unsuccessful bear fishing attempts, bear stream usage other than fishing (e.g., grazing), or the study team not finding evidence of bear fishing. Bear fishing sign (i.e., fish parts) was found to be ephemeral due to the activity of various scavengers on the streams.

Annual variation in the occurrence and timing of spawning runs and bear activity was evident. Seven streams had evidence of a spawning run on 1 year and not another; 12 streams had associated bear sign only 1 of the 2 or 3 years surveyed. Comparisons of activity levels for key streams showed that the beginning, peak and end of spawning activity and subsequent bear use in 1986 was approximately 1-2 weeks later than in 1985 and 3-4 weeks later than in 1987 (Figs. 30 and 31).

Table 23. Tributary streams – Yellowstone Lake.

Stream name or old number	New SONYEW number	Years surveyed by IGBST	Survey summary results ^{a,b}			
			1985	1986	1987	Hoskins (1974, 1975)
Solution Cr	1163	1985, 1987	S, B	-	S, B	S
211	1162	1985	N ^{b, 1, 2}	-	-	S
206	1161	1985	N ^{b, 1, 2}	-	-	
205	1160	1985, 1987	S	-	N ^{b, 1, 2}	
204	1159	1985, 1987	N ^{b, 1}	-	N ^{b, 1, 2}	
203	1158	1985, 1987	S, B	-	S, B, F	S, B
202	1157	1985, 1987	S	-	S, B, F	S, B
201	1156	1985, 1987	N ^{b, 1}	-	N ^{b, 1, 2}	
Flat Mountain Stream	1155	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S, B, F
199	1154	1985	N ^{b, 4, 5}	-	-	
198	1153	1985	N ^{b, 4, 5}	-	-	
197	1152	1985	N ^{b, 4, 5}	-	-	
196	1151	1985	N ^{b, 4, 5}	-	-	
195	1150	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S, B, F
194	1149	1985, 1987	N ^{b, 8}	-	N ^{b, 1, 2}	
193	1148	1985, 1986, 1987	N ^{b, 4} , B	N ^{b, 4} , B	N ^{b, 4} , B	S, B
192	1147	1985, 1986, 1987	N ^{b, 4}	S, B	N ^{b, 7} , B	S
191	1146	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S, B, F
190	1145	1985, 1986, 1987	N ^{b, 1, 4} , B	N ^{b, 1, 4} , B	N ^{b, 1, 4} , B	S
189	1144	1985, 1986, 1987	S, B	N ^{b, 7} , B	S, B	
188	1143	1985, 1986, 1987	S, B	S, B	N ^{b, 2} , B	S, B
187	1142	1985, 1986, 1987	N ^{b, 1}	N ^{b, 1} , B	N ^{b, 1}	
186	1141	1985, 1986	S, B	-	S, B, F	S
182	1140	1985	N ^{b, 1, 5}	-	-	
181	1139	1985, 1987	N ^{b, 8}	-	S, B	S
180	1138	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S, B, F
179	1137	1985, 1987	N ^{b, 7}	-	S, B	S, B
178	1136	1985	N ^{b, 1, 4}	-	-	
177	1135	1985	N ^{b, 1}	-	-	
176	1134	1985, 1986, 1987	S ^{b, 2} , B	-	N ^{b, 2}	S
175	1133	1985, 1987	N ^{b, 8}	-	N ^{b, 2}	
174	1132	1985, 1987	S	-	S, B	S
173	1131	1985, 1987	S, B	-	S, B	S
172	1130	1985, 1987	N ^{b, 1}	-	N ^{b, 1}	S
171	1129	1985	N ^{b, 1}	-	-	
170	1128	1985	N ^{b, 1}	-	-	
169	1127	1985, 1987	S, B, F	-	S, B, F	S, B
168	1126	1985, 1987	S, B, F	-	S, B, F	S, B, F
Grouse Cr	1125	1985, 1987	S, B	-	S, B	S
162	1124	1985	N ^{b, 1, 5}	-	-	
161	1123	1985, 1987	S, B	-	S, B, F	S
160	1122	1985, 1987	S, B	-	S, B, F	S
Chipmunk Cr	1121	1985, 1987	S	-	S, B	S
152	1120	1985, 1987	N ^{b, 4, 5}	-	N ^{b, 4, 5}	
Alder Lake Outlet	1119	1985, 1987	N ^{b, 5}	-	S ^{b, 5}	
145	1118	1985, 1987	S, B	-	S, B	

Table 23. Continued.

Stream name or old number	New SONYEW number	Years surveyed by IGBST	Survey summary results ^{a, b}			
			1985	1986	1987	Hoskins (1974, 1975)
144	1117	1985, 1987	N ^{b, 8}	-	N ^{b, 8}	
143	1116	1985, 1987	N ^{b, 8}	-	N ^{b, 1, 4}	
142	1115	1985, 1987	S	-	S	
141	1114	1985, 1987	S, B	-	S, B	
138	1113	1985, 1987	S, B	-	S, B	S, B, F
137	1112	1985, 1987	N ^{b, 8}	-	N ^{b, 8}	
136	1111	1985, 1987	S, B	-	S, B, F	S, B, F
135	1110	1985, 1987	N ^{b, 1}	-	N ^{b, 1}	
134.5	110901	1987	-	-	N ^{b, 1}	
134	1109	1985, 1987	N ^{b, 7}	-	N ^{b, 7}	S
133	110801	1985, 1987	N ^{b, 4}	-	N ^{b, 4}	
132	110802	1985, 1987	N ^{b, 4, 5} , B	-	N ^{b, 4, 5} , B	
131	110803	1985, 1987	S, B	-	S, B	
Trail Cr	1108	1985, 1987	S, B	-	S, B	
Yellowstone R Inlet	0040	Not surveyed	-	-	-	
Beaverdam Cr	1107	1985, 1987	S	-	B, F	S
124	1106	1985, 1987	N ^{b, 2, 4}	-	N ^{b, 2, 4}	S
123	1105	1985, 1987	N ^{b, 1, 4}	-	N ^{b, 1, 4}	
122	1104	1985, 1987	N ^{b, 1, 4}	-	N ^{b, 2, 4}	
121	1103	1985, 1987	S	-	S, B, F	S
120	1102	1985, 1987	N ^{b, 2, 4}	-	N ^{b, 2, 4}	
119	1101	1985, 1987	N ^{b, 1, 2}	-	N ^{b, 1, 2}	
Alluvium Cr	1100	1985, 1987	N ^{b, 6} , B	-	N ^{b, 6}	
Columbine Cr	1099	1985, 1987	S, B	-	S, B	
114	1098	1985	N ^{b, 1, 2}	-	-	
Meadow Cr	1097	1985, 1987	S	-	S, B, F	S
112	1096	1985	N ^{b, 1, 4}	-	-	
Clear Cr	1095	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S
103	1094	1985, 1986, 1987	S	S, B	N ^{b, 2}	S
Cub Cr	1093	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S
099	1092	1985	N ^{b, 1, 4}	-	-	
098	1091	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S
097	1090	1986	-	N ^{b, 1, 4}	-	
Sedge Cr	1089	1986	-	N ^{b, 6}	-	
Indian Pond Outlet	1087	1986	-	N ^{b, 1, 4}	-	
088	1086	1986	-	N ^{b, 2}	-	
Pelican Cr ^c	1005		S, B	S, B, F	S, B, F	S, B, F
Yellowstone R Outlet		Not surveyed	-	-	-	
272	1204	1986, 1987	-	N ^{b, 1}	N ^{b, 1}	
Pumping St. Cr	1203	1986, 1987	-	S, B	S, B, F	S
Hotel Cr ^d	1202	1986, 1987	-	N ^{b, 3}	S ^{b, 1, 3} , B, F	
Hatchery Cr	1201	1986, 1987	-	S, B	S, B, F	S
268 ^d	1200	1986, 1987	-	S ^{b, 4}	S ^{b, 4} , B, F	S
267	1199	1986, 1987	-	S ^{b, 3}	S ^{b, 3} , B, F	S
266 ^d	1198	1986, 1987	-	S ^{b, 3}	S ^{b, 3} , B, F	S
265	119701	1986	-	NS ^{b, 1}	-	

Table 23. Continued.

Stream name or old number	New SONYEW number	Years surveyed by IGBST	Survey summary results ^{a, b}			
			1985	1986	1987	Hoskins (1974, 1975)
Bridge Cr	1197	1986, 1987	-	S, B	S, B, F	S
259	1196	1986	-	N ^{b, 1}	-	
258	1195	1986	-	N ^{b, 1, 3}	-	
257	1194	1986	-	N ^{b, 1, 3}	-	
256	1193	1986, 1987	-	N ^{b, 1, 3}	N ^{b, 1, 3}	
Weasel Cr	1192	1986, 1987	-	S ^{b, 3} , B	S ^{b, 3} , B, F	S
252	1191	1986, 1987	-	N ^{b, 8}	N ^{b, 1, 2}	
251	1190	1986, 1987	-	N ^{b, 1}	N ^{b, 1, 2}	
250	1189	1986, 1987	-	N ^{b, 1}	N ^{b, 1, 2}	S
249	1188	1986, 1987	-	N ^{b, 1, 4}	N ^{b, 1, 4}	
248	1187	1986, 1987	-	N ^{b, 3}	N ^{b, 3}	S
247	1186	1986, 1987	-	N ^{b, 1, 3}	N ^{b, 1, 3}	
239	1185	1986	-	N ^{b, 1}	-	
238	1184	1985, 1986	N ^{b, 1}	N ^{b, 1}	-	
Arnica Cr	1183	1986, 1987	-	S, B, F	S, B	S
Little Arnica Cr	1182	1986, 1987	-	S, B	S, B, F	S
233	1181	1986, 1987	-	N ^{b, 1}	N ^{b, 1}	
232	1180	1986, 1987	-	S	S, B, F	S
231	1179	1985, 1986, 1987	S, B, F	S, B	S, B, F	S
230	1178	1986, 1987	-	N ^{b, 3, 4}	N ^{b, 3, 4} , B	
229	1177	1985, 1986, 1987	S, B, F	S, B < F	S, B, F	S, B, F
Little Thumb Cr	1176	1985, 1986, 1987	S, B, F	S, B, F	S, B, F	S, B, F
227	1175	1986, 1987	-	N ^{b, 8}	N ^{b, 1, 2}	
226	1174	1986, 1987	-	N ^{b, 1, 2}	N ^{b, 1, 2}	
225	1173	1986, 1987	-	N ^{b, 1, 2}	N ^{b, 1, 2}	
222	1172	1986, 1987	-	N ^{b, 8}	N ^{b, 1, 6}	
221	1171	1986, 1987	-	N ^{b, 8}	N ^{b, 1, 6}	
220	1170	1986, 1987	-	N ^{b, 8}	N ^{b, 1, 6}	
219	1169	1986, 1987	-	S, B, F	S, B, F	S
Thumb Cr	1168	1986, 1987	-	S, B	S, B	S
217	1167	1986, 1987	-	S	S, B, F	S
Sandy Cr	1166	1986, 1987	-	S	S, B, F	S
215	1165	1986, 1987	-	N ^{b, 2}	N ^{b, 1}	S
Sewer Cr	1164	1985, 1986, 1987	S, B	S, B, F	S, B, F	S, B, F

^a Survey results: - = No survey that year, N = No spawning run observed, S = Spawning run, B = Bear sign, F = Bear fishing.

^b Reasons for nonspawning run or impeded spawning run: 1 – Stream size or flow too small, 2 – Natural block, 3 – Man-made block, 4 – Too steep gradient, 5 – Unsuitable substrate, 6 – Chemical barrier, 7 – Unknown causes, 8 – Stream not found.

^c Observations from Gunther (1986).

^d Observations from French (personal communication, 1988).

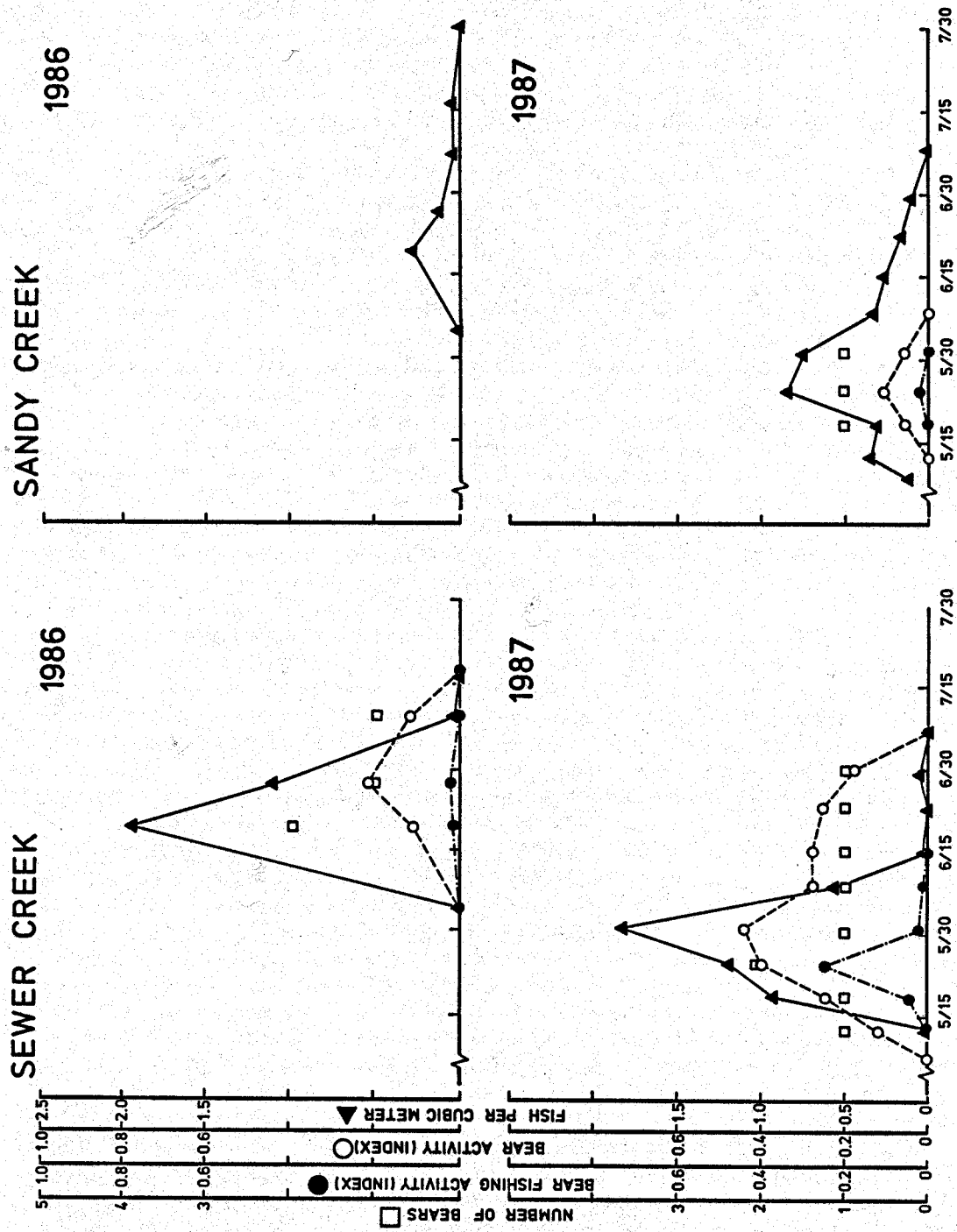


Fig. 30. Indices of bear numbers, bear fishing level, and fish density by date for Sewer Creek (1164) and Sandy Creek (1167) in 1986 and 1987.

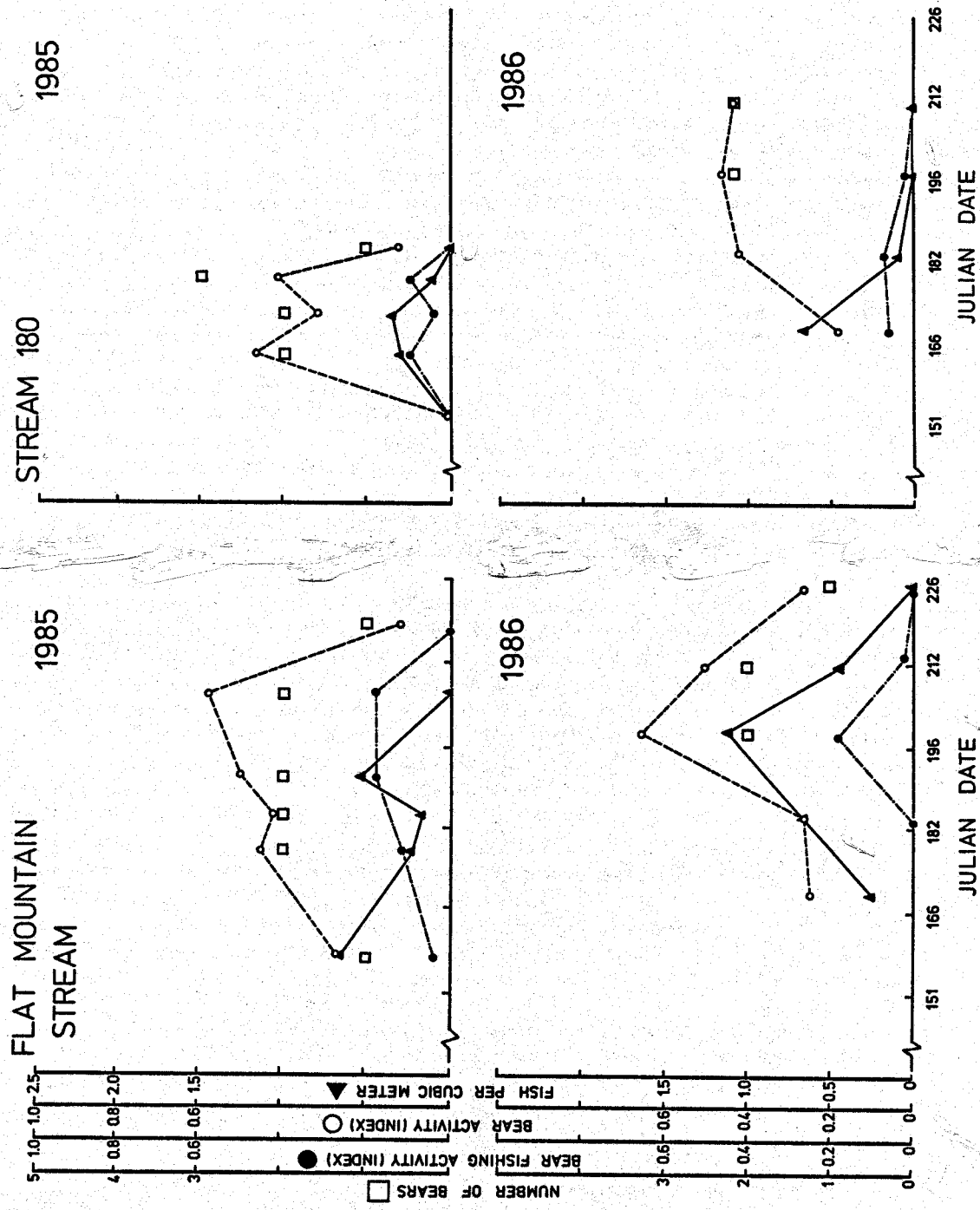


Fig. 31. Indices of bear numbers, bear fishing level, total bear activity level, and fish density by date for Flat Mountain Stream (1155) and Stream 180 (1138) in 1985 and 1986.

There was no difference between the number of spawning streams found during this survey and during Hoskins' 1974-75 study. He found 59 compared to my 59 streams with spawning runs. There were more differences, however, between the 2 studies in the amount of bear activity found. Hoskins found 17 streams with bear activity and 11 of these streams fished by bears, compared to my findings of 56 streams with bear activity and 36 streams fished by bear.

From track analysis, I estimate that between 42 and 61 adult bears used the backcountry streams in 1985; between 37 and 55 bears used these same streams in 1987. On the front-country streams, between 8 and 12 and between 7 and 9 bears were estimated to be present in 1986 and 1987, respectively. Between 68 and 72% of these animals were grizzlies.

DISCUSSION

Bear use of spawning streams was primarily related to spawner density or the number of fish per unit volume of water. More bear fishing occurred on streams with higher spawner density. Total number of spawners in a stream can be misleading; smaller streams may have less fish but a higher density due to their smaller size. This is illustrated by Figure 30. Peak numbers of fish counted in Sewer Creek in 1987 was 337. In Sandy Creek the peak number was 971. Because Sandy Creek had larger stream dimensions, spawner density was computed at 0.85 fish per cubic meter of stream compared with 1.87 for Sewer Creek; much more bear fishing activity was observed at Sewer Creek compared to Sandy Creek.

Other variables important to spawning stream usability were:

1. The physical parameters of the stream. Again, smaller streams appeared more suitable for bear fishing. Streams less than 1 decimeter in depth appeared to be fished more successfully than deeper streams. Some streams were fished with more success after peak flows with lower depths.
2. Proximity of other spawning streams. Track analysis revealed that bears utilized a series of proximal streams. This was shown from observations of a radio-collared grizzly (No. 134) utilizing a set of streams near the Lake area. She was found to fish the same 5 to 7 streams on a daily basis (French, pers. comm., 1988). Travel corridors were associated with use of these proximal streams. Corridors utilized by bears around Yellowstone Lake included park trails, power line cuts, and lake shore beaches.
3. Abundance and quality of streamside vegetation. Most tributary streams around Yellowstone Lake had a vegetative habitat component characterized by grasses and forbs more lush than the surrounding forest habitat. Streamside community types varied from narrow, shaded wetland corridors to open, moist grass-sedge meadows. Seat analysis showed that foliferous vegetation comprised 54% of total seat volume compared to 25% cutthroat trout remains. Trout is considerably more digestible than vegetation and is underrepresented in seat analysis on a

percent volume basis. Vegetation along these streams, however, was an important food source for bears in addition to cutthroat trout.

4. Security of habitat. Backcountry streams were found to be utilized more consistently by bears than front-country streams. In 1987, bear use of spawning streams near major development areas decreased after the openings of those areas.

Front-country streams (those which were associated with a park road or development) comprised 38% of the total streams around Yellowstone Lake. These streams included 35% of all spawning streams, 33% of streams with bear activity, and 48% with bear fishing. At least 10 streams, however, had manmade blocks that blocked or shortened the length of the spawning run (Table 23). Some spawning streams had trout on the first 20 to 50 m; beyond they were rendered impassable to fish by road culverts.

Consistency of bear fishing among years was the most notable difference between back- and front-country spawning streams. Fifty-six percent of fished backcountry streams evidenced bear use on a consistent yearly basis compared to 24% of front-country streams. Greater variability in bear fishing activity on front-country streams could be explained by yearly differences in spawning run timing relative to the opening of developments in that area. Front-country bear fishing was more substantial in 1987 compared to 1986. Snowpack was lighter, spring runoff was earlier in 1987, and fish were in the streams 2 to 3 weeks earlier than in 1986 (Fig. 30). In 1987 the availability of spawning trout to bears occurred prior to the time of increased human visitation to those areas.

CONCLUSIONS

Almost half of all tributary streams around Yellowstone Lake supported a cutthroat trout spawning run. Of these streams, most had associated bear use and over half had evidence of bear fishing.

The timing and magnitude of the snowpack melt-off appeared to be the primary basis for seasonal variation in timing of cutthroat trout spawning runs and associated bear use. Because of habitat security factors, timing appeared more critical to bear use of front-country streams.

Bear use of spawning streams appeared to be largely a positive function of spawner density; bear use was secondarily related to stream physical parameters, proximity of other spawning streams, abundance and quality of streamside vegetation, and security of habitat.

Comparisons of Hoskins' study of 1974-75 with this study revealed slight differences in the total number of spawning streams. However, the number of streams utilized by bears has increased considerably between 1975 and 1985. Evidence of increased cutthroat trout biomass in Yellowstone Lake and increased bear use over the last 10 years suggest that spawning streams have become more important to the seasonal food habits of Yellowstone grizzly bears.

1987 AVERSIVE CONDITIONING

Study Progress Report Abstract

By

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Grizzly bear mortality from management control actions has become a significant proportion of overall grizzly deaths in the Greater Yellowstone Ecosystem and elsewhere. Traditional methods to resolve conflicts do not prevent problems from recurring, and bears that are repeat offenders eventually are removed or destroyed. This report deals with the second year of a planned 3-year Wyoming Game and Fish Department (WGF) study.

The objective of this study was to develop techniques and evaluate the effectiveness of a potential aversive conditioning agent in keeping grizzly bears away from sites of human habitation and/or anthropogenic food sources. Trials were conducted on radio-instrumented, problem grizzly bears in the Yellowstone Ecosystem. A simple within-subjects design, using subject-as-own control with counterbalancing during the testing phase, was attempted during the second year of the study in 1987. Each subject (Ss) was to receive conditioning with an unconditioned aversive stimulus (US) in the presence of 1 of 2 similar, but different, randomly assigned conditioned stimuli (CS). Following this treatment, all Ss were to be tested for the effects of learned aversion by means of presenting the CS in 1 trial and a neutral one in another trial. The unconditioned aversive stimulus was a 602-grain plastic bottle filled with 30 cc of water, traveling with 299.7 F.P.E., and fired from a modified Model 267 Smith & Wesson Gas and Flare Gun. During 1986, 2 subadult and 1 adult (with 2 cubs-of-the-year) female grizzly bears were shot at 8 times and hit 6 times at 8 specific problem sites. During 1987, 2 adult female grizzly bears (1 with 2 yearlings) were shot at 4 times and hit 3 times at 4 roadside sites.

Results thus far are encouraging but are based on both a small number of Ss and only 1 sex is represented; especially with respect to the testing phase, the data are limited. When hit, all bears immediately ran from the site, often leaving the general area. No aggressive responses were displayed. After being hit, bears that were causing problems at specific sites would generally not reenter the site while the researchers were there; often they did not return to the site for 2 to 4 weeks regardless of the researcher's presence. Bears hit while foraging along the roadsides did not return to the specific sites where they were hit and generally reduced their foraging immediately adjacent to the roadsides; they also ceased using roadways as travel routes and began crossing roadways at a run. Trapping and relocation efforts may have affected the responses of these bears.

The data with respect to the testing phase of the study are much more limited at this time. Both Ss were present with a trial apiece of the Cs, but the results are equivocal. The possible effects of food availability and social pressures on bear responses to aversive conditioning are discussed. During 1986 and 1987 conditioning efforts were limited by the low number of candidate bears available. In 1987 study methods were revised and interagency cooperation addressed so that during 1988 testing of a larger number of candidates should be possible.

Appendix. Annual flight summaries during March through November, 1973-87.

	Total radio flights	Total radio flight hours	Total observation flights	Total observation flight hours	Unmarked grizzlies/hour		Total radio locations
					Radio flights	Observation flights	
March							
1975	0	0.0	1	1.0	-	-	0
1976	3	4.3	0	0	-	-	11
1977	2	5.5	0	0	-	-	15
1978	6	13.6	0	0	-	-	56
1979	5	20.4	0	0	0.05	-	67
1980	3	8.8	0	0	-	-	20
1981	4	10.8	0	0	-	-	39
1983	3	3.2	0	0	-	-	15
1984	2	3.5	0	0	-	-	10
1985	1	0.7	0	0	-	-	3
1986	1	1.8	0	0	-	-	43
1987	1	1.8	0	0	-	-	5
April							
1974	-	-	3	9.4	-	-	-
1975	-	-	4	9.3	-	0.32	-
1976	7	11.6	0	0	0.35	0	19
1977	8	26.4	-	-	0.11	-	55
1978	7	17.5	-	-	0.06	-	57
1979	4	21.4	1	4.0	0.05	-	36
1980	7	19.2	-	-	0.47	-	54
1981	6	15.7	-	-	-	-	54

Appendix. Continued.

	Total radio flights	Total radio flight hours	Total		Total observation flight hours	Unmarked grizzlies/hour		Total radio locations
			observation flights	observation flight hours		Radio flights	Observation flights	
April (cont.)								
1982	3	9.0	-	-	-	0.44	-	25
1983	7	16.4	-	-	-	0.12	-	41
1984	5	10.8	-	-	-	0.65	-	23
1985	5	9.3	-	-	-	-	-	29
1986	1	1.8	-	-	-	-	-	4
1987	3	12.0	-	-	-	0.33	-	32
May								
1973	-	-	3	12.0	-	-	1.33	-
1974	-	-	6	18.1	-	-	0.83	-
1975	1	2.5	8	14.3	-	0.40	0.21	1
1976	10	23.1	-	-	-	0.22	-	21
1977	8	27.6	0	0	-	0.36	0	61
1978	4	13.8	-	-	-	0.15	-	36
1979	7	34.8	-	-	-	0.26	-	64
1980	7	30.1	1	3.0	-	0.53	1.67	71
1981	7	27.3	-	-	-	0.26	-	69
1982	4	11.8	-	-	-	0.34	-	40
1983	8	15.6	12	35.7	-	0.06	0.28	42
1984	7	15.6	-	-	-	0.13	-	26
1985	9	21.8	-	-	-	0.14	-	43
1986	7	17.9	-	-	-	0.17	-	34
1987	4	14.8	-	-	-	0.81	-	28

Appendix. Continued.

	Total radio flights	Total radio flight hours	Total observation flights	Total observation flight hours	Unmarked grizzlies/hour		Total radio locations
					Radio Flights	Observation flights	
June							
1973	-	-	5	19.3	-	0.52	-
1974	-	-	12	38.9	-	0.57	-
1975	1	2.7	2	1.4	1.48	-	1
1976	7	15.6	2	6.3	0.83	2.22	18
1977	11	48.1	-	-	0.23	-	110
1978	12	50.9	-	-	0.08	-	92
1979	7	41.9	1	4.8	0.12	0.21	64
1980	10	32.1	-	-	0.44	-	69
1981	10	42.9	-	-	0.14	-	72
1982	7	25.9	-	-	0.23	-	63
1983	5	13.3	16	43.4	0.30	0.30	34
1984	15	46.0	-	-	0.22	-	82
1985	6	19.8	-	-	0.61	0	49
1986	3	15.1	10	19.8	0.07	0.51	27
1987	11	27.5	6	13.7	0.07	0.44	67
July							
1973	-	-	4	13.1	-	1.76	-
1974	-	-	11	30.5	-	1.48	-
1975	3	5.2	9	21.2	0.39	0.67	5
1976	12	32.5	-	-	0.19	-	31
1977	10	45.7	-	-	0.48	-	103
1978	7	34.8	-	-	0.03	-	60
1979	10	62.9	4	20.0	0.11	0.35	95
1980	9	43.4	5	24.3	0.09	0.91	111

Appendix. Continued.

	Total radio flights	Total radio flight hours	Total observation flights	Total observation flight hours	Unmarked grizzlies/hour		Total radio locations
					Radio Flights	Observation flights	
July (cont.)	8	28.4	4	19.0	0.25	0.68	68
	7	33.4	4	16.3	0.21	1.17	69
	7	30.9	7	21.1	0.16	0.33	45
	13	42.6	8	22.2	0.45	1.22	97
	7	23.1	7	16.8	0.26	0.66	45
	8	12.1	10	22.8	1.98	0.66	22
	7	13.8	7	17.2	0.36	1.40	41
August	-	-	3	9.5	-	-	-
	-	-	7	19.9	-	1.86	-
	13	36.7	-	-	0.08	-	31
	13	43.4	-	-	0.46	-	73
	8	35.7	-	-	0.03	-	80
	12	59.3	-	-	0.03	-	109
	14	75.4	1	3.5	0.15	1.71	131
	9	29.7	-	-	0.24	-	72
	17	52.5	-	-	0.50	-	142
	17	49.1	2	8.8	0.08	0.46	115
	12	34.1	6	24.1	0.18	0.25	68
	16	42.5	3	6.8	-	-	95
	6	17.9	6	11.0	-	0.91	31
	12	34.1	4	9.4	0.44	0.43	76
	10	20.2	7	16.3	0.50	0.31	53

Appendix. Continued.

	Total radio flights	Total radio flight hours	Total observation flights	Total observation flight hours	Unmarked grizzlies/hour		Total radio locations
					Radio flights	Observation flights	
September							
1973	-	-	3	7.9	-	0.25	-
1974	-	-	6	16.8	-	0.06	-
1975	12	31.5	-	-	-	-	44
1976	12	60.6	3	12.2	-	1.31	113
1977	13	63.9	-	-	0.28	-	138
1978	9	36.0	-	-	0.03	-	82
1979	15	49.9	-	-	0.06	-	79
1980	9	28.7	-	-	-	-	56
1981	11	36.5	-	-	0.16	-	93
1982	12	45.9	-	-	0.07	-	99
1983	16	41.0	-	-	0.02	-	89
1984	9	32.3	-	-	0.06	-	70
1985	4	8.3	-	-	-	-	15
1986	4	12.8	-	-	0.54	-	31
1987	8	21.8	-	-	-	-	54
October							
1973	-	-	5	11.9	-	0.67	-
1974	-	-	5	12.7	-	0.63	-
1975	8	13.8	-	-	0.07	-	40
1976	9	36.3	-	-	-	-	56
1977	18	49.4	-	-	0.22	-	126
1978	10	50.4	-	-	0.02	-	117
1979	11	39.2	-	-	0.08	-	86

Appendix. Continued.

	Total radio flights	Total radio flight hours	Total observation flights	Total observation flight hours	Unmarked grizzlies/hour		Total radio locations
					Radio flights	Observation flights	
October (cont.)							
1980	10	30.2	-	-	0.03	-	88
1981	9	28.1	-	-	0.04	-	71
1982	9	20.0	-	-	0.10	-	59
1983	9	13.7	-	-	-	-	55
1984	9	24.7	-	-	0.04	-	75
1985	7	18.1	-	-	0.11	-	43
1986	8	28.8	-	-	0.04	0	55
1987	14	26.8	-	-	-	-	61
November							
1973	-	-	1	2.18	-	-	-
1975	4	5.7	-	-	-	-	19
1976	7	15.9	-	-	-	-	44
1977	9	19.2	-	-	-	-	52
1978	5	20.8	-	-	0.05	-	61
1979	10	30.8	-	-	-	-	78
1980	7	16.6	-	-	-	-	43
1981	6	14.9	-	-	-	-	38
1982	4	8.1	-	-	-	-	22
1983	1	1.5	-	-	-	-	2
1986	1	4.0	-	-	-	-	1
1987	3	8.3	-	-	-	-	25

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