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YELLOWSTONE GRIZZLY BEAR INVESTIGATIONS

ANNUAL REPORT OF THE INTERAGENCY STUDY TEAM

1986

National Park Service
U.S. Forest Service
Montana Fish and Game Department
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U. S. Department of the Interior
National Park Service

May 1987

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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, in press). 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, Mattson et al. 1986) 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., in press). 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

Production and Movements

Since 1975, 131 grizzly bears have been fitted with radio collars and monitored for varying lengths of time. Of these bears, 58 were known or suspected to be dead at the end of the 1986 field season (Table 1); 88% of these deaths were man-caused; only 26 of the total 131 bears were known to be alive during 1986.

During 1986, 36 individual grizzly bears were captured 50 times (Table 2) at 21 locations throughout the study area (Fig. 1). In accordance with 1986 study goals to monitor 10 adult females, the IGBST captured 12 grizzly bears, including 5 adult females; 2 subadult females and 5 males were captured incidentally. Additional adult females were captured in management actions (5) and unintentionally during attempts by Montana to capture black bears (2). Seventeen grizzlies captured in management actions were transported 29 times to various sites throughout the study area.

During 1986, 29 radio-telemetered grizzly bears were monitored for varying lengths of time, including 14 adult females (Table 3). Of the 29 monitored bears, five were killed or otherwise removed from the population, five cast their transmitters, and 3 transmitters apparently failed. Radio-telemetered bears were located an average once every 9 days. Four to 14 adult females were monitored during the year (Fig. 2). The goal of monitoring a minimum of 10 adult females was achieved for approximately 8 weeks from mid-August to mid-October.

Population Trend

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 breeding females. Assuming a 3-year breeding cycle (indicated by current data), and summing backwards for 3 years the number of females with cubs-of-the-year observed each year yields a minimum number of breeding females in the population. In 1983 the ad hoc committee for population analysis used this data as the basis for a minimum population estimate for 1980.

<u>Procedures</u>.--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

Table 1. Status of instrumented grizzly bears, 1975-86 (n = 131).

KNOWN DEAD			SUSPECTED DEAD				
Man-caused	Natural	Unknown	Man-caused	Natural	Off-air		Active
3	12	77	7	54	1	*111	13
4	56	108	11	55	2	112	50
5	65	---	24	---	16	*114	72
6	---	2	31	2	19	*115	83
8	3	Total	32	Total	21	**116	86
9	Total		75		23	*117	101
10			102		33	*119	104
14			---		34	**123	107
15			7		35	**130	118
17			Total		36	**132	124
18					37	---	125
20					40	56	126
22					41	Total	128
25					42		129
26					**43		131
27					44		133
28					45		134
29					48		---
30					51		17
38					57		Total
39					61		
46					64		
47					68		
49					*70		
58					71		
59					73		
60					74		
62					78		
63					**79		
67					80		
69					82		
76					84		
81					85		
88					87		
90					*89		
93					91		
94					92		
95					96		
105					*97		
113					98		
120					99		
122					100		
121					103		
127					**106		
---					*109		
44					**110		
Total							

*Known alive in 1985. **Known alive in 1986.

Table 2. Grizzly bears captured during 1986.

Bear	Sex	Age	Date	Location	Release site	Trapper
122	F	3	04-20	Yanceys Hole/YNP(mgt)	Swan Lk Flats/YNP	YNP
			09-28	Tower/YNP (mgt)	Beaverdam Cr/YNP	IGBST
123	M	2	05-29	N Fk Shoshone, WY	On-site	IGBST
124	F	6	06-01	N Fk Shoshone, WY	On-site	IGBST
G24	M	3	06-28	Pelican Valley/YNP	On-site	IGBST
G25	M	5	06-29	Flat Mtn Arm/YNP	On-site	IGBST
101	F	4	07-22	Richards Pond/YNP	On-site	IGBST
133	M	5	08-01	Pelican Valley/YNP	On-site	IGBST
			08-28	Independence/MT(mgt)	Tepee Cr/MT	YNP
83	F	18	08-03	Pelican Valley/YNP	On-site	IGBST
			11-29	Lake/YNP (mgt)	Pelican Cr/YNP	YNP
125	F	3	08-06	Antelope Cr/YNP	On-site	IGBST
126	F	14	08-07	Antelope Cr/YNP	On-site	IGBST
50	F	12	08-07	West Yell./MT (mgt)	Parker Pk/YNP	MT
			08-17	Mesa Pit Rd/YNP(mgt)	Crawfish Cr/YNP	IGBST
			08-29	West Yell./MT (mgt)	Eagle Cr/YNP	IGBST
127	M	1	08-08	West Yell./MT (mgt)	Badger Cr/YNP	MT
			10-05	Signal Inn/WY (mgt) (near Togwotee)	Turbid Lk/YNP	WY
			10-20	Lake/YNP (mgt)	To Detroit Zoo	YNP
128	F	1	08-08	West Yell./MT (mgt)	Badger Cr/YNP	MT
129	F	5	08-18	Cooke City/MT(xtra)[1]	On-site	MT
G26	F	Cub	08-19	Cooke City/MT (xtra)	On-site	MT
G27	M	Cub	08-19	Cooke City/MT (xtra)	On-site	MT
130	F	4	08-18	Cooke City/MT (xtra)	On-site	MT
13	F	17	08-20	Cooke City/MT (xtra)	On-site	MT
131	M	1	08-19	Cooke City/MT (xtra)	On-site	MT

Table 2. Continued.

Bear	Sex	Age	Date	Location	Release site	Trapper
132	F	1	08-19	Cooke City/MT (xtra)	On-site	MT
76	F	6	08-25	Little Tr. Cr/MT(mgt)	Crawfish Cr/YNP	MT
G28	M	Cub	08-26	Little Tr. Cr/MT(mgt)	Crawfish Cr/YNP	MT
			09-07	Bear Cr/MT (mgt)	To zoo	
G29	M	Cub	08-26	Little Tr. Cr/MT(mgt)	Crawfish Cr/YNP	MT
110	M	3	08-31	West Yell./MT (mgt)	Blacktail/YNP	IGBST
			09-10	West Yell./MT (mgt)	Bechler/YNP	MT
104	F	4	08-29	Sylvan Pass/YNP	On-site	IGBST
72	F	9	09-06	Turpin Mdws/WY (mgt)	Blacktail/YNP	WY
116	F	12	08-23	West Yell./MT (mgt)	Sunlight Cr/WY	MT
			09-06	West Yell./MT (mgt)	Crandall Cr/WY	MT
G30	F	Cub	08-23	West Yell./MT (mgt)	Sunlight Cr/WY	MT
			09-06	West Yell./MT (mgt)	Crandall Cr/WY	MT
G31	F	Cub	08-23	West Yell./MT (mgt)	Sunlight Cr/WY	MT
			09-06	West Yell./MT (mgt)	Crandall Cr/WY	MT
G32	F	Cub	08-23	West Yell./MT (mgt)	Sunlight Cr/WY	MT
			09-06	West Yell./MT (mgt)	Crandall Cr/WY	MT
59	F	8	09-04	Canyon/YNP (mgt)	Cub Cr/YNP	IGBST
79	F	12	09-15	Stephens Cr/YNP(mgt)	Turbid Lk/YNP	IGBST
			09-27	Blanding RS/MT (mgt)	Escaped on-site	MT
G33	F	Cub	09-16	N of Gardiner/MT(mgt)	Turbid Lk/YNP	IGBST
G34	F	Cub	09-16	N of Gardiner/MT(mgt)	Turbid Lk/YNP	IGBST
134	F	4	09-28	Lake/YNP (mgt)	Blacktail/YNP	IGBST
118	F	3	10-18	Pahaska/WY	On-site	IGBST/WY

Table 2. Continued.

SUMMARY

			Retraps			Retraps
FEMALES:	Adults	12	5	MANAGEMENT:	17	14
	Subadults	14	4	RESEARCH:	12	0
				EXTRA:	7	0
MALES:	Adults	2	1		--	--
	Subadults	8	4		36	14
		--	--			
		36	14	TRANSPORTS:	17	2

[1]xtra = Grizzly bears captured unintentionally.

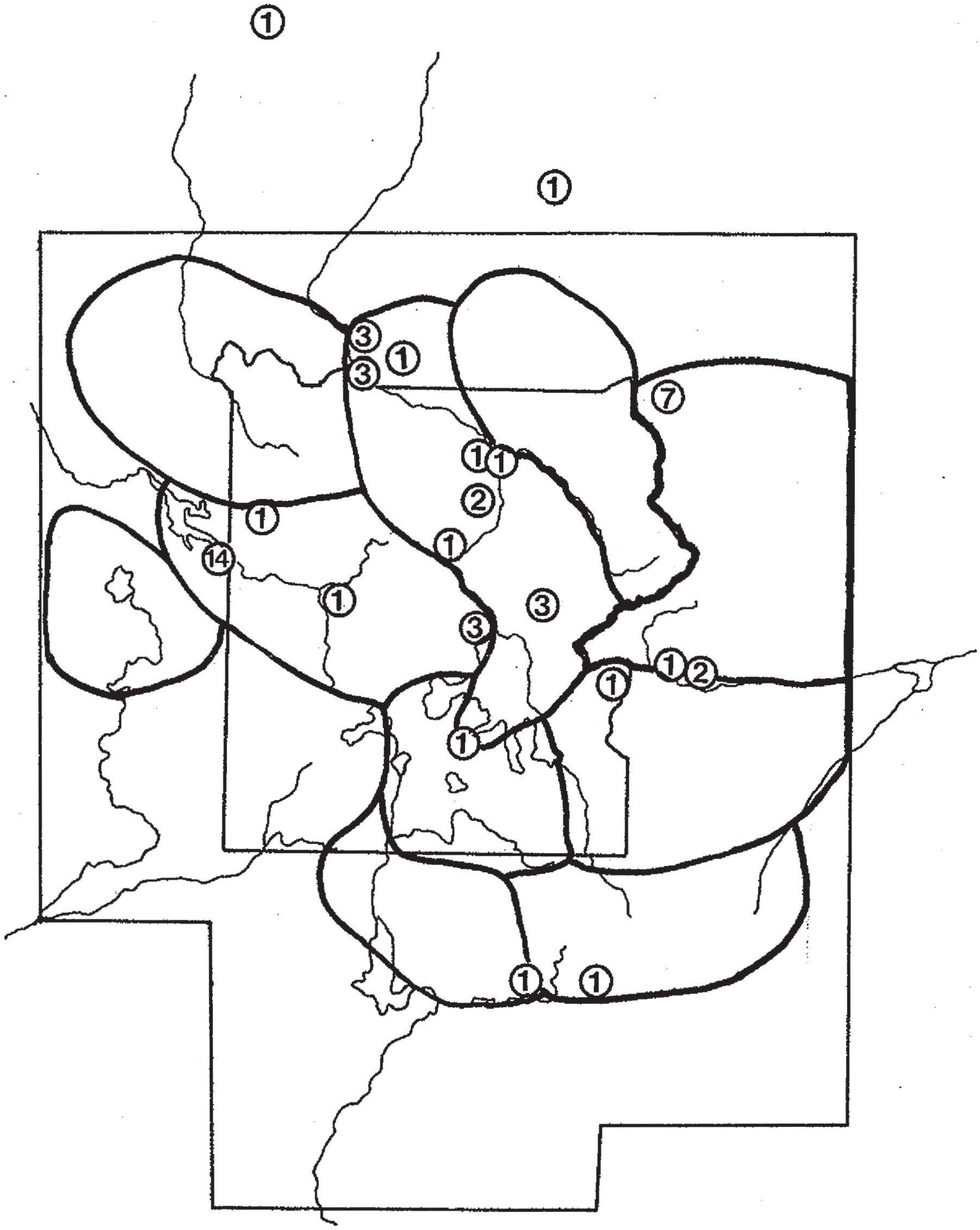


Fig. 1. Capture sites with numbers of bears captured at each site during 1986, and observation flight boundaries.

Table 3. Grizzly bears monitored during 1986 (n = 29).

Bear	Sex	Age	Number of locations	Interval monitored	Last location	Status
13	F	17	9	94 days	12-01	On air (via #131)
43	F	9	6	77	05-15	Off air--radio failure
50	F	12	21	229	10-14	On air
59	F	8	5	33	10-07	Management kill
72	F	9	6	46	10-22	On air
76	F	6	4	12	09-06	Illegal kill
79	F	12	5	13	09-27	Off air--cast collar
83	F	18	27	141	12-26	On air
101	F	4	15	140	12-09	On air
104	F	4	11	108	12-15	On air
106	F	10	15	196	09-17	Off air--radio failure?
107	M	7	20	347	12-16	On air
110	M	3	16	160	09-08	Off air--collar removed
116	F	12	15	40 & 45	10-07	Off air--cast collar
118	F	3	22	214	11-01	On air
121	M	6	1			Management kill
122	F	3	35	240	12-16	Illegal kill
123	M	2	13	97	09-03	Off air--cast collar
124	F	6	16	197	12-15	On air
125	F	3	15	117	12-01	On air
126	F	14	16	116	12-01	On air
127	M	1	16	73	10-20	To zoo
128	F	1	12	126	12-12	On air
129	F	5	5	17	09-04	Lost
130	F	4	1		08-18	Radio failure or lost
131	M	1	8	94	12-01	On air
132	F	1	4	57	10-15	Off air--collar cast
133	M	5	8	116	10-22	On air
134	F	4	10	75	12-12	On air

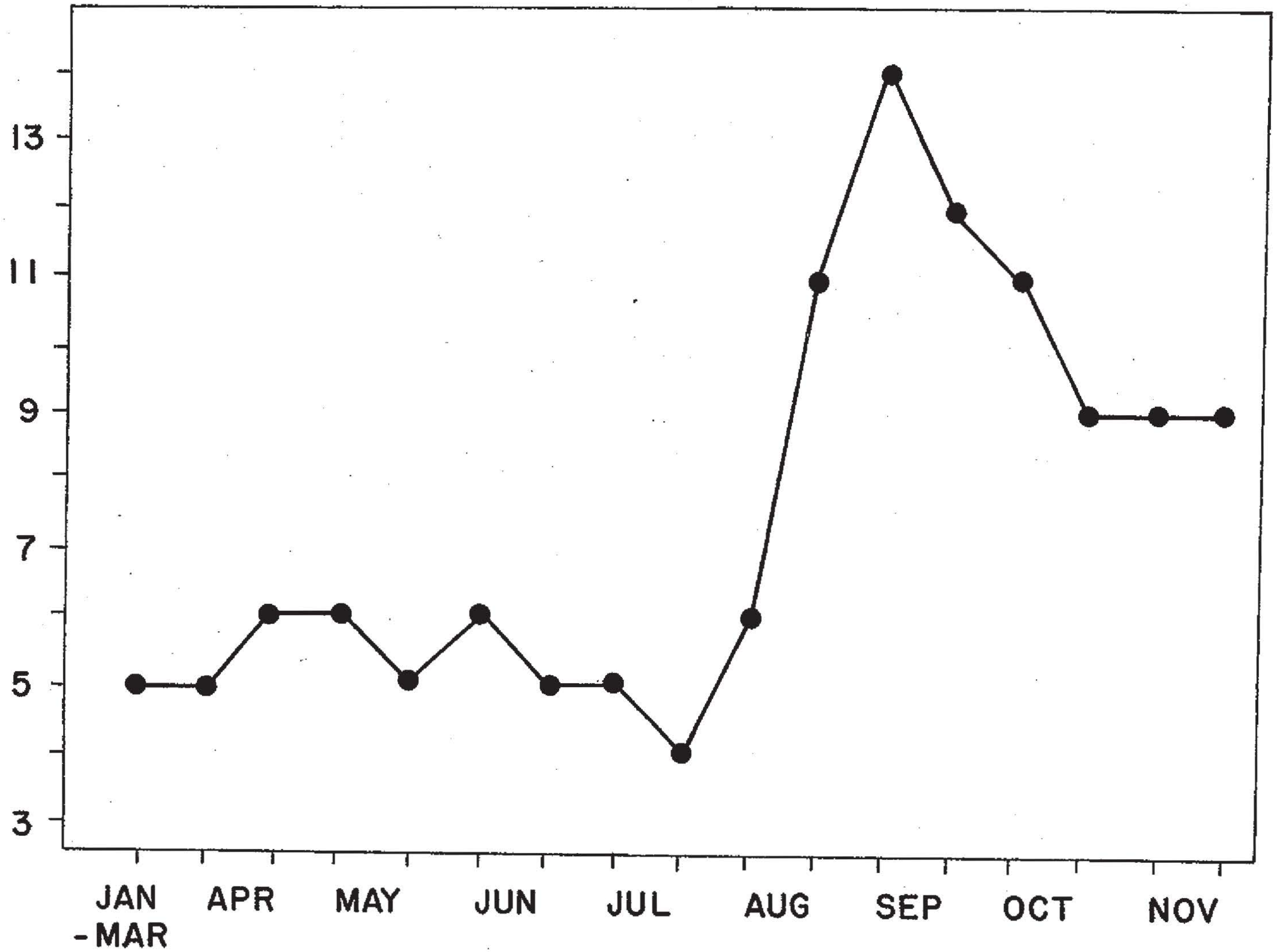


Fig. 2. Numbers of radio-telemetered adult female grizzly bears during 2-week intervals in 1986.

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, "V" 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 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 made this impractical. Beginning in 1986, segments were flown when possible and sequence was determined by weather conditions. Experience 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. Chances of observing bears in timbered areas are too low to justify the time and cost involved. 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 covered during a 2-hour observation period (Fig. 1). Flight areas vary in size depending upon topography and proportion of open areas. Observation flights are concentrated over open terrain, specifically open/timber edges. Each flight segment is flown when opportune, beginning June 1 and continuing through August.

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 ($r = 0.93$, $P < 0.05$) from 1983-86. Each year an average of 35% of the unduplicated females were recorded on IGBST observation flights at a mean rate of 0.09 females per hour. Annual average observation flight hours flown was 59 hours, and an average flight was 2.6 hours. An average of 46% of the unduplicated observations came from ground sightings that were not duplicated on observation flights, 13% from IGBST radio-tracking flights only, and 3% from observation flights by other researchers over the study area.

OBSERVATIONS

Unmarked grizzly bears were most frequently observed from the air during July on both radio-tracking and observation flights (Table 4). Annual flight summaries are listed in the appendix.

POPULATION PARAMETERS

Production

Twenty-four unduplicated females with 46 cubs-of-the-year (COY) were monitored during 1986 (Table 5). This was the highest number of females with cubs observed not only during this study, but also for as long as such records have been kept for the Yellowstone population.

By 1986 we had a sample of 14 reproductive cycles for 13 females not known to use garbage as a major food source (Table 6). These 13 females had a mean reproductive rate of 0.546 compared to 0.800 for two females that relied on garbage as a food source. Mean reproductive rate for all 15 females was 0.597.

First litters were produced at the mean age of 5.94 years (n = 18). For the first time during this study, two females were recorded as having their first cubs as 4-year-olds (No. 72 in 1981 and No. 104 in 1986). Mean age at first cub production for 14 females using natural foods was 6.0 years compared to 5.8 years for 4 garbage-eating females. Mean litter size during the total study period was 2.11 cubs (n = 97 cubs in 46 litters). First litters tended to be smaller than subsequent litters (Table 7) ($P = 0.141$, $t = 1.093$, $df = 40$). Litters produced by garbage-eating females were slightly larger than those produced by females using natural foods, 2.13 cubs compared to 2.08, but not significantly so.

First litters were less frequently composed of 3 cubs compared to subsequent litters (Table 7). Only 1 of 14 first litters contained 3 cubs, while 32% (9 of 28) of subsequent litters were 3-cub litters. Three-cub litters were produced only in the age class 8 to 13 years (n = 9), the same age class with greatest mean female body weights (Blanchard, in press). One-cub litters were produced only in the age classes 5 to 10 years (n = 4) and 18+ years (n = 2). The female producing the one 3-cub first litter was 8 years old, 2 years older than the mean age of first production.

Three-cub litters were more frequent during 1986 than the study average (Table 8). Three-cub litters are generally more frequent following seasons of highest habitat productivity (e.g., previous fall, current spring, current summer). The abundant whitebark pine nut crop during the fall of 1985 very likely influenced 1986 cub production to a large degree. Three-cub litters were also more frequent than average during 1979, following an abundant nut crop during the fall of 1978.

Table 4. Flight data summary for 1986.

Month	Flight type [1]	Number flights	Total hours [2]	Radio locations	(seen)	Unmarked GB's total [3]	Unmarked GB's w/cubs	GB's per hour Total	GB's per hour w/cubs
Feb	rl	1	1.5	4	(0)				
Mar	rl	1	1.8	3	(0)				
Apr	rl	1	1.8	4	(0)				
May	rl	7	17.9	34	(5)	3		0.17	
	*	3		1	(1)	13	1w/3		
Jun	rl	3	15.1	27	(2)	1		0.07	
	obs	10	19.8			10	1w/1 2w/2	0.51	0.15
	*	1				10	2w/2		
Jul	rl	8	12.1	22	(1)	24	3w/1 3w/2 1w/3	1.98	0.58
	obs	10	22.8			15	1w/1 3w/2 1w/3	0.66	0.22
	*	4		1	(1)	14	2w/2 1w/3		
Aug	rl	12	34.1	76	(18)	15	1w/1 2w/2	0.44	0.09
	obs	4	9.4			4	1w/2	0.43	0.11
	*	2		1	(1)	6	2w/2		
Sep	rl	4	12.8	31	(5)	7	2w/2	0.54	0.16
Oct	rl	8	28.8	55	(7)	1		0.04	
Nov	rl	1	4.0	9	(3)				
Dec	*	6		15	(4)	1			
Total	rl	46	129.9	265	(41)	51	4w/1 7w/2 1w/3	0.39	0.25
	obs	24	52.0	0		29	2w/1 6w/2 1w/3	0.56	0.50
	*	16		18	(7)	45	6w/2 2w/3		

1/ 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.

2/ Hours do not include ferry time.

3/ Total unmarked grizzly bears (GB's) include young of adult females.

Table 5. Unduplicated female grizzly bears with cubs of the year, 1973-86.

Year	Females	Cubs	Mean litter size
1973	14	26	1.9
1974	15	26	1.7
1975	4	6	1.5
1976	17	32	1.9
1977	13	25	1.9
1978	9	18	2.0
1979	13	29	2.2
1980	12	23	1.9
1981	13	24	1.9
1982	11	20	1.8
1983	13	22	1.7
1984	17	30	1.8
1985	9	16	1.8
1986	24	46	1.9
	184	343	1.86

Table 6. Reproductive rates for adult females monitored from 1975-86.

Bear	Total cubs	No. litters	No. known cycles	Cycle lengths	Used to compute reproductive rate[a] No. litters	No. cubs
8	8	4	3	8	3	6
10	7	3	2	5	2	4
	15	7	5	13	5	10

Mean cycle length = 2.50
Reproductive rate = 8/10 = **0.800**

Bear	Total cubs	No. litters	No. known cycles	Cycle lengths	No. litters	No. cubs
6	3	2	1	1	1	1
12	4	3	2	4	2	3
13	1	1	*1	[b]7	1	1
16	4	2	1	3	1	2
21	4	2	1	3	1	2
26	1	1	*1	[b]6	1	1
38	5	2	1	3	1	3
43	5	2	1	3	1	2
50	4	2	1	3	1	2
59	4	2	1	2	1	2
83	4	2	1	4	1	2
97	1	1	1	2	-	-
116	6	2	1	3	1	3
	46	24	14	44	13	24

Mean cycle length = 3.39
Reproductive rate = 24/44 = **0.546**

*Not complete.

[a]Unweaned cubs cannot be used to compute reproductive rate since their cycle is not complete. Number of litters should not exceed number of cycles.

[b]Cycle is not complete, but at least this length.

Table 7. Sizes of first litters compared with subsequent litters (May-October 1975-87).

	n	Mean litter size	Frequency of litter sizes 1	2	3	Mean age of female
First litters	14	1.93	0.14	0.79	0.07	5.93
> first litters	28	2.21	0.14	0.50	0.36	12.57

Table 8. Annual litter size frequency.

Year	1	(%)	2	(%)	3	(%)
1973	4	(28.6)	8	(57.1)	2	(14.3)
1974	6	(40.0)	7	(46.7)	2	(13.3)
1975	2	(50.0)	2	(50.0)	0	(0.0)
1976	3	(17.7)	13	(76.5)	1	(5.9)
1977	3	(23.1)	8	(61.5)	2	(15.4)
1978	2	(22.2)	5	(55.6)	2	(22.2)
1979	2	(15.4)	6	(46.2)	5	(38.5)
1980	2	(16.7)	9	(75.0)	1	(8.3)
1981	3	(23.1)	8	(61.5)	2	(15.4)
1982	3	(27.3)	7	(63.6)	1	(9.1)
1983	6	(46.2)	5	(38.5)	2	(15.4)
1984	5	(29.4)	11	(64.7)	1	(5.9)
1985	3	(33.3)	5	(55.6)	1	(11.1)
1986	6	(25.0)	14	(58.3)	4	(16.7)
TOTAL	50	(27.2)	108	(58.7)	26	(14.1)

Survivorship

Survivorship by sex and age class is listed in Table 9.

Sex and Age Structure

Since 1975 we have radio-instrumented 131 different grizzly bears. An additional 15 have been captured, ear-tagged, and released; and 45 cubs and yearlings have been associated with captured females but not tagged. Of these bears, 56 (29%) of known age were alive at some time during 1986 (30 instrumented, 2 tagged, and 24 young of instrumented females).

Annual age structures for 1975-86 are illustrated in Fig. 3. Data included only captured and marked animals and unmarked young accompanying a marked female.

Data from bears of known sex alive in 1986 gave an adult (5+ years) sex ratio of .22M:.78F and a subadult sex ratio of .35M:.65F (Table 10). Females were probably over-represented in the adult sample for two reasons: Research trapping methods were designed to capture adult females; and management captures consisted largely of females and subadults, probably as a result of low whitebark pine nut availability (see Food Habits). For the third consecutive year, the subadult sex ratio favored females, compared to a male-dominated subadult sex ratio from 1975-82. An increase in the proportion of females in the adult age class during the last 2 years generally coincides with trends toward increased production in numbers of female offspring and greater subadult female survival rates as subadult females are recruited into the adult age class (Fig. 4).

The sex ratio for cubs of known litter composition was .51M:.49F (n = 47 cubs in 20 litters). Cub sex ratios have changed from predominantly male during the early years of the study to predominantly female during the last years (Table 11). Cubs in first litters tended to be the same sex and were more often male than cubs of subsequent litters (Table 12); only 1 of the 6 first litters, where sex was known, was of mixed sex. Predominance of males in litters during the early years of the study could not be attributed to a larger sample of first litters, as first litters were equally represented throughout the study (Table 11).

Mortalities

Categories of grizzly bear mortalities included known, probable, and possible deaths. A mortality involving a retrieved carcass, or parts of a carcass, was a known mortality. Reports of a death by a reliable source (as determined by the Team Leader) with no carcass retrieved were counted as probable mortalities. Persistent and repeated rumors of a death were recorded as possible mortalities. 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.

Table 9. Grizzly bear survivorship rates by sex and age class.

	Sample size			Survivorship		
Age	Male	All	Female	Male	All	Female
Cub	26	95	23	0.88	0.89	0.95
1	23	60	18	0.83	0.80	0.78
2	23	40	14	0.61	0.70	0.79
3	23	37	16	0.74	0.86	0.94
4	15	30	15	0.73	0.83	0.93
5	13	26	13	0.92	0.92	0.92
6	13	26	13	0.92	0.85	0.77
7	10	22	12	0.90	0.91	0.92
8	9	21	12	1.00	0.90	0.83
9	6	16	10	0.83	0.88	0.90
10	7	17	10	1.00	1.00	1.00
11	7	15	8	1.00	1.00	1.00
12	6	14	8	0.50	0.71	0.88
13	4	9	5	1.00	0.89	0.80
14	4	9	5	0.75	0.89	1.00
15	3	7	4	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	2	1	1.00	1.00	1.00
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

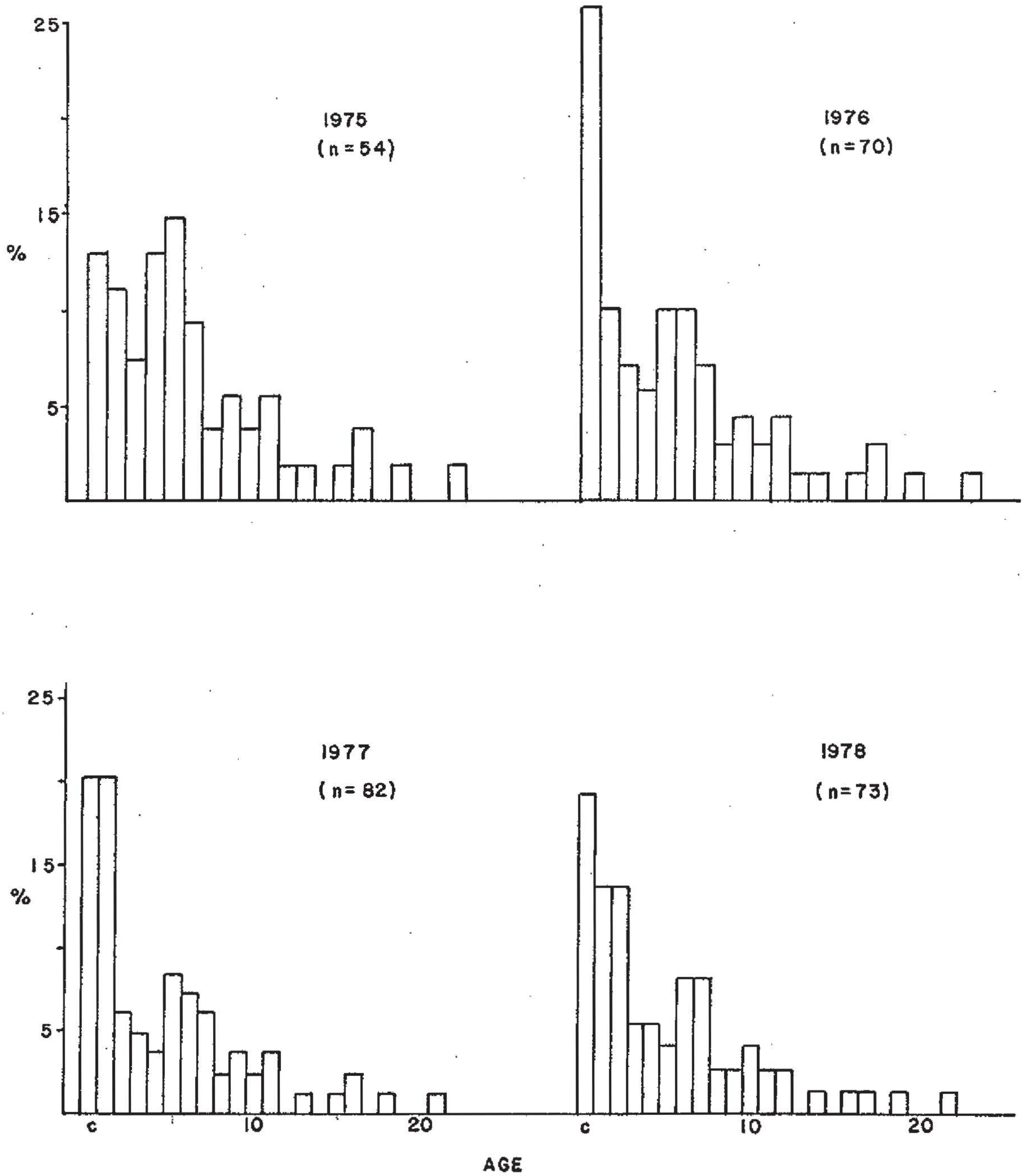


Figure 3. Annual age structures constructed from capture data, 1975-86.

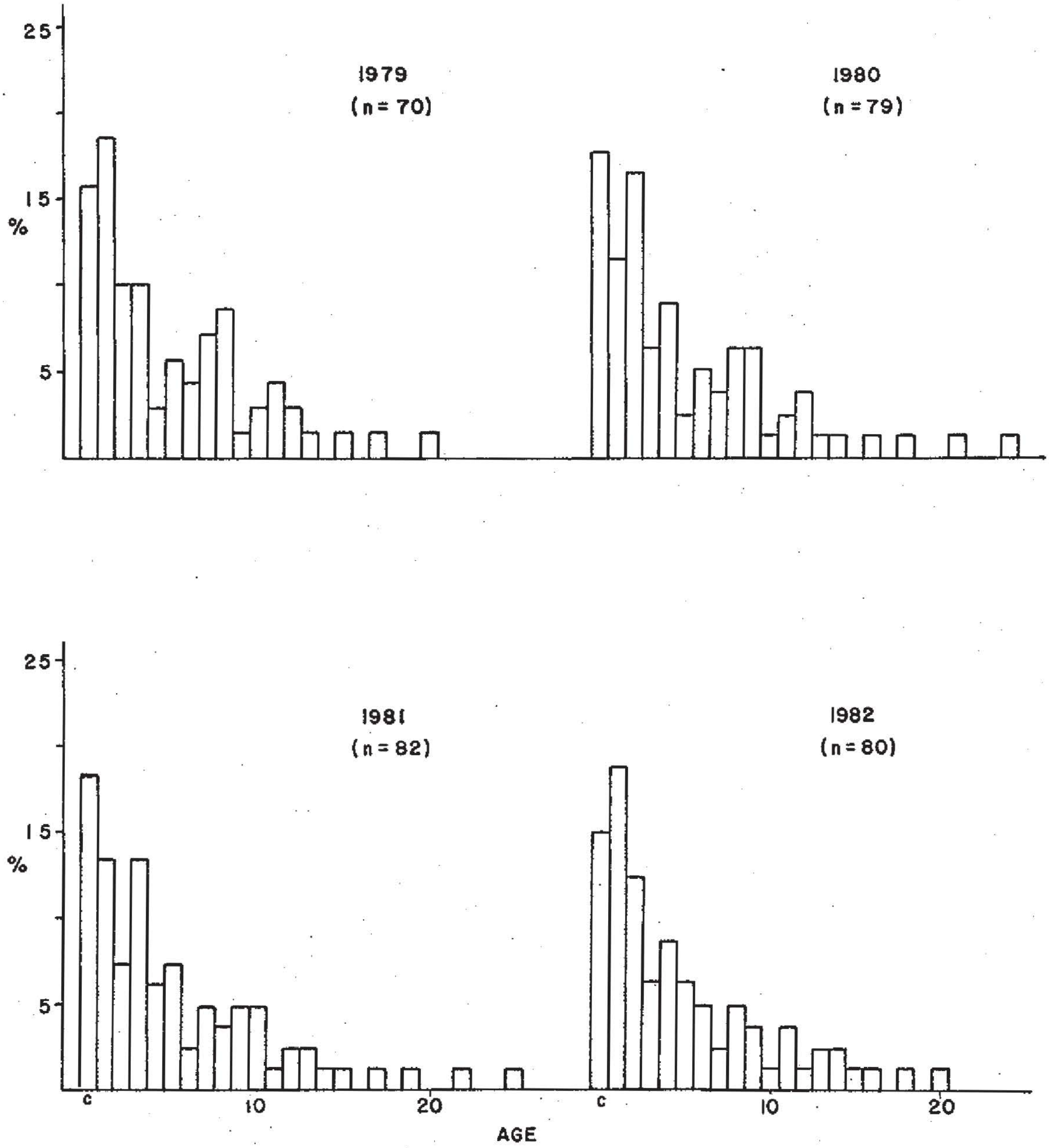


Figure 3. Continued.

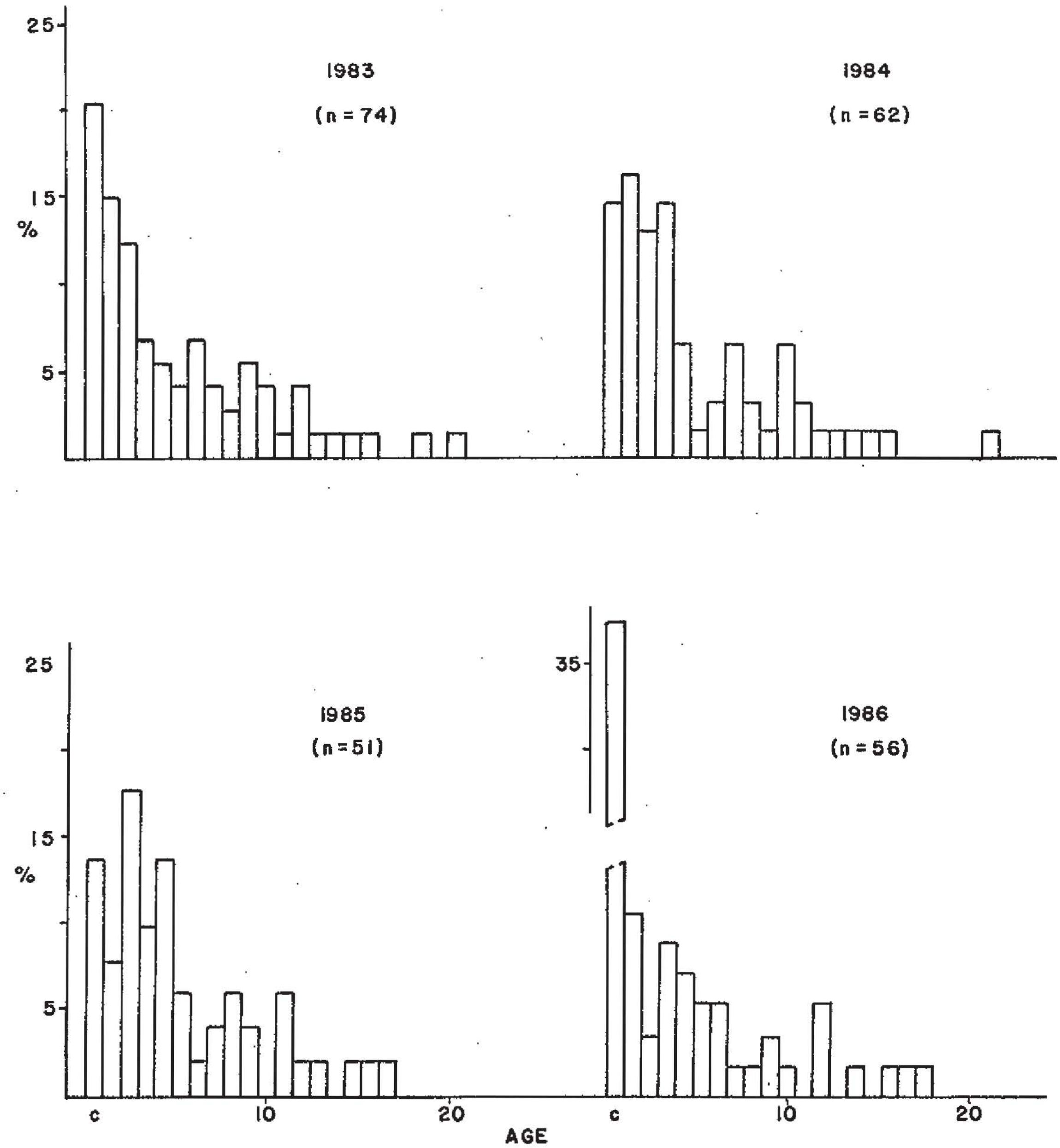


Figure 3. Continued.

Table 10. Sex ratios of adult (5+ years) and subadult (cub through 4 years) grizzly bears captured and radio-marked, 1975-86. Sample includes unmarked young accompanying radio-marked females.

	Sample size					Sex ratios		
	Adults		Subadults			Adult	Subadult	Ad/SAd
Year	M	F	M	F	Unk	M / F	M / F	
1975	9	15	17	14	1	.38/.62	.55/.45	.43/.57
1976	13	16	22	14	5	.45/.55	.61/.39	.41/.59
1977	14	20	20	14	14	.41/.59	.59/.41	.42/.58
1978	15	16	22	15	5	.48/.52	.60/.40	.43/.57
1979	14	16	25	11	4	.47/.53	.69/.31	.43/.57
1980	14	17	28	15	5	.45/.55	.65/.35	.39/.61
1981	17	17	25	16	7	.50/.50	.61/.39	.41/.59
1982	14	17	23	17	9	.45/.55	.58/.42	.39/.61
1983	14	16	18	20	6	.47/.53	.47/.53	.41/.59
1984	9	13	13	20	7	.41/.59	.39/.61	.36/.64
1985	5	14	9	15	8	.26/.74	.38/.62	.37/.63
1986	4	14	8	15	15	.22/.78	.35/.65	.32/.68
Total	142	191	230	186	86	.43/.57	.55/.45	.40/.60
1975-79	65	83	106	68	29	.44/.56	.61/.39	.42/.58
1980-83	59	67	94	68	27	.47/.53	.58/.42	.40/.60
1984-86	18	41	30	50	30	.31/.69	.38/.62	.35/.65

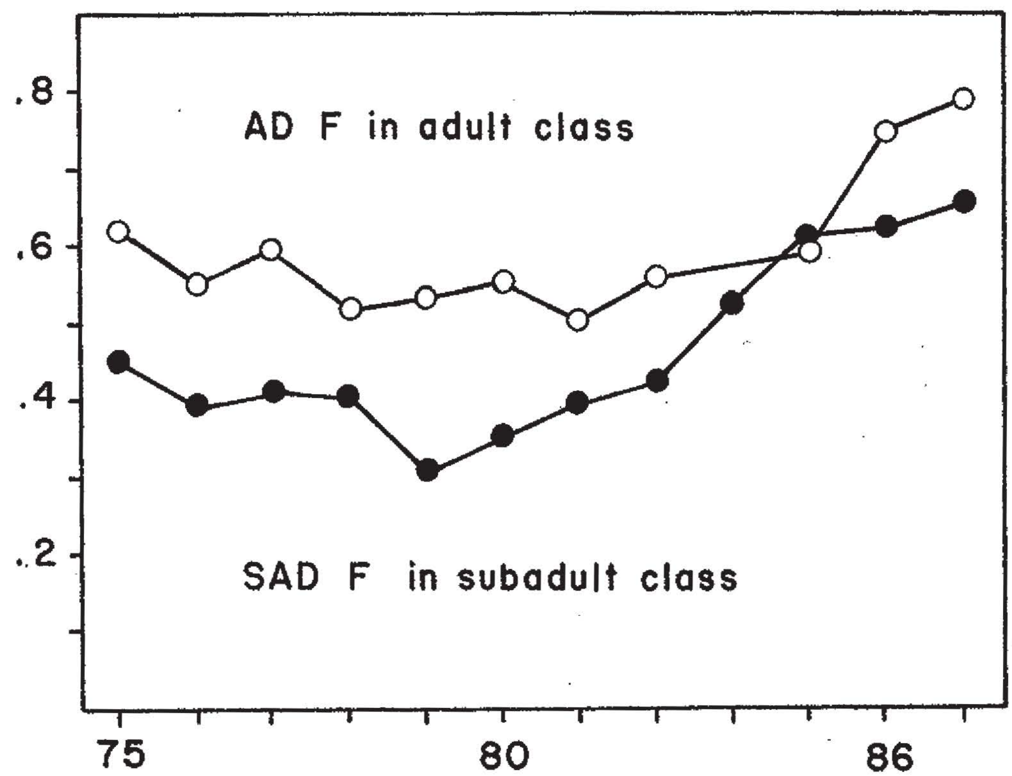


Figure 4. Proportion of females in adult and subadult age classes, 1975-86.

Table 11. Sex ratios of cub litters during three periods of the study.

Period	n	No. of first litters	Sex ratio M / F
1976-79	6	2	.73 / .27
1980-83	8	2	.44 / .56
1984-86	6	2	.36 / .64

Table 12. Sex ratios of first litters compared to subsequent litters.

	n	Sex ratio M / F
First litters	6	.79 / .21
> first litters	12	.45 / .55

Mortalities from 1973 through 1986 are summarized in Table 13. Eleven known mortalities were recorded during 1986, including 2 adult females and 3 subadult females (Table 14).

Cubs were naturally weaned at a mean age of 1.8 years (n = 11 litters), compared to 0.7 years for man-induced weanings (n = 7 litters). Man-induced weanings occurred during management actions when young were separated from the mother either intentionally or accidentally. Mortality rates were higher for cubs from man-induced weanings (50%; 8 of 16) compared to rates for naturally weaned young (36%; 8 of 22).

FOOD HABITS

Procedures

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

All bear scats collected and classified as grizzly and species unknown were included in the analysis. Dried scats were soaked in water to soften them and washed through two 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. 5). 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 two angles. Cones were counted in July and early August when they had reached mature size, but few had been

Table 13. Summary of grizzly bear mortalities, 1973-86.

Year	Known	Probable	Possible	Total (known/ probable)	Adult female (known and probable)
1986	11	0	0	11	2
1985	11	2	0	13	2
1984	10	1	0	11	2
1983	6	0	0	6	2
1982	17	0	0	17	4
1981	10	3	3	16	5
1980	7	3	0	10	1
1979	3	6	2	11	2
1978	5	2	3	10	2
1977	12	4	1	16	4
1976	5	1	0	6	1
1975	2	1	0	3	1
1974	15	0	1	16	4
1973	13	5	3	21	4

Table 14. Grizzly bear mortalities, 1986.

Bear	Sex	Age	Date	Location	Cause
KNOWN					
Unmarked	F	Cub	06-09	LeHardy Rapids, Yellowstone R, YNP	Natural; starvation
121	M	6	July	Gravelly Mtns, MT	Mgt control; sheep depredation
76	F	6	09-06	Bear Cr, MT (south of Bozeman)	Illegal; defense of property
G28	M	Cub	09-06	Bear Cr, MT	To zoo
G29	M	Cub	09-06	Bear Cr, MT	Illegal; defense prop.
Unmarked	M	3-4?	09-25	Wolverine Cr, MT	Illegal; hunter mis-taken for black bear
Unmarked	F	2?	09-27	Wapiti Cr, MT	Illegal; hunter, defense of property
Unmarked	?	Cub	Sep.	Pelican Valley, YNP	Natural (predation?); cub of No. 83
59	F	8	09-04	Canyon, YNP	Mgt control; human fatality
127	M	1	10-20	Lake, YNP	Mgt control
122	F	3	Btwn. 10-24 and 12-15	Beartooth Plateau or N Fk Shoshone River, WY	Illegal; unknown type

TOTAL:		SAd F;	Ad F;	SAd M;	Ad M;	SAd ?
	Natural	1	0	0	0	1
	Mgt control	0	1	1	1	
	Self-defense	1	1	2		
	Illegal --					
	Hunter			1		
	Unknown	1				
		3	2	4	1	1

TOTAL = 11

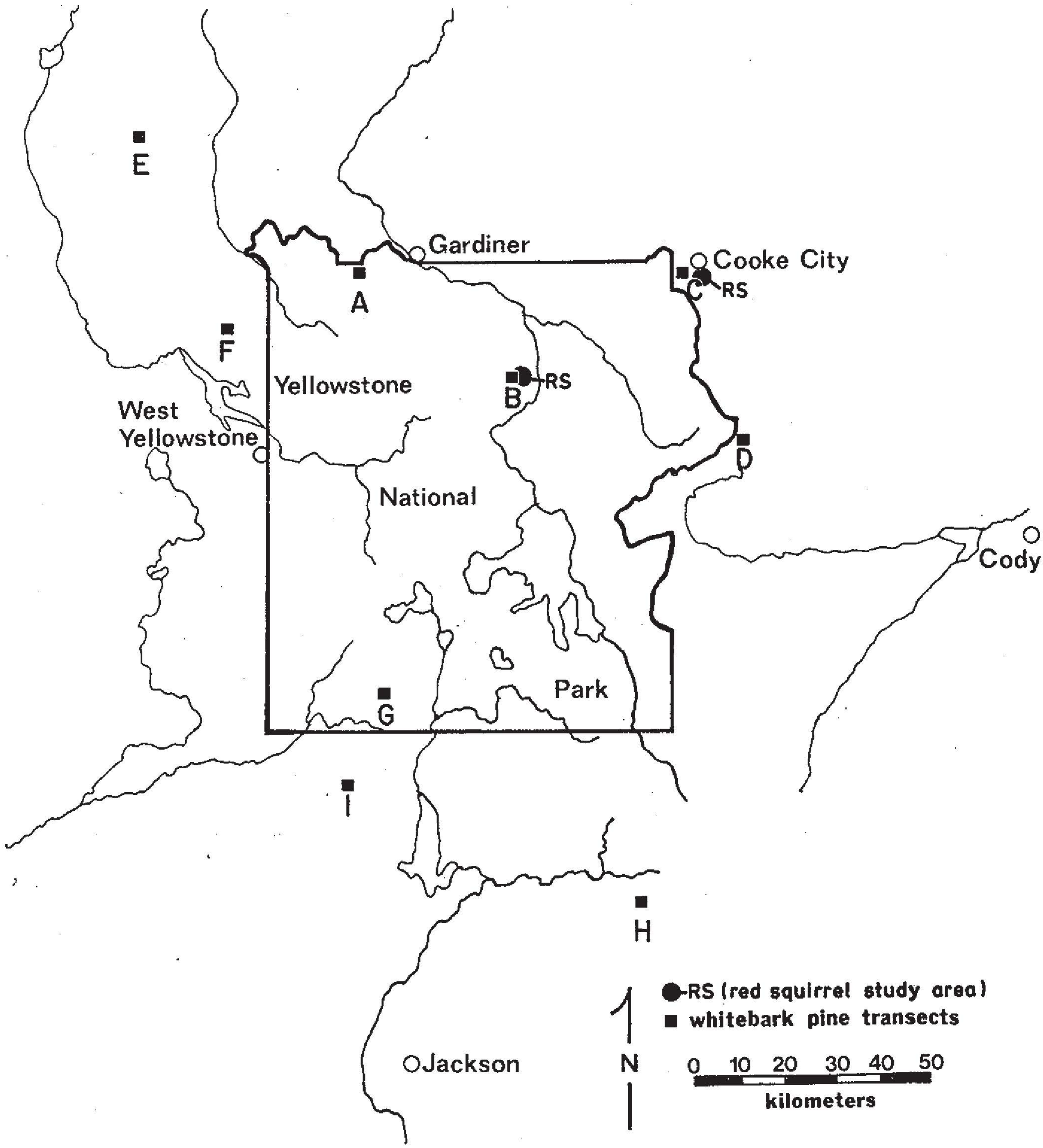


Fig. 5. Locations of whitebark pine cone production transects and red squirrel study subunits.

harvested by squirrels. All trunks joined at the base were considered one tree.

Results

Scat analysis.-- Food habits data 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, animal matter, berries, and roots are especially underrepresented in scats relative to the vegetal grazing resource. Also, summary data represented in Table 15 represent an agglomeration across all months and seasons. Fall and spring food habits are substantially underrepresented in such a summary. Caution should therefore be used in imputing spring and fall feeding activities from this table.

During 1986, 525 scats were collected and analyzed for content (Table 16), including 69 spring (March-May), 326 summer (June-August), and 130 fall (September-October) scats.

Graminoids were the most frequently observed fecal item during spring and also constituted the greatest scat volume, although both pine nuts and mammals, primarily elk and bison, were nearly as well represented (Table 15). Pine nuts eaten during this season were surplus cones cached by red squirrels during the fall of 1985 when pine nut production was high.

Bears continued to feed on surplus cone caches throughout the summer, with consumption appearing to peak in July. However, graminoid and forb foliage were most frequently observed in fecal material and in the greatest volume. Other important food items during this season were cutthroat trout; a variety of mammals, including black bears; ants; roots, primarily corms of onion grass (*Melica spectabilis*) and tubers of yampa (*Perideridia gairdneri*); and horsetail (*Equisetum* spp.).

During fall, foliage continued to dominate the fecal contents. Roots became an important food item as surplus pine nut caches were depleted and virtually none were produced during the fall of 1986. Important root crops included *Osmorhiza chilensis* and yampa. Ants, horsetail, and various mammals were also consumed in notable quantities to compensate for the unavailability of pine nuts.

Once again, food habits in 1986 reflected availability of whitebark pine nuts. Surplus cones from the previous fall were consumed from spring through summer in apparent preference to alternate food items. However, radio-telemetry data indicated females with cubs-of-the-year preferred security from large males over pine nuts and were, in general, not able to take advantage of the surplus cones when males were utilizing these food sources. Late summer and fall food habits reflected the low production of pine nuts during the fall of 1986. Major alternate food items were root crops, most notably those of *Osmorhiza chilensis* and *Perideridia gairdneri*. Bears also sought food in association with

Table 15. Scat content analysis, 1986 (n = 528).

Food item	No. scats	% Frequency occurrence	% Diet volume	% Scat composition
Trees				
Pinus albicaulis (pine nuts)	105	19.89	17.59	88.43
Shrubs				
Ribes sp.	8	1.52	0.91	60.00
Shepherdia canadensis	3	0.57	0.11	20.00
Vaccinium scoparium	6	1.14	0.85	75.00
Total	13	2.46	1.88	76.15
Sporophytes				
Equisetum sp.	32	6.06	3.09	50.94
Puffballs	5	0.95	0.22	23.00
Mushrooms	5	0.95	0.27	28.00
Total	40	7.58	3.57	47.13
Graminoids				
Agropyron caninum	2	0.38	0.25	65.00
Bromus sp.	5	0.95	0.31	33.00
Carex sp.	10	1.89	0.80	42.50
Elymus sp.	1	0.19	0.19	100.00
Melica sp.	1	0.19	0.04	20.00
Melica spectabilis	8	1.52	1.12	73.75
Phleum pratense	1	0.19	0.06	30.00
Poa sp.	39	7.39	3.39	45.90
Grass	10	1.89	1.14	60.00
Grass/sedge	213	40.34	23.08	57.21
Total	275	52.08	30.37	58.31
Forbs				
Unidentified forb	7	1.33	0.45	33.57
Allium sp.	1	0.19	0.15	80.00
Angelica sp.	2	0.38	0.09	25.00
Cirsium scariosum	17	3.22	1.93	60.00
Claytonia lanceolata	3	0.57	0.45	80.00
Epilobium angustifolium	1	0.19	0.04	20.00
Heracleum sp.	1	0.19	0.19	100.00
Heracleum lanatum	7	1.33	0.43	32.14
Lomatium sp.	3	0.57	0.11	20.00
Lomatium cous	1	0.19	0.03	15.00
Monotropa uniflora	2	0.38	0.15	40.00
Osmorhiza chilensia	28	5.30	3.39	63.93

Table 15. Continued.

Food item	No. scats	% Frequency occurrence	% Diet volume	% Scat composition
Penstemon wilcoxii	1	0.19	0.17	90.00
Perideridia gairdneri	22	4.17	2.69	64.55
Polygonum sp.	1	0.19	0.05	25.00
Ranunculus sp.	3	0.57	0.10	18.33
Taraxacum officinale	39	7.39	3.67	49.74
Tragopogon sp.	1	0.19	0.03	15.00
Tragopogon dubius	7	1.33	1.17	88.57
Trifolium sp.	45	8.52	3.56	41.78
Trifolium repens	7	1.33	0.87	65.71
Umbelliferae/Apiaceae	2	0.38	0.31	82.50
Total	178	33.71	20.05	59.47
Mammals				
Elk	50	9.47	4.73	50.00
Bison	16	3.03	1.51	49.69
Black bear	5	0.95	0.72	76.00
Deer	8	1.52	0.45	30.00
Grizzly bear	1	0.19	0.14	75.00
Moose	4	0.76	0.55	72.50
Mountain goat	1	0.19	0.05	25.00
Pocket gopher	1	0.19	0.02	10.00
Microtinae	1	0.19	0.08	40.00
Microtus sp.	2	0.38	0.17	45.00
Spermophilus citellus	1	0.19	0.03	15.00
Tamiasciurus sp.	4	0.76	0.24	31.24
Total	90	17.05	8.68	50.94
INSECTS				
Ants	79	14.96	2.91	19.43
Bees	1	0.19	0.04	20.00
Grasshoppers	3	0.57	0.29	21.67
Bot fly larvae	1	0.19	0.04	20.00
Total	83	15.72	3.28	20.84
Cutthroat trout	46	8.71	6.05	69.46
Grouse	1	0.19	0.19	100.00
Debris	164	31.06	8.35	26.89

Table 16. Seasonal scat content analysis for 1986.

	Spring[a] (n = 69)			Summer[b] (n = 326)			Fall[c] (n = 130)		
	n	% Freq.	% Vol.	n	% Freq.	% Vol.	n	% Freq.	% Vol.
Pine nuts	23	33.33	32.10	68	20.86	18.39	13	10.00	7.50
Berries				4	1.23	1.23	9	6.92	4.54
Grass/sedge	29	42.03	30.94	167	51.23	29.15	68	52.31	28.23
Forbs (foliage)	5	7.24	1.82	77	21.77	10.08	39	29.90	18.31
Roots	4	5.80	2.68	22	6.76	4.04	39	30.00	18.61
Mammals	24	34.78	23.41	45	13.80	6.17	20	15.38	7.19
Insects	8	11.59	1.30	63	19.33	4.33	12	9.23	1.77
Fish				46	14.11	9.80			
Birds				1	0.31	0.31			
Sporophytes	4	5.80	2.75	24	7.36	3.90	12	9.23	3.27
Debris	19	27.54	5.00	88	26.99	8.22	56	43.08	24.55

[a]Spring = March, April, May
[b]Summer = June, July, August
[c]Fall = September, October

human activity more often than during years of abundant pine nut production (see whitebark pine production results). Females with young and subadults were more frequently involved in these human/grizzly confrontations than were single adults, perhaps a reflection of sex and age classes able to profit most from the surplus 1985 nut crop during the current spring and summer.

Whitebark pine cone production.--Whitebark pine cone production has been recorded at 9 locations throughout the study area from 1980-86 (Table 17). Mean cone production during 1986 was the lowest recorded during the 7-year period, with all transects for which data were collected producing well below the overall mean of 16.4 cones per tree (Table 18). Virtually no pine nuts were discovered in scats deposited during late summer and fall. Grizzly bears were able to utilize pine nuts from squirrel caches during the spring of 1986. These caches were left over from the abundant cone crop of 1985.

Whitebark pine nuts are by far the most important fall food of Yellowstone grizzly bears, and availability of nuts greatly influences numbers of grizzly/human conflicts and resulting management actions. Management actions are few during years of good nut production and high when nut crops are poor (Table 19) ($r = -0.89$, $P < 0.05$). In general, low pine nut production is positively correlated with high mortality rates. An average 13.5 bears (3.3 adult females) died during years of low nut production (1977, 1981, 1984, 1986) compared to 11.0 bears (1.8 adult females) during years of high nut production (1978, 1979, 1980, 1985). Based on these findings, potential intensity of grizzly/human conflicts during late summer and fall can be predicted when nut production is assessed during July.

Table 17. Numbers of cones in 10 whitebark pine trees at 9 locations, 1980-86.

		TREE NUMBER											
Transect		1	2	3	4	5	6	7	8	9	10	Mean	Avg
	a	0	10	47	2	7	4	14	38	25	80	22.7	
	b	12	36	11	1	6	0	24	23	27	138	27.8	
A	c	11	12	22	4	3		1	17	41	30	15.7	
YNP	d	7	35	10	22	19		23	30	9	32	20.8	18.9
Deaf Jim	e	4	3	1	0	0		1	0	0	5	1.6	
	f	37	30	80	15	27		15	22	77	75	42.0	
	g	1	0	0	0	0		0	0	0	0	0.1	
		20	25	10	34	35	26	31	6	20	28	23.5	
		17	0	2	27	10	16	0	7	8	0	8.7	
B		192	45	10	49	39	14	27	12	20	55	46.3	
YNP		0	13	10	31	15	26	9	15	16	5	14.0	18.5
Washburn		8	3	9	23	5	11	3	2	9	2	7.5	
		50	14	6	29	23	44	54	35	22	6	28.3	
		6	0	0	0	0	2	0	0	1	0	0.9	
		7	8	23	6	23	20	0	8	4	40	13.9	
		4	0	13	3	5	6	4	11	2	6	5.4	
C		28	6	36	25	6	15	4	11	7	18	15.6	
SNF		6	10	19	13	30	13	1	16	0	13	12.1	16.6
Woody Cr		Data not collected for 1984											
		15	25	23	68	123	120	30	42	21	19	48.6	
		4	10	8	0	1	4	3	3	0	5	3.8	
		18	19	19	5	12	6	19	8	6	32	14.4	
		12	10	14	6	15	11	5	5	4	7	8.9	
D		10	5	7	17	8	15	17	12	10	34	13.5	
SNF		10	30	13	12	40	5	3	7	6	29	15.5	23.0
Sunlight		Data not collected for 1984											
		39	30	15	50	170	50	35	54	20	162	62.5	
		Data not collected for 1986											
		32	26	21	16	28	14	6	18	16	14	19.1	
		0	0	0	2	0	0	3	0	3	0	0.8	
E		0	0	0	0	0	0	0	0	0	0	0.0	
GNF		3	15	5	5	17	29	6	2	3	41	12.6	7.0
Lone Mtn		4	1	4	0	0	0	2	0	15	3	2.9	
		20	17	5	5	4	11	18	21	27	10	13.8	
		0	0	0	0	0	0	0	0	0	0	0.0	

Table 17. Continued

Transect	1	2	3	4	5	6	7	8	9	10	Mean	Avg
	TREE NUMBER											
	25	11	51	50	51	169	20	60	65	60	56.2	
	0	0	5	0	0	0	5	3	1	0	1.4	
F	0	0	0	0	0	0	0	0	0	0	0.0	
GNF	75	10	20	12	7	81	5	0	32	23	26.5	15.2
Cabin Cr	Data not collected for 1984											
	0	0	6	6	0	20	0	0	15	20	6.7	
	0	0	0	0	0	0	0	0	1	0	0.1	
	35	8	50	52	12	90	53	5	28	18	35.1	
	3	1	5	50	18	20	22	3	22	0	14.4	
G	1	0	5	28		8	3	15	8	0	7.6	
YNP	1	0	10	38		0	33	3	2	0	9.7	13.5
Pitchstone	0	0	9	6			6	0		0	3.0	
	0	0	5	6			5	1			2.8	
	Data not collected for 1986											
	30	25	9	24	30	13	18	28	47	24	24.8	
	45	24	18	99	36	50	60	45	100	12	48.9	
H	14	4	38	2	20	17	57	100	110	34	39.6	
SNF	43	28	27	17	43	71	27	30	79	7	37.2	26.2
Moccasin	12	5	10	7	11	10	11	12	38	8	12.4	
Basin	15	10	14	7	31	17	25	40	26	9	19.4	
	0	3	0	3	2	0	0	2	2	0	1.2	
	42	11	0	18	12	26	14	11	65	16	21.5	
I	4	1	0	2	0	0	1	5	15	0	2.8	
TNF	9	2	0		8			25	21	19	12.0	12.1
Hominy Pk	Transect discontinued; J substituted starting 1983											
	12	3	6	10	11	1	5	7	10	13	7.8	
J	12	2	12	11	30	8	6	6	2	8	9.7	
TNF	13	3	7	16	54	7	8	8	3	5	12.4	8.2
Hominy Pk	0	2	4	0	9	6	5	3	0	1	3.0	

a 1980
b 1981
c 1982
d 1983
e 1984
f 1985
g 1986

Blank cells indicate dead trees.

Table 18. Total annual whitebark pine cone production.

Year	n	Mean No. cones/tree	Standard deviation	Coefficient of variation	Range	Total cones
1980	90	25.69	23.87	92.92	0-169	2313
1981	90	13.23	22.85	172.65	0-138	1191
1982	85	16.98	27.63	162.73	0-192	1443
1983	88	17.97	17.61	97.94	0-81	1528
1984	56	6.43	7.28	113.30	0-38	360
1985	85	27.20	32.38	119.06	0-170	2312
1986	69	1.32	2.32	2.30	0-10	91

Table 19. Annual relationship between whitebark pine nut production and numbers of management actions involving grizzly bears.

Year	Whitebark pine nut production (mean cones/tree)	Management actions (trappings) (Ind. Bears)
1977	Poor	5
1978	Great	0
1979	Good	0
1980	26	0
1981	13	21
1982	17	7
1983	18	3
1984	6	14
1985	27	0
1986	1	31?

GRIZZLY BEAR, RED SQUIRRELS, AND WHITEBARK PINE:

THIRD YEAR PROGRESS REPORT

by

David J. Mattson
Daniel P. Reinhart

INTRODUCTION AND METHODS

A study was initiated by the IGBST in 1984 to investigate relationships among density and probability of red squirrel (*Tamiasciurus hudsonicus*) midden use by grizzly bears (*Ursus arctos horribilis*), site and stand characteristics, and indices of squirrel activity and population levels. Study area units were located on Mt. Washburn in Yellowstone National Park and in the vicinity of Cooke City (see Fig. 5). Analysis of study data related grizzly bear use of middens to different whitebark pine (*Pinus albicaulis*) overstory characteristics and indexed squirrel population levels. Analysis of 1986 data, stand timber overstory characteristics, and trends in squirrel sign since 1984 for the Mt. Washburn study unit are presented in this report. Field methods and study area were described in detail by Mattson and Reinhart (1986).

Calculation of line densities for variables among habitat types differed between the 1986 and current year's report. In the 1986 progress report, line densities were reported as the mean among stands. In this report, line densities were calculated as the quotient of summed variable counts divided by total transect length across all stands of a given type. High variation among stands of a given type attributable to stand transect length made the second method of calculation more meaningful.

PRELIMINARY RESULTS

Data were collected from 134 stands in 1984 and 152 stands each year for 1985 and 1986. Fifty of the stands sampled in 1984 and 84 of those sampled in 1985 and 1986 were located in the Mt. Washburn study unit. Transects totaled 20.3 km in 1984 and 29.5 km in 1985 and 1986 in the Washburn unit.

Whitebark pine cone production was much higher in 1985 compared to 1984 and 1986 in the Washburn study unit, and much higher in 1985 compared to 1986 in the Cooke City study unit (Table 20). Pine nuts dominated the grizzly bear diet in the fall of 1985 (Knight et al. 1986) and were virtually absent from the diet during the fall of 1986 (page 28, this volume); grizzly bear are known to make near exclusive use of pine nuts in the Yellowstone area when nut crops are large (Knight et al. 1984, Kendall 1983).

Table 20. Mean (standard deviation) cone production per tree at transects in the Cooke City and Mt. Washburn study units, by year.

Study unit	Year 1984	1985	1986
Cooke City	Missing	48.6 (41.3)	3.8 (3.3)
Mt. Washburn	7.5 (6.4)	28.3 (17.3)	0.9 (1.9)

Whitebark pine overstory characteristics varied among habitat types and cover types in the Mt. Washburn study unit. Mean whitebark pine basal area was near equal to or greater than 100 sq ft/acre in all but the WB1 whitebark pine cover types (WB2, WB3, WB); whitebark pine basal area averaged substantially less (40 sq ft/acre) in the early successional WB1 type (Table 21). Moderate whitebark pine basal area characterized mid- to late lodgepole pine (Pinus contorta) successional stage (LP2, LP3) and spruce-fir (Picea engelmannii-Abies lasiocarpa) (SF) cover types of the wet habitat types and Abies lasiocarpa/ Vaccinium globulare-V. scoparium (Abla/Vagl-Vasc) and A.l./Vaccinium scoparium-Pinus albicaulis (Abla/Vasc-Pial) phases. Virtually no whitebark pine occurred in the A.l./Vaccinium scoparium-V. scoparium (Abla/Vasc-Vasc) phase and A.l./Linnaea borealis (Abla/Libo) and A.l./Thalictrum occidentale (Abla/Thoc) habitat types. Ten-year growth increment of whitebark pine tended to be greatest in the Pinus albicaulis (Pial) habitat type series and wet site habitat types and least in the Abla/Vagl-Vasc phase.

Squirrel middens were found in stands of all site types except the Pial series in the Mt. Washburn study unit during the 1986 survey. Forty-six active and 64 inactive middens were examined. Middens ranged in size from approximately 1 to 300 m^2; size did not differ significantly among types. Middens where bear digging was evident were significantly larger than middens where no digging was evident, even after accounting for newly established middens typically less than 12 m^2 in size (Tables 22 and 23).

Table 21. Whitebark pine basal area and last 10-year growth increment, by habitat type and cover type, for the Mt. Washburn study unit. Data were derived from standard variable radius overstory inventory plots.

		Basal area (ft^2/acre)				10-yr increment (1/20 in)			
Habitat type acronym	Cover type code	n	$\bar{X}$	S.D.	C.V.	n	$\bar{X}$	S.D.	C.V.
Pial	WB1	9	40.0	30.0	0.75	16	4.19	1.72	0.41
	WB2	3	140.0	52.9	0.38				
	WB3	12	106.7	64.0	0.60				
	WB	19	97.9	62.8	0.64				
Abla/Vasc-Pial	WB2	60	134.0	87.2	0.65	57	3.02	1.30	0.43
	WB3	102	102.5	68.7	0.67				
	SF2	3	106.7	92.4	0.86				
	SF	17	32.9	47.4	1.44	6	3.00	1.41	0.47
	LP2	26	16.9	30.3	1.79				
	LP3	36	31.9	47.5	1.49				
Wet types	WB2	6	100.0	33.5	0.33	9	4.22	1.99	0.47
	WB3	4	105.0	79.0	0.75				
	SF	17	21.2	37.7	1.78				
Abla/Vasc-Vasc	LP1	15	0.0	0.0	--	0	--	--	--
	LP2	12	0.0	0.0	--				
Abla/Libo	LP2	8	0.0	0.0	--	0	--	--	--
	LP3	27	2.4	9.7	4.04				
	SF	10	0.0	0.0	--				
Abla/Thoc	LP2	31	5.2	17.1	3.29	0	--	--	--
	LP3	21	7.7	20.4	2.66				
Abla/Vagl-Vasc	LP2	40	35.0	50.8	1.45	22	2.77	1.60	0.58
	LP3	35	49.1	66.6	1.36				
	SF	7	5.7	15.1	2.65				

Table 22. Analysis of variance for midden size with respect to presence of bear diggings and habitat type; 1986 Mt. Washburn data.

Factor	All Middens (n = 83)			Middens > 12 m^2 (n = 72)		
	df	F	P	df	F	P
A. Presence of digging	1	8.18	0.006	1	5.58	0.021
B. Habitat type	2	0.64	0.529	2	0.23	0.799
AxB	2	1.52	0.224	2	1.88	0.161

Table 23. Mean (standard deviation) midden size and dug area for dug and undug, active and inactive middens, by habitat type. Calculated from 1986 Mt. Washburn data.

Habitat type acronym	ACTIVE MIDDENS			INACTIVE MIDDENS		
	Dug		Undug	Dug		Undug
	Size (m^2)	Dug area (%)	Size (m^2)	Size (m^2)	Dug area (%)	Size (m^2)
Pial	--	--	--	--	--	--
Abla/Vasc-Pial	106.1 (65.9)	53.6 (22.6)	21.3 (15.0)	71.9 (56.3)	57.2 (17.2)	42.0 (21.0)
Wet types	70.0 (-)	75.0 (-)	24.0 (35.6)	92.2 (62.3)	44.0 (20.4)	--
Abla/Vasc-Vasc	56.0 (-)	20.0 (-)	2.2 (1.8)	--	--	12.0 (--)
Abla/Libo	176.0 (-)	75.0 (-)	130.0 (-)	50.0 (-)	65.0 (-)	--
Abla/Thoc	72.7 (14.7)	50.0 (10.0)	33.9 (33.5)	116.8 (186.4)	41.2 (17.5)	16.8 (9.1)
Abla/Vagl-Vasc	49.3 (21.0)	58.3 (24.7)	50.5 (42.0)	30.0 (20.0)	33.3 (14.4)	6.0 (-)

Line density of middens dug out by bears ranged from 0.0 to 0.30 middens/100 m among habitat types (Table 24). Considering only middens dug during the fall of 1985 or spring of 1986, densities ranged from 0.0 in the Pial series to 0.29 in the wet habitat types. Line density of dug out middens was also high (0.25/100 m) in the Abla/Thoc habitat type and low (0.05/100 m) in the Abla/Vasc-Vasc phase.

The probability of an examined midden having been dug out by a bear also varied considerably among habitat types (Table 24). Probability was highest (67-79%) in the wet habitat types and Abla/Vasc-Pial phase and lowest (20-37%) in the Abla/Thoc habitat type and Abla/Vasc-Vasc phase. Among types, probability (y) was related to mean whitebark pine basal area (x) ($r = 0.90$, $r^2 = 0.81$, $n = 6$, $P = 0.015$; $\hat{y} = (942.8 + 58.18X)^{-2}$).

Line density of active middens and squirrel sightings-vocalizations varied among types and years (Fig. 6). Typically, density of both middens and sightings-vocalizations was consistently highest in the mesic (Abla/Libo, Abla/Thoc, Abla/Vagl-Vasc) types. These variable levels were also comparatively high in the wet types during 1985. Lowest densities of squirrel sign characterized the Pial series. Density of middens was lowest in all types but the Abla/Vasc-Vasc phase during 1986, compared to 1984 and 1985; density of sightings and vocalizations was also lower in most types during 1986, especially compared to 1985. Across all types, the difference in line density of both active middens and squirrel sightings-vocalizations between 1985 and 1986 was statistically significant (Wilcoxon paired signed-rank test: $\hat{T} = 2.0$, $n = 7$, $P < 0.05$; $\hat{T} = 3.0$, $n = 7$, $P < 0.05$; for middens and sightings-vocalizations, respectively).

Change in active midden density between 1985 and 1986 (1986 level as a percent of the 1985 level) was related to probability of bear digging during the fall of 1985 or spring of 1986. Most variation (96%) in 1986 midden density as a percent of 1985 density (y) among types was explained by probability of bear digging (x) ($r = -0.98$, $n = 5$, $P = 0.003$; $\hat{y} = (41.97 + 72.70x)^{-2}$).

Between stand variation of most squirrel-related variables was high for the Mt. Washburn study unit (Table 25). Between stand variation of squirrel sightings-vocalizations (SQUIR) was lower than that of active or inactive middens in all types but the Abla/Vasc-Pial phase. Within stand sample sizes (n) were also substantially higher for SQUIR compared to ACTM and INACTM.

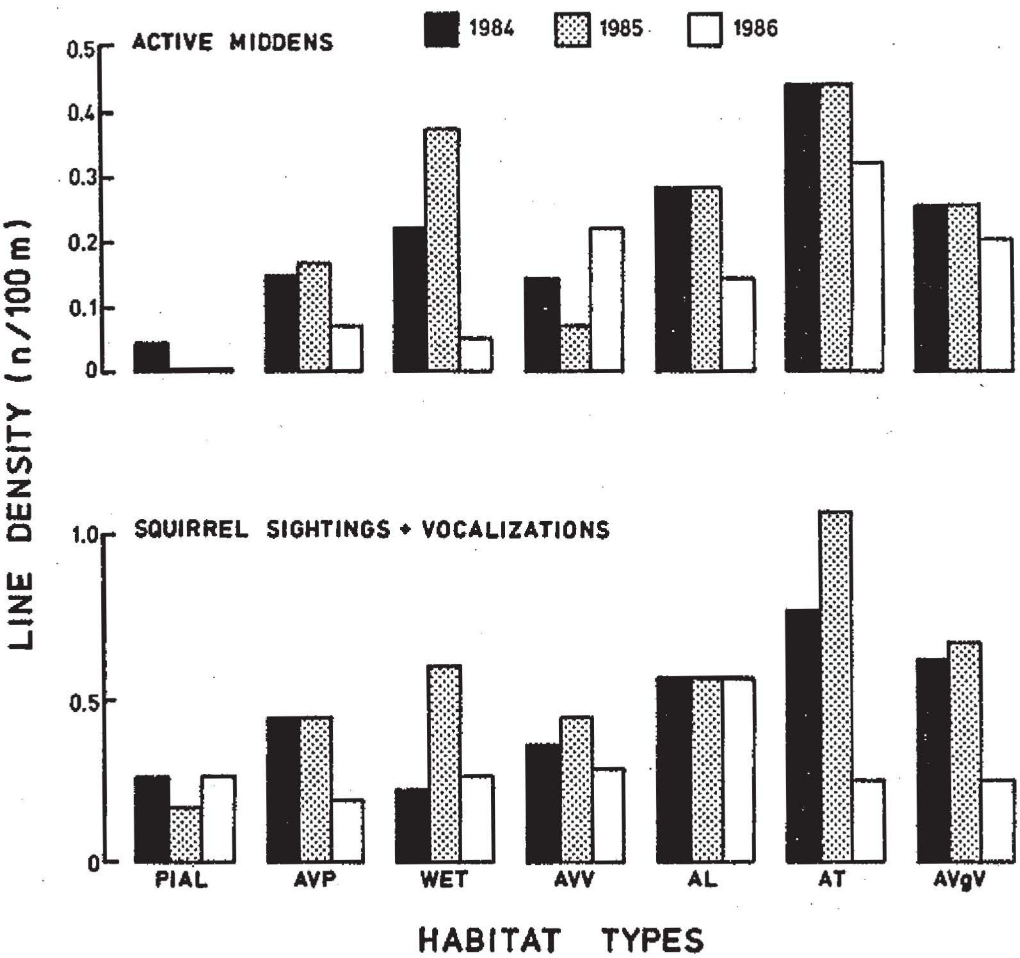
Between-stand variation was computed using only stands containing greater than 300 m of transect. Because of low squirrel sign densities, within-stand estimates for a given type were not stable except for stands with greater than 300 m of transect. At shorter transect lengths a dichotomy in stand values was characteristic; there were numerous zero values as well as high densities resulting from low value denominators (transect length) in the density equation.

Table 24. Number and line density (number/100 m) of middens dug by bears, total evident for all years (TOTAL) and only during the fall of 1985 and spring of 1986 (FALL85-SPR86); also probability of an observed midden having been dug by a bear, for all middens (TOTAL) and only for middens active back to and including fall 1985 (FALL85-SPR86).

Habitat type acronym	DUG MIDDENS Total n	Density	FALL85-SPR86 n	Density	DIG PROBABILITY Total	FALL85-SPR86
Pial	0	0.0	0	0.0	--	--
Abla/Vasc-Pial	42	0.30	23	0.16	79.2	79.2
Wet types	6	0.29	6	0.29	66.7	66.7
Abla/Vasc-Vasc	1	0.05	1	0.05	20.0	25.0
Abla/Libo	2	0.12	2	0.12	50.0	50.0
Abla/Thoc	7	0.25	7	0.25	35.0	36.8
Abla/Vagl-Vasc	6	0.14	3	0.07	54.5	42.8

Table 25. Between-stand coefficient of variation ($S_{\bar{x}}/\bar{X}$) for variable levels; active midden line density (ACTM), inactive midden line density (INACTM), squirrel sightings and vocalizations line density (SQUIR), and inactive middens as a proportion of total middens (FLUX). These estimates were derived from 1986 data for stands containing >300 m of transect.

Habitat type acronym	COEFFICIENT OF VARIATION ACTM	INACTM	SQUIR	FLUX	SAMPLE SIZE (No. stands >300 m transect) ACTM	INACTM	SQUIR	FLUX
Pial	-	1.40	0.28	-	2	2	2	1
Abla/Vasc-Pial	1.77	0.76	1.18	0.46	17	17	17	15
Wet types	1.56	1.18	0.98	1.06	4	4	4	3
Abla/Vasc-Vasc	1.45	-	0.02	-	2	2	2	1
Abla/Libo	0.88	0.84	0.43	-	3	3	3	2
Abla/Thoc	0.67	0.69	0.40	0.60	5	5	5	5
Abla/Vagl-Vasc	2.00	1.78	1.00	1.04	7	7	7	3



KEY:

PIAL - *Pinus albicaulis* series
AVP - Abla/Vasc-Pial phase
WET - wet (Abla/Caca, Abla/Stam) habitat types
AVV - Abla/Vasc-Vasc phase
AL - Abla/Libo habitat type
AT - Abla/Thoc habitat type
AVgV - Abla/Vagl-Vasc phase

Fig. 6. Cumulative line density of active middens and squirrel sightings-vocalizations in habitat types of the Mt. Washburn study unit, for the years 1984, 1985, and 1986.

DISCUSSION

The comparatively high 10-year growth increment of whitebark pine in the Pial series was intriguing; a high increment in the wet types was more understandable. Greater increment of whitebark pine in the harsh Pial series, especially compared to that in the more mesic Abla/Vasc-Pial and Abla/Vagl-Vasc phases, suggests that competition with other arboreal species may have played a significant role in whitebark pine growth. By definition, both the Abla/Vasc-Pial and Abla/Vagl-Vasc phases were dominated by or contained a considerable admixture of conifer species other than whitebark pine. Whitebark pine is generally considered to be a seral shade-intolerant species in all types except the Pial series (Steele et al. 1983). Thus, whitebark pine apparently grows more slowly on mesic sites in the presence of equal-sized arboreal competitors than in purer stands, albeit on more exposed drier sites.

The absence of squirrel middens along transects in the Pial series during 1986 corroborates our assessment of the Pial series as inhospitable to red squirrels (Mattson and Reinhart 1986). Despite availability of an abundance of high energy content cones during the fall of 1985 and spring of 1986, there was apparently no move by squirrels to establish in near pure whitebark pine stands of the Pial series. Thus, whitebark pine cones were not made available to bears during the spring of 1986 by squirrel caching in the Mt. Washburn Pial series. However, we did observe grizzly bear making extensive use of whitebark pine nuts in a pure whitebark pine stand (Pial/Vasc h.t.) during early summer of 1986, in the Absaroka Mountains. Either by natural dehiscence or because of weather (wind, ice, snow abrasion, etc.), numerous cones had fallen to the forest floor. Two or three different bears resided in the immediate area for several weeks consuming nuts of the fallen cones.

The tendency for bears to dig larger middens probably reflects energetic efficiencies as well as probability of encounter. All other things equal, a bear on a random walk through the whitebark pine zone would have been more likely to encounter large rather than small middens. It may also be more efficient for a bear to exploit a larger midden over a smaller one once encountered. Return per-unit effort may be greater in a larger compared to smaller midden, especially for females accompanied by young.

Wet habitat types appear to have been the most heavily used and favored sites by bears within the whitebark pine zone. Line density of middens dug during fall 1985-spring 1986 was highest and probability of midden use second highest among all types in wet sites. Although density of dug middens was moderate in the Abla/Vasc-Pial series, probability of use was highest. This was very likely a consequence of highest proportionate caching of whitebark pine cones in the Abla/Vasc-Pial phase compared to any other type. The Pial series would very likely have been even more favored by this parameter, except that no squirrels lived in the type to cache cones.

Squirrel populations were apparently densest and most stable in the mesic (Abla/Libo, Abla/Thoc, Abla/Vagl-Vasc) habitat types. Moderate population densities and greater flux characterized the Abla/Vasc-Pial, Abla/Vasc-Vasc, and wet types. This greater 1984-86 flux was apparently related to level of bear use; types with greatest flux were also characterized by greatest probability of midden use by bears. Given the very strong relationship between percent change in midden density between 1985 and 1986 and probability of midden bear use, bears are implicated as a factor regulating red squirrel populations in areas with substantial whitebark pine basal area. This may be a result of both direct competition (depriving squirrels of cached food) and predation (squirrel remains occasionally show up in grizzly bear pine nut scats). Certainly, contrary to what has been found in other red squirrel populations (cf. Kemp and Keith 1970, Rusch and Reeder 1978, Hall 1981), the abundant availability of high value food (whitebark pine nuts) in the Mt. Washburn whitebark pine zone did not result in comparable or increased amount of direct squirrel sign or active squirrel middens. This difference between studies is likely attributable to bear foraging activities.

YELLOWSTONE LAKE TRIBUTARY STUDY:

SECOND YEAR PROGRESS REPORT

by

Daniel P. Reinhart
David J. Mattson

INTRODUCTION

Brown bears (Ursus arctos) are known to use spawning salmonids as a food source in several different areas. In coastal systems of Alaska and British Columbia, salmon comprise a major part of seasonal bear diets (Erickson 1965). This is particularly evident at McNeil River Falls on the Alaska Peninsula where 60 to 80 brown bears congregate each summer to fish for migrating chum salmon (Oncorhynchus keta) (Stonorov and Stokes 1972, Luque and Stokes 1976). Bears also fish other streams on the Alaska Peninsula for spawning sockeye or red salmon (O. nerka), silver salmon (O. kisutch), and king salmon (O. tschawytscha) (Luque and Stokes 1976, Glenn and Miller 1980). Kodiak bears (U.a middendorffi) fish for red salmon, chum salmon and pink salmon (O. gorbuscha) in various streams on Kodiak Island, Alaska (Clark 1957, 1959). In British Columbia, bears are known to use salmon in the Kimsquit (Hamilton and Archibald 1985, Banner et al. 1986), Nakina (Mechan 1961), and Atnarko rivers; brown bears also fish for spawning Siberian salmon (O. keta) and Japanese salmon (O. masu) in the Sista and Tatibe Rivers in the southeast Soviet Union (Bromlei 1973). In the northern Rocky Mountains, grizzly bears (U.a. horribilis) are known to fish spawning kokanee salmon (O. nerka) on lower McDonald Creek in Glacier National Park (Kendall, pers. comm., 1986).

In Yellowstone National Park grizzly bears prey on spawning cutthroat trout (Salmo clarkii) in tributary streams of Yellowstone Lake (Hoskins 1975, Mealey 1975, Reinhart and Mattson 1986). The importance of spawning cutthroat trout to Yellowstone bears is not fully understood. A study was initiated in 1985 to investigate grizzly bear use of cutthroat trout in Yellowstone Park. This has been a cooperative study conducted by the Interagency Grizzly Bear Study Team (IGBST) and the U.S. Fish and Wildlife Service (USFWS). Jones et al. (1986) presented methods used and results obtained by the USFWS. IGBST methods and objectives were described in detail by Reinhart and Mattson (1986). A report of the IGBST second-year findings and analysis is presented here.

STUDY AREA

Yellowstone Lake is an oligotrophic, subalpine lake located at a mean elevation of 2358 m in the east-central portion of Yellowstone National Park (Benson 1961). There were 114 found and 124 known tributaries to

Yellowstone Lake in 1985 and 1986 (Table 26). The 1986 study area was in part comprised of streams located on the north shore from Sedge Creek to the Lake development area, and on the west shore south to the Grant Village development area (VIII and VII in Fig. 7). These streams were all characterized as "front country" due to close proximity of primary roads and developments. All front-country streams had substantial human activity along some portion; and in a few front-country streams, trout spawning was impeded by road culverts. The 1985 study area was comprised of backcountry streams along the east shore; the Southeast, South, and Flat Mountain Arms; and from Flat Mountain Arm to Grant Village (Reinhart and Mattson 1986) (I, II, III, IV, V, VI in Fig. 7).

Table 26. Tributary streams - Yellowstone Lake.

Name or Hoskins No.	Old SONYEW number	New SONYEW number	Year surveyed by IGBST
Sedge Cr	0092	1089-	1986
Indian Pond outlet	0089	1087-	1986
10	0088	1086-	1986
Pelican Cr	0070	1005-	Not surveyed
Yellowstone R outlet			Not surveyed
--	0272	1204-	1986
111	0271	1203-	1986
Hotel Cr	0270	1202-	1986
Hatchery Cr	0269	1201-	1986
12	0268	1200-	1986
13	0267	1199-	1986
Wells Cr	0266	1198-	1986
15	0265	119701-	1986
Bridge Cr	0260	1197-	1986
17	0259	1196-	1986
16	0258	1195-	1986
18	0257	1194-	1986
19	0256	1193-	1986
Weasel Cr	0255	1192-	1986
42	0252	1191-	Not found
20	0251	1190-	1986
21	0250	1189-	1986
22	0249	1188-	1986
23	0248	1187-	1986
24	0247	1186-	1986
26	0239	1185-	1986
25	0238	1184-	1986
Arnica Cr	0235	1183-	1986
Little Arnica Cr	0234	1182-	1986
28	0233	1181-	1986
29	0232	1180-	1986
30	0231	1179-	1986
31	0230	1178-	1986
32	0229	1177-	1986
Little Thumb Cr	0228	1176-	1986
--	0227	1175-	Not found
33	0226	1174-	1986
34	0227	1173-	1986
--	0222	1172-	Not found
--	0221	1171-	Not found
35	0220	1170-	Not found
36	0219	1169-	1986
Thumb Cr	0218	1168-	1986
37	0217	1167-	1986

Table 26. Continued.

Name or Hoskins No.	Old SONYEW number	New SONYEW number	Year surveyed by IGBST
Sandy Cr	0216	1166-	1986
39	0215	1165-	1986
Sewer Cr	0214	1164-	1985, 1986
Solution Cr	0212	1163-	1985, 1986
41	0211	1162-	1985
---	0206	1161-	1985
109	0205	1160-	1985
---	0204	1159-	1985
108	0203	1158-	1985
107	0202	1157-	1985
---	0201	1156-	1985
Flat Mountain stream	0200	1155-	1985, 1986
105	0199	1154-	1985
104	0198	1153-	1985
103	0197	1152-	1985
102	0196	1151-	1985
101	0195	1150-	1985, 1986
100	0194	1149-	Not found
99	0193	1148-	1985, 1986
98	0192	1147-	1985, 1986
97	0191	1146-	1985, 1986
96	0190	1145-	1985, 1986
95	0189	1144-	1985, 1986
94	0188	1143-	1985, 1986
93	0187	1142-	1985, 1986
92	0186	1141-	1985
91	0182	1140-	1985
89	0181	1139-	Not found
88	0180	1138-	1985, 1986
87	0179	1137-	1985
86	0178	1136-	1985
85	0177	1135-	1985
84	0176	1134-	1985
83	0173	1133-	Not found
82	0174	1132-	1985
81	0173	1131-	1985
80	0172	1130-	1985
79	0171	1129-	1985
78	0170	1128-	1985
77	0169	1127-	1985
76	0168	1126-	1985
Grouse Cr	0165	1125-	1985
75	0162	1124-	1985
74	0161	1123-	1985
73	0160	1122-	1985

Table 26. Continued.

Name or Hoskins No.	Old SONYEW number	New SONYEW number	Year surveyed by IGBST
Chipmunk Cr	0153	1121-	1985
72	0152	1120-	1985
Alder Lake outlet	0146	1119-	1985
112	0145	1118-	1985
69	0144	1117-	Not found
68	0143	1116-	Not found
67	0142	1115-	1985
66	0141	1114-	1985
65	0138	1113-	1985
70	0137	1112-	Not found
64	0136	1111-	1985
63	0135	1110-	1985
62	0134	1109-	1985
61	0133	110801-	1985
60	0132	110802-	1985
59	0131	110803-	1985
Trail Cr	0129	1108-	1985
Yellowstone R inlet	--	0040-	Not surveyed
Beaverdam Cr	0125	1107-	1985
58	0124	1106-	1985
57	0123	1105-	1985
56	0122	1104-	1985
55	0121	1103-	1985
54	0120	1102-	1985
53	0119	1101-	1985
Alluvium Cr	0118	1100-	1985
Columbine Cr	0115	1099-	1985
8	0114	1098-	1985
Meadow Cr	0113	1097-	1985
9	0112	1096-	1985
Clear Cr	0104	1095-	1985, 1986
6	0103	1094-	1985, 1986
Cub Cr	0100	1093-	1985, 1986
5	0099	1092-	1985
2	0098	1091-	1985, 1986
1	0097	1090-	1986

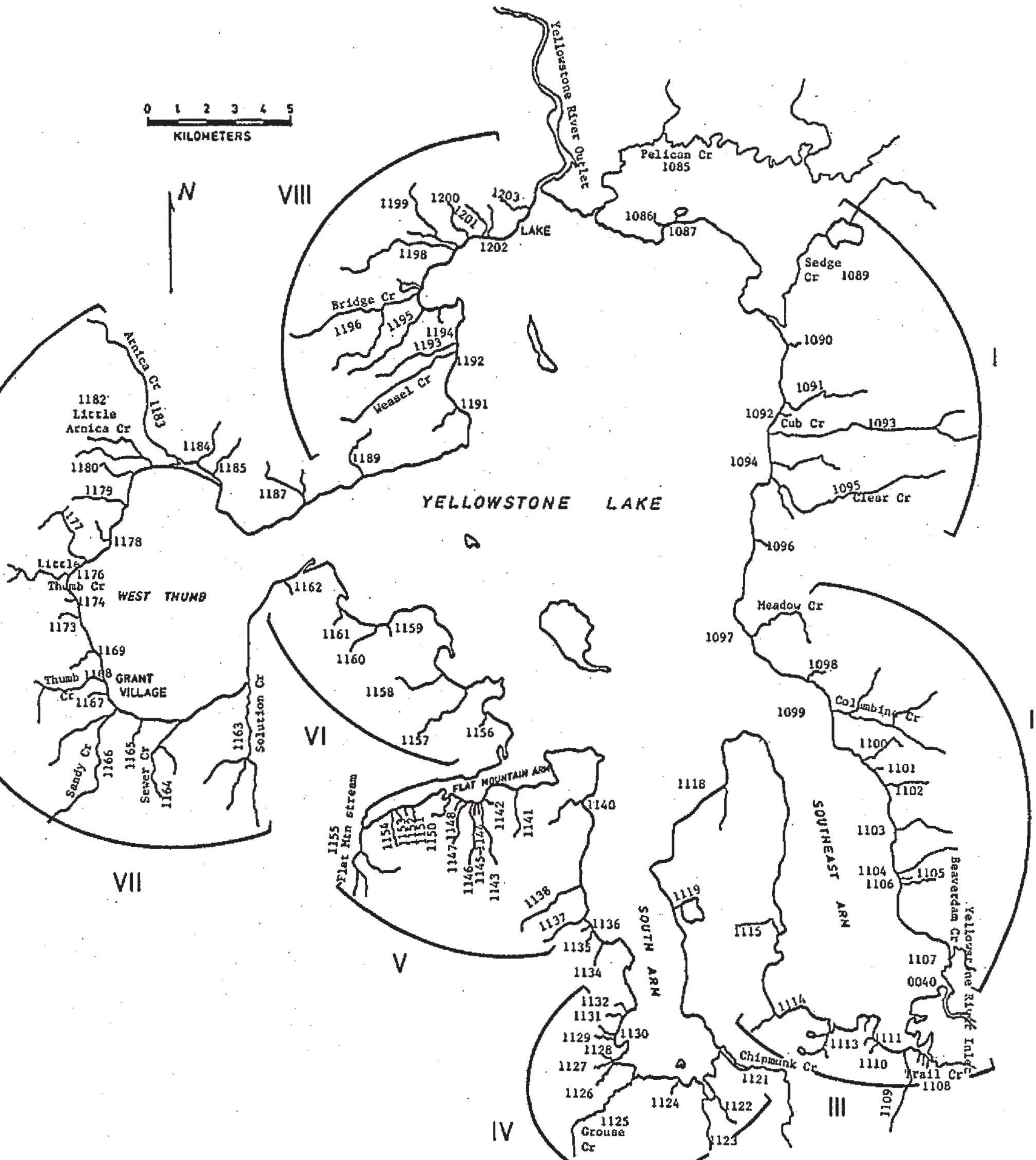


Fig. 7. Map of Yellowstone Lake and tributary streams. Streams are designated by new SONYEW numbers.

FIELD METHODS

Field work was conducted from 8 May to 13 August 1986. Field methods were basically the same in 1986 as in 1985. Briefly, all study area streams were visited to determine if a spawning run was present. Once a run was observed, systematic surveys were performed that enumerated the spawning run length, fish density, stream physical characteristics, vegetation community types, and bear activity level (from scats, fish parts, tracks, and trail use). Bear trail use along the stream was described by a five-part code, as follows:

1. None, where no tracks were found.
2. Light, where few tracks and light trail use were found.
3. Moderate, where an increased number of tracks and discernible matting of vegetation was apparent.
4. Heavy, where tracks were common and vegetation matting was considerable enough to form a distinctive swath.
5. Very heavy, where the swath of vegetation matting was wider and more evident on both sides of the stream; tracks were abundant.

All tracks found along streams were measured across the pad; Klein (1959) has suggested that front pad width is the single-most reliable track measurement. Tracks were also identified as front or rear, and left or right. Bear species was determined from the Palmisciano method (Blanchard 1985).

ANALYSIS

Streams were classified by the following criteria (Reinhart and Mattson 1986):

1. Streams with spawning runs - migrating cutthroat trout or longnose suckers (*Catostoma catostoma*) were observed.
2. Streams with bear activity - either scats, tracks, bear trails, daybeds, bear hair, evidence of grazing, and/or individuals were observed.
3. Streams with conclusive bear fishing - fish parts or scats containing fish parts were found.

Streams were listed by their name or 2-digit Hoskins' number, old SONYEW (a 4-digit number used since 1985 to designate streams), and revised SONYEW number (Jones et al. 1986) (Table 26). New SONYEW numbers were used to reference streams in this report.

Scats were analyzed to determine volumetric representation of major bear foods. Mean percent diet item content was calculated for all scats found along a specific stream for each visit. Scat analysis was further stratified by three major stream groupings consisting of the West Thumb, east shore, and Flat Mountain Arm. For each stream visit, diet content of fish, vegetation and other foods were plotted to show shifts in feeding habits in these strata (see Fig. 11). Finally, relative digestibility of fish and vegetation was considered in comparing intake of these foods by bears.

Graphs were used to display temporal changes in spawning trout density, bear activity, and bear fishing. For each stream sampled, indices of fish density and bear use were calculated. Fish density index (F_i) was calculated by dividing mean number fish per 100 m of stream (F_n) by mean estimated stream volume per 100 m (S_v):

$$F_i = F_n/S_v$$

Stream volume (S_v) was the product of multiplying mean stream width ($\overline{w}$), by mean stream depth ($\overline{d}$), by 100 m:

$$S_v = \overline{w} \times \overline{d} \times 100 \text{ m}$$

Fish density was therefore expressed as the mean number of fish per cubic meter of stream. This value ranged from 0 to 2.5.

Two variables were used to determine level of bear activity (B_i): (1) the number of scats found, and (2) the degree of bear trail use along the stream. Bear scats (B_s) were expressed as the mean number found per 100 m. Trail use (B_t) was expressed as a 5-part code: None = 0, light = 0.5, moderate = 1.0, heavy = 1.5, and very heavy = 2.0. Both of these variables ranged in value from 0 to 2. These variables were first added and then multiplied by 0.25 to yield B_i, with a range of 0 to 1.0:

$$B_i = (B_s + B_t) \times 0.25$$

Bear fishing activity (B_{fi}) was calculated in a similar manner using the two variables: (1) mean percent composition of fish in scats, and (2) mean number of fish parts per 100 m of stream. Percent composition of fish in scats (B_{sf}) was multiplied by 0.02 to give a range of 0 to 2. Mean number of fish parts (B_p) was multiplied by 0.3 to likewise give a range of 0 to 2. The two variables were first added together and then multiplied by 0.25 to yield B_{fi} with a range of 0 to 1.0:

$$B_{fi} = (B_{sf} \times 0.02) + (B_p \times 0.3) \times 0.25$$

The three indexes were plotted on a graph for each stream to display temporal changes in spawner density, bear use, and bear fishing. The number of adult bears estimated to have used the stream at each time period was also plotted (Figs. 8, 9, and 10).

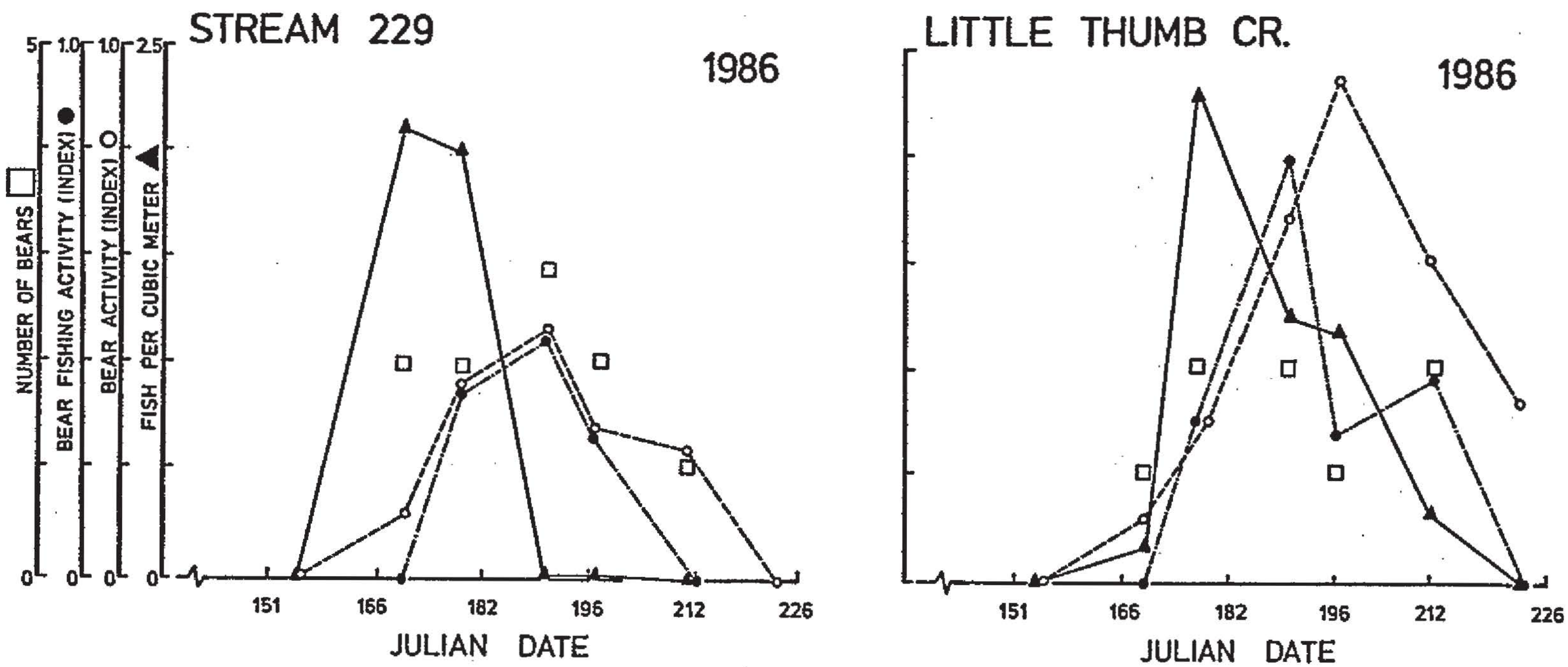


Fig. 8. Indices of bear numbers, bear fishing levels, total bear activity level, and fish density by date for stream 229 (1177) and Little Thumb Creek (1176); 1986.

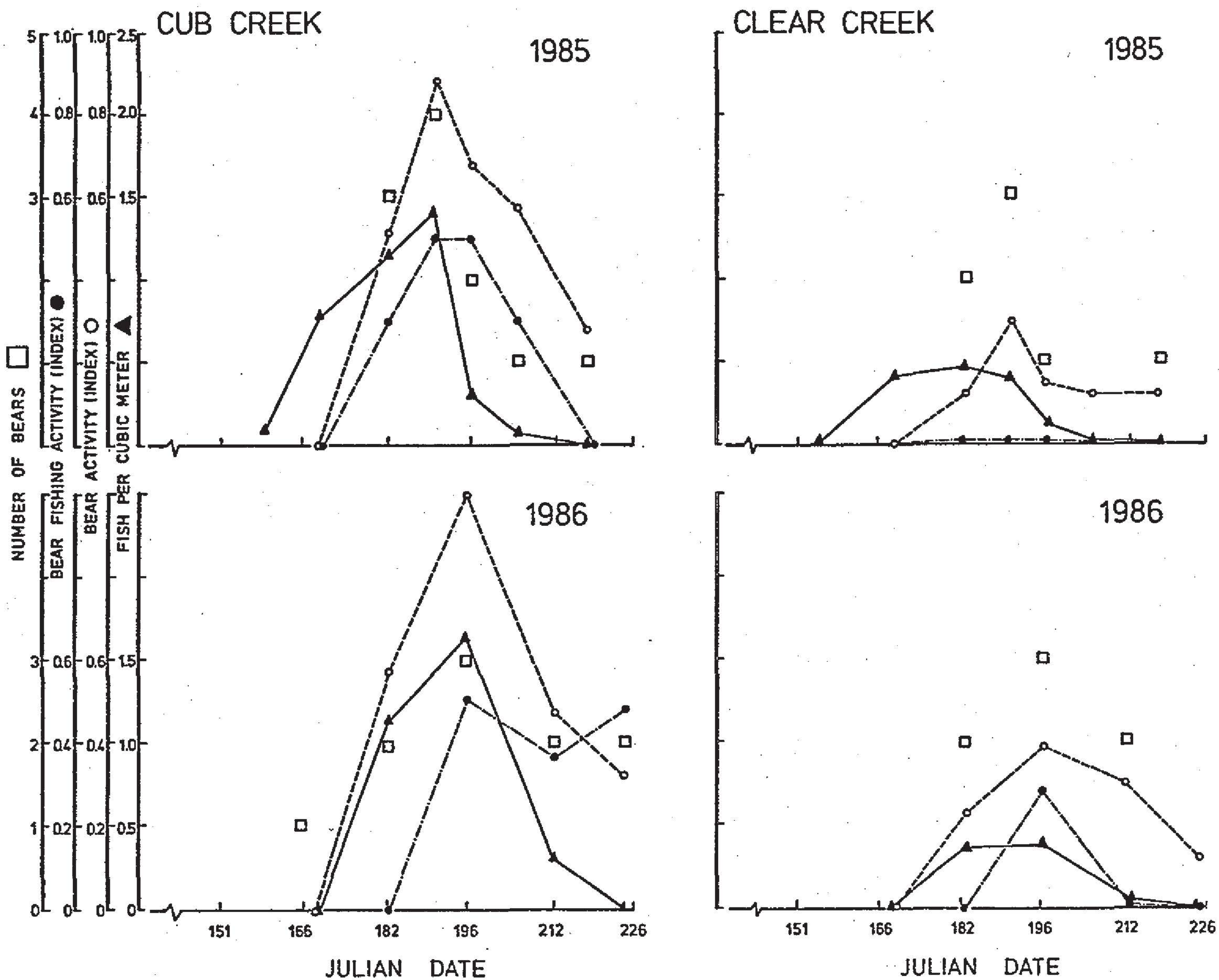


Fig. 9. Indices of bear numbers, bear fishing level, total bear activity level, and fish density by date for Cub Creek (1093) and Clear Creek (1095) in 1985 and 1986.

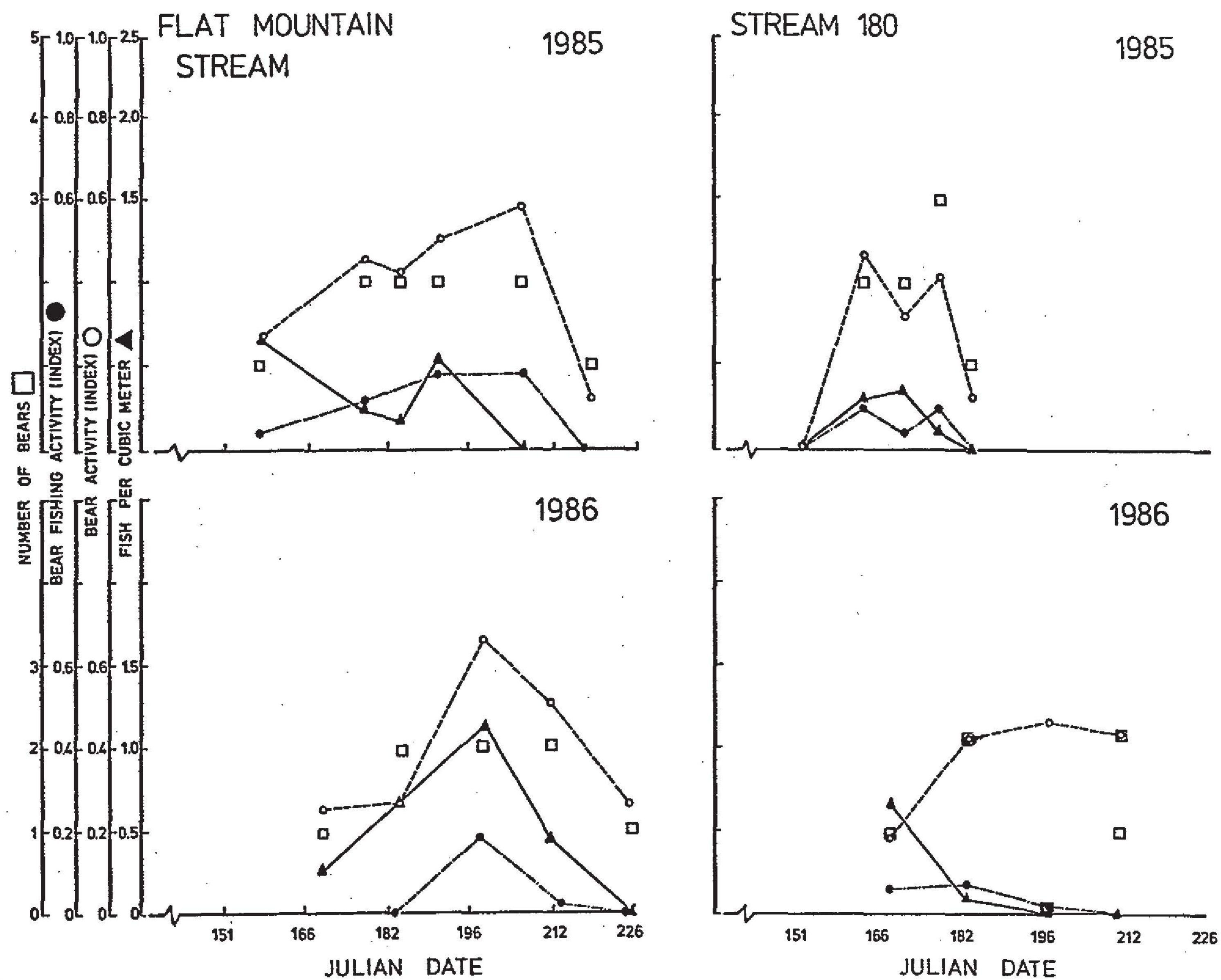


Fig. 10. Indices of bear numbers, bear fishing level, total bear activity level, and fish density by date for Flat Mountain Stream (1155) and Stream 180 (1138) in 1985 and 1986.

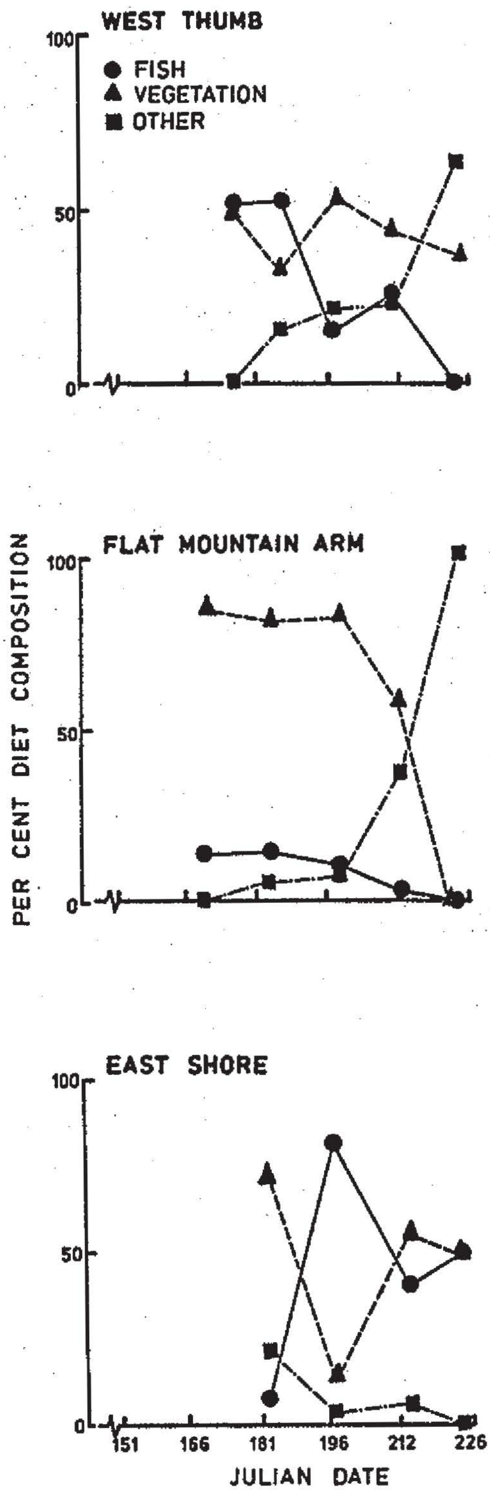


Fig. 11. Percent fish, vegetation and other foods in scats found along streams in the West Thumb, Flat Mountain Arm, and east shore areas in 1986.

Track analysis was used to estimate the number of bears using a spawning stream. Streams were allotted to eight groups around Yellowstone Lake defined by proximity to each other (Fig. 7). Free interchange of bears among streams within each group was assumed.

Track measurements for each group were plotted for each study team visit. A number of individuals was estimated based on track measures and clustering for each stream group and time interval. Concurrence of larger tracks and substantially smaller tracks was the basis for inferring presence of a female with young.

Estimated track sizes for individuals were then compared across time periods within each group. Tracks of nearly equal size estimated for different time periods were considered to be of the same individual. Finally, estimated track sizes for individuals were compared between proximal stream groups. Again, individuals were consolidated on the basis of similar track sizes. When a clear pattern of track size clusters was not distinct within sizable track size groups, a range of bears was given - usually one to two bears. This was especially true with cubs of a female.

Track differentiation for censusing bears has been used in other studies (Klein 1959, Edwards and Green 1959, Camarra 1986). Accurate track measurement appeared to be facilitated by presence of mud banks and sand bars. In these other studies, use of track-count measurements as a population index was of limited value. This was attributed to variation in track sizes due to substrate characteristics, speed of the animal, and age of the track. Difficulties also resulted when numerous tracks were present from individuals of comparable foot size. Environmental conditions such as recent precipitation also complicated collection of track data.

We have concluded that conditions in the Yellowstone study area are more favorable to use of track analysis as a censusing technique. By all indications no more than five bears are estimated to have used a given stream during a given time period; enough tracks are also present to allow differentiation, but not so many as to generate confusion. Edwards and Green (1959) also concluded that track measurement was of value for determining relative or seasonal abundance in small areas such as along salmon streams.

From the methods described, the total number of bears estimated was probably less than the actual number. Thus, the number of bears using spawning streams around Yellowstone Lake suggested in this report should be considered a conservative estimate.

RESULTS AND DISCUSSION

Forty-six front-country streams were visited between 1 and 10 times by the IGBST in the summer of 1986. Of these, 18 streams or 39% were found

to have a spawning run and were surveyed a mean of 6.8 times. Some streams could not support a spawning run because of road culvert drops that made passage by spawning fish impossible. Twelve streams or 26% showed evidence of bear activity and were sampled a mean of 7.2 times. Of these, five streams or 11% of the total had conclusive evidence of bear fishing and were examined a mean of 9.0 times (Fig. 12). It should be noted, however, that only two streams - streams 1176 (Little Thumb Creek) and 1177 - supported substantial bear fishing activity. The other fished streams - 1164 (Sewer Creek), 1167, and 1183 (Arnica Creek) had only incidental evidence of fishing activity.

Of the five front-country streams supporting bear fishing activity in 1986, three were known to be fished by bears in 1974 or 1975 (Hoskins 1975) - streams 1164, 1176, and 1177. The only other front-country stream known to be fished by bears in 1974-75 was Pelican Creek (for longnose suckers) (Hoskins 1975). Pelican Creek was not surveyed by the IGBST in 1986, but incidental and sporadic bear fishing was observed in the upper Pelican drainage in 1986 from Pelican Cone lookout (Gunther 1986).

Of the backcountry streams surveyed in 1986, nine streams contained spawning runs in both 1985 and 1986. Stream 1144 in Flat Mountain Arm did not have a spawning run in 1986 but did in 1985. Streams 1142 and 1147 did not have a spawn in 1985 but did in 1986. All streams that showed bear activity in 1985 also had sign in 1986. In addition, stream 1094 on the east shore and stream 1142 on Flat Mountain Arm showed bear activity in 1986. All of the streams fished by bears in 1985 were also fished in 1986.

A total of 125 scats were collected from 18 June to 13 August 1986 on 14 different streams. Cutthroat trout remains were present in 46 or 37% of all scats and comprised 25% of the total scat volume. Foliferous vegetation was found in 69 or 55% of all scats and comprised 54% of scat volume. Of the vegetation, grass-sedge (*Calamagrostis*, *Poa*, *Bromus*, *Carex*) was most abundant (31% of content), followed by *Taraxacum* (8%), *Equisetum* (7%), *Cirsium* (4%), *Trifolium*, *Angelica*, *Ranunculus*, and *Heracleum* (the last four all with 1% or less). Ants (Formicidae) were found in 24 or 19% of all scats and comprised 4% of scat volume. Large mammals in the form of elk, bison, deer, and moose (Cervidae-Bovidae) were in 14 or 11% of all scats (2.5% scat volume). Whitebark pine nuts (*Pinus albicaulis*) were found in only 2 scats (1.6%; 0.4% total scat volume).

Scat analysis does not present an adequate summary of food intake by bears. Items high in protein content such as animal matter are underrepresented in scats due to their high digestibility compared to vegetation (Bunnell and Hamilton 1983). Mealey (1975) estimated that cutthroat trout were 74% digested and vegetation 13% to 16% digested by Yellowstone grizzlies. After adjusting for digestibilities, intake of cutthroat trout was considered to be approximately 2.4 times greater than ingestion of vegetation, even though trout comprised less than half (46%) of the volumetric scat content.

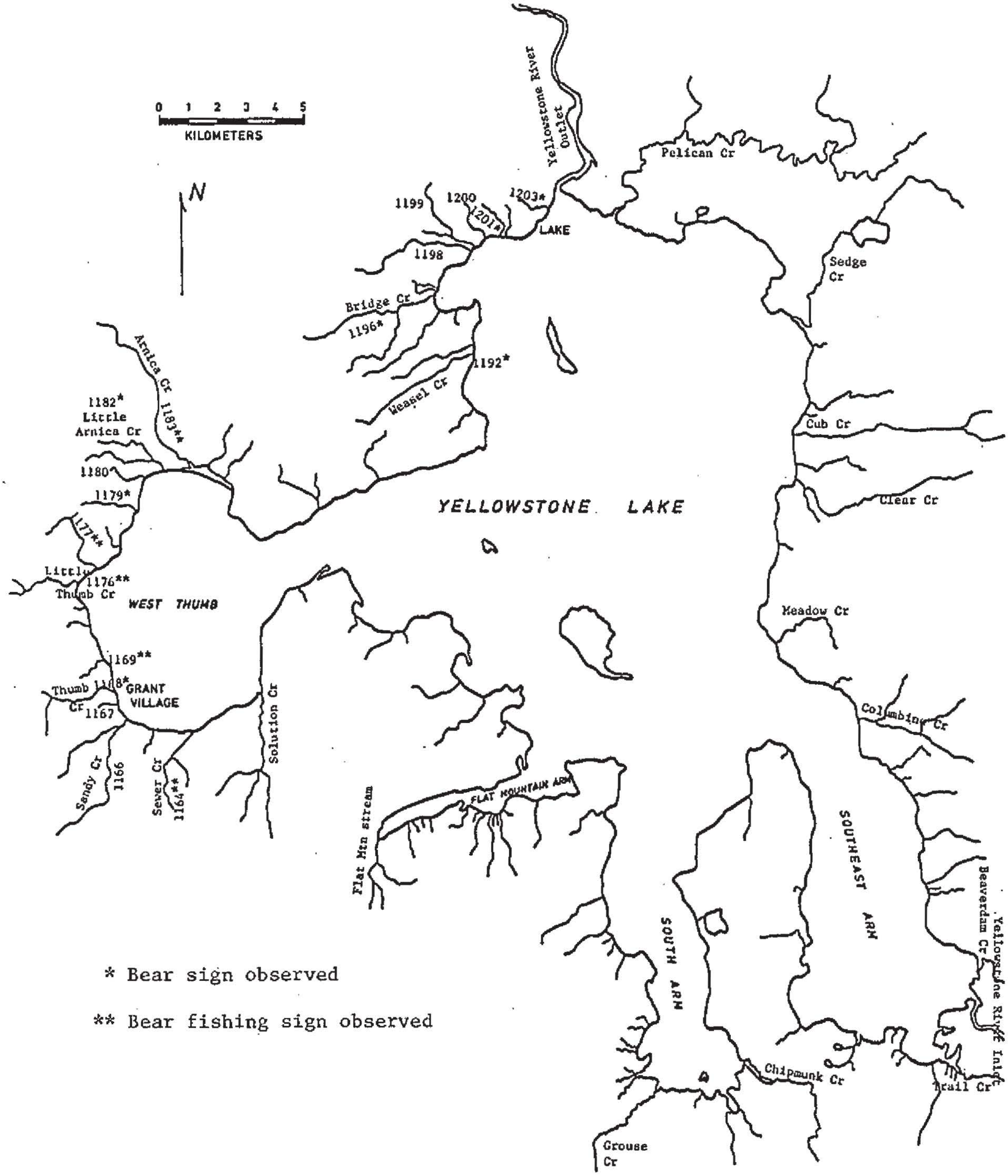


Fig. 12. Front-country streams with spawning runs in 1986.

Cutthroat trout use peaked in late June-early July on the West Thumb and Flat Mountain Arm, and in mid- to late July on the east shore. Vegetation use was usually greatest before peak trout use. Other diet items such as ants and animals were most abundant in scats after peak trout use (Fig. 11). First trout use by bears was concurrent with first observation of scats along streams surveyed in 1986. This suggests that availability of fish attracted bears to the vicinity of streams. Bear use of habitat along streams continued, however, after the peak spawn. This phenomenon is apparent in the graph analyses of trout spawn, bear use, and bear fishing. Bear use began with the onset of the spawn, was highest with the peak spawn or immediately after, and continued after spawning activity was diminished or ceased. Bear fishing was shown to begin at the peak of the spawn, was highest after the peak spawn, and thereafter declined (Figs. 8, 9, and 10).

Two explanations for this pattern in bear fishing activity are possible:

(1) Fish in their post-spawn state were fatigued from spawning activity (digging redds), swam slower, and were thus more vulnerable to predators. (Ball and Cope (1961) determined the average mortality of spawners in five streams of Yellowstone Lake was 48.1%.)

(2) Because stream depths decreased significantly in the summer months, trout density and stream fishability effectively increased.

A comparison of variable levels for key streams between 1986 and 1985 showed that the beginning, peak and end of spawning activity and subsequent bear use was approximately 1-2 weeks later in 1986 than in 1985 (Figs. 9 and 10). This was due, in large part, to differences in timing of melt-off between the 2 years. Melt-off in 1986 started late and occurred fast. In 1985 melt-off began and ended very early.

A total of 10 to 17 bears were estimated to have used front-country streams in 1986. These animals consisted of 4 to 5 lone grizzlies, 1 to 2 female grizzlies with 1 to 2 cubs each, and 3 to 5 individual black bears.

A total of 14 to 19 bears were estimated to have used east shore streams in 1986: 10 to 14 lone grizzlies, 2 female grizzlies with 1 to 3 cubs each, 2 to 3 lone black bears, and 1 female black bear with 1 to 2 cubs. In 1985, 17 to 21 grizzly bears were estimated to have used these same streams. These animals consisted of 7 to 9 lone animals, and 3 to 4 females with 1 to 2 cubs each. There were no black bear tracks found in 1985.

On Flat Mountain Arm in 1986, a total of 13 to 19 bears were estimated to be present: 2 to 4 lone grizzlies, 3 female grizzlies with 1 to 2 cubs each, 1 to 2 lone black bears, and 2 female black bears with 1 to 2 cubs, and 1 cub. In 1985 there were 12 to 20 bears estimated to be present: 6 to 8 lone grizzlies, 2 to 3 female grizzlies with 1 to 2

cubs each, and 2 to 3 lone black bears. In the entire backcountry stream system during 1985 there were 50 to 71 bears estimated to be present. This consisted of 29 to 43 lone grizzlies, 8 to 10 grizzly family groups, and 5 to 8 black bears.

During both years, tracks of females with young were observed predominantly in the first 2 to 3 weeks of a spawning run and usually before the peak spawn. At the peak of bear fishing, there were fewer females with young and more lone adults present. This suggests that during the optimal fishing time periods, females with young may have been displaced by lone adults.

CONCLUSION

Our 1985 and 1986 track analyses indicate that a substantial number of Yellowstone's grizzly bears use spawning streams of Yellowstone Lake. Since the dump closures in Yellowstone Park in 1970 and 1971, the importance of high quality natural food sources to Yellowstone grizzlies has been increasingly recognized by managers. Implementation of angler restrictions for Yellowstone Lake's cutthroat fishery has resulted in not only an increased cutthroat population but also a proportionate increase in numbers of larger fish (Varley 1983, Jones et al. 1986). Yellowstone's bears have very likely benefited by these measures.

The IGBST Lake Tributary Study has also provided a means of censusing bears by track analysis. If continued in a systematic manner, track analysis could be used to monitor trends in bear numbers around Yellowstone Lake.

We estimated that approximately 6 to 8 female grizzlies with young during 1986, and 8 to 10 females with young during 1985 used surveyed streams. This suggests that spawning streams may play an important role in the dynamics of the Yellowstone grizzly population; displacement of females with young during times of optimal fishing warrants further study.

Another year of study during which all spawning streams of Yellowstone Lake would be surveyed is highly recommended. A survey of upper reaches of larger streams around Yellowstone Lake would also be valuable, to determine levels of bear use in these more remote areas. Year-to-year variation in spawning runs and characteristics of their use by bears would be further estimated, as well as the importance of fish to the entire grizzly population or to specific population segments.

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

SECOND YEAR PROGRESS REPORT

by

David J. Mattson
Jeff Henry

INTRODUCTION

Brown bear (*Ursus arctos*) are known to use winter-killed and weakened ungulates in many areas (c.f. Bromlei 1965, Reynolds 1980, Pearson 1975, Kaal 1976, Slobodyan 1976, Chatelain 1950). This has been documented in the northern Rocky Mountains for grizzly bear (U.a. *horribilis*) by Russell et al. (1979), Aune (1983), Servheen (1983), Hamer and Herrero (1983), and Kendall (1986). Nowhere, however, do ungulates dominate the spring diet as in the Yellowstone area. After accounting for different digestibilities of animal and vegetal matter, ungulates comprised 40% to 60% of the April-May diet (Knight et al. 1984). This relative abundance of ungulate in the grizzly bear diet resulted from large populations and high densities of principally bison (*Bison bison*) and elk (*Cervus elaphus nelsoni*) in the Yellowstone area.

Spring grizzly bear habitat productivity in Yellowstone is a function primarily of ungulate availability (Knight et al. 1984). Spring productivity in turn apparently plays a major role in determining productivity, condition, and ultimately survivorship of adult female grizzlies in the Yellowstone area (Mattson 1986). Knight and Eberhardt (1984, 1985) have identified female survivorship as key to the future viability of the Yellowstone grizzly bear population. Thus, over-winter ungulate mortality and condition are identified as an important regulatory factor, and an area where management might potentially benefit the Yellowstone grizzly bear population.

For this reason a study was initiated by the Interagency Grizzly Bear Study Team (IGBST) in 1985 to investigate relationships among carcass characteristics and availability, human (*Homo sapien*) and scavenger activities, and bear use. The study continued through the winter of 1985-86. Preliminary analysis results of 1985 data are presented in this progress report. Interpretation of these results is also presented, primarily to facilitate timely management.

STUDY AREA AND FIELD METHODS

The study area consisted of habitat occupied by over-wintering elk and bison between and including Lone Star geyser basin to the south and Fountain Flats-Fairy Meadows in the north (Fig. 13). These areas

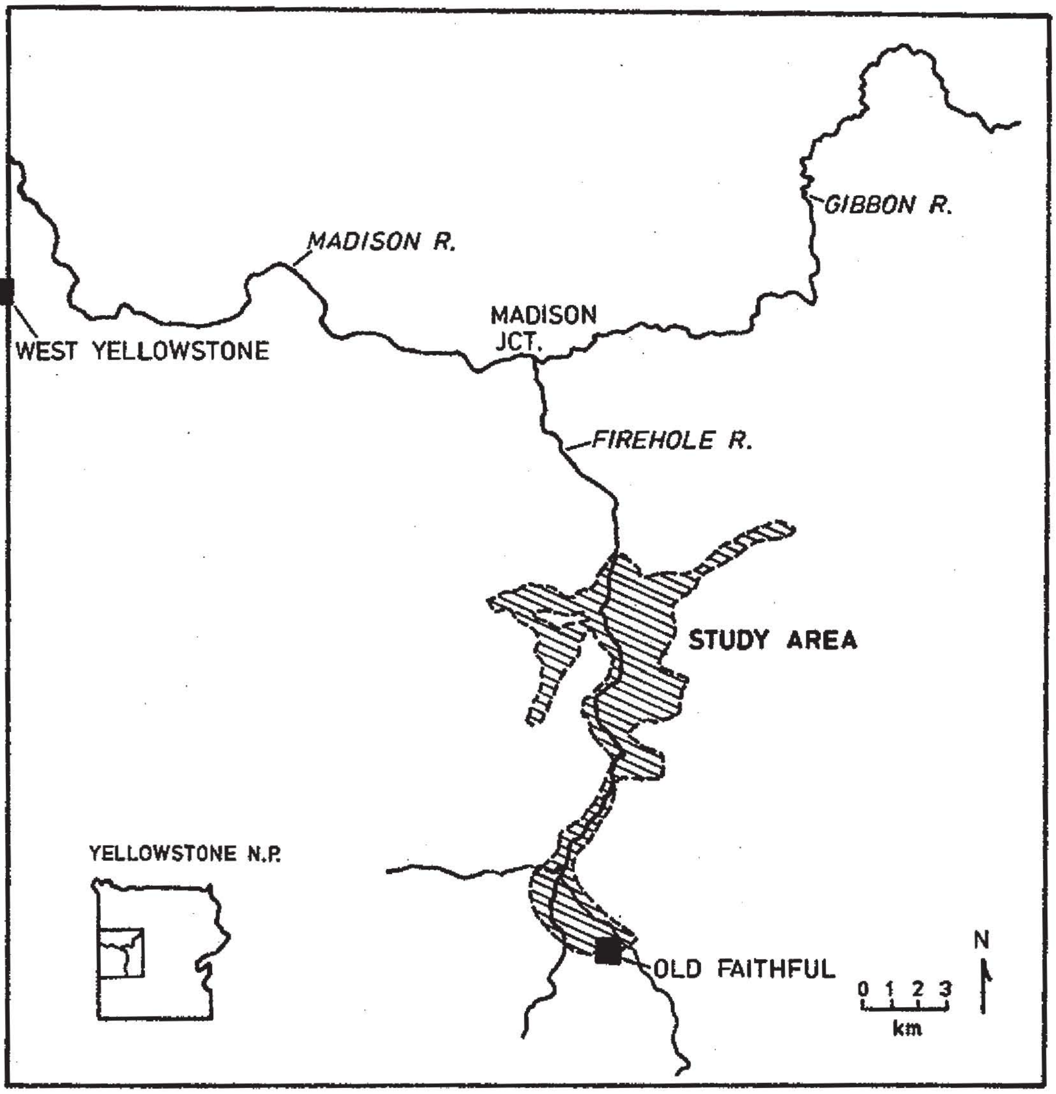


Fig. 13. Firehole drainage study area in Yellowstone National Park.

coincided with geothermal influence and shallower, shorter duration snow cover. Geothermal soil warming allowed elk and bison to winter in the otherwise inhospitable area (Craighead et al. 1973).

During the winter of 1984-85 carcass species, sex, age class, use, distribution, and time of death were noted coincident to intensive surveys of thermal basins in the Firehole drainage. More exact estimates of location, site characteristics, and biomass depletion were made for carcasses during a 23-24 April survey.

More rigorous methods were employed during the winter of 1985-86. The study area was subdivided into units that were intensively surveyed on an approximate 1-month cycle. Site characterization and chronology of individual carcass use were more detailed. Bear sign was more closely and systematically monitored. Scats were collected, tracks measured, and feeding activity other than on carcasses described.
Distribution of live ungulates was also noted. Methods used during the winter of 1985-86 will in most respects be duplicated for the winter of 1986-87.

RESULTS

Fifty-two ungulate carcasses were examined 1 January through 24 April 1985, and 89 carcasses 15 January through 30 May 1986. Detailed analysis of the 1985 carcass data is presented here.

Of the carcasses examined in 1985, 25 were bison and 27 were elk; no mule deer carcasses were observed (Table 27). Of the elk, 12 were adult and 8 were yearling females, and 2 were adult and 1 yearling males. One adult and 3 yearlings were not able to be sexed. (Yearling is used here to designate animals born the previous spring of 1984). Of the bison, 7 were adult and 3 yearling females, and 5 were adult and 2 yearling males. Eight yearling bison were not able to be sexed.

Carcasses were not sexed as a direct consequence of carcass condition (Table 27). Unsexed carcasses were almost totally consumed and disarticulated; constituent parts were also typically scattered.

Adult females comprised a surprisingly large percentage (44%) of observed elk carcasses. During the winter of 1978-79 only 24% of 31 elk carcasses were classified as adult females during a study of wildlife response to winter recreationists (Aune 1981). This disparity may reflect sampling bias, population status, or idiosyncracies of environmental conditions and their effects on specific elk sex and age classes.

Another marked difference exists between our results and those of Aune (1981). During the winters of 1978-79 and 1979-80, Aune observed a total of 6 bison carcasses. This contrasts with 25 bison carcasses observed during the winter of 1984-85 alone; elk mortality was comparable between 1984-85 and 1978-79. This difference in bison

Table 27. Number, percent consumed, and level of bear use for carcasses stratified by species, sex, and age class (1985 data); baseline date of 23-24 April.

		ELK						BISON				
		Adult			Yearling			Adult		Yearling		
		Female	Male	Unknown	Fem.	Male	Unk.	Fem.	Male	Fem.	Male	Unk.
	n:	12	2	1	8	1	3	7	5	3	2	8
% consumed}	$\bar{x}$:	74	90	100	87	85	92	72	54	28	35	84
	S_x:	31	7	-	6	-	10	44	51	49	50	31
Bear use}	$\bar{x}$:	0.7	0.5	1.0	1.1	0.0	1.0	1.2	1.3	0.8	0.0	0.9
	S_x:	1.0	0.7	-	1.1	-	1.7	1.5	1.4	1.4	0.0	1.1

mortality is probably attributable to an increasing and subsequently stabilized bison population between 1978 and 1984 (Aune 1981; M. Meagher, pers. comm.).

Ungulate deaths on the Firehole winter range were not evenly timed (Fig. 14). A distinct peak in deaths occurred during the last half of March and the first half of April. Aune (1981) also observed this timing of mortality in the Firehole area. Very little mortality occurred prior to 1 March or after 15 April. Deaths of adult bison had a more even time distribution than other ungulate classes. Subadults evidenced the sharpest time-specific mortality peak, during the first half of April.

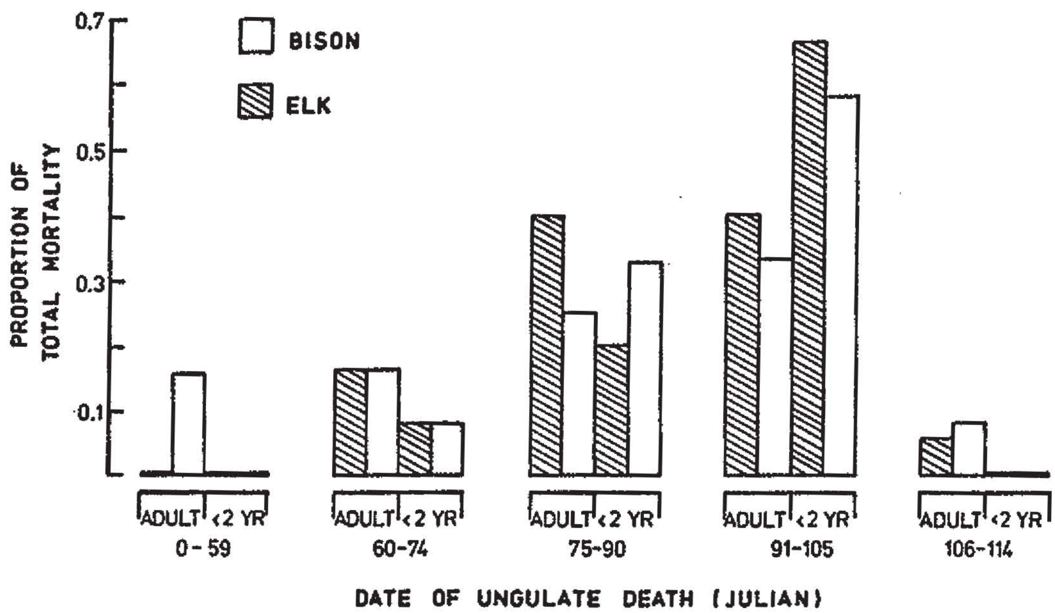


Fig. 14 Ungulate mortality distribution by time period, species, and age class (1985 data).

Very little black bear (Ursus americanus) sign was observed during either study winter. Virtually all sign and sightings were of grizzly bears. Our observations suggest that black bears, when present, were more likely to forage closer to Old Faithful.

Bear use of carcasses was in other respects dramatically affected by proximity to the Old Faithful development (Fig. 15). Within 5 km of Old Faithful, bears used only 6% and 7% of available carcasses, for the springs of 1985 and 1986, respectively. Beyond 5 km, bears used between 50%-100% of available carcasses. The three peaks in carcass availability evident in Fig. 14 corresponded to the Upper and Midway geyser basins and, farthest out, the Fountain Flats-Nez Perce Creek vicinity.

Bear use of carcasses was also affected by carcass age (Fig. 16); this was a twofold phenomenon reflecting absolute date of ungulate death as well as time elapsed since death. Very little bear use of ungulates dead before 1 March was evident. Prior to this date most bears had not left their dens. In the interim, the few available carcasses were probably completely consumed by a substantial population of other vertebrate and invertebrate scavengers.

An approximate 32-day lag was evident in March and April between an ungulate's death and maximum probability of encounter by bears (Fig. 16). Any lag between death and visitation by a bear would very likely have had serious consequences for the bears, given competition from other scavengers.

Consumption of carcass biomass progressed very quickly in March and April (Fig. 17). Consumption initiated sooner and progressed rapidly beyond 5 km of Old Faithful; this further suggests that winter-time human visitors and residents at Old Faithful complicated scavenger exploitation of carcasses. A few 3-week-old carcasses were observed in the near vicinity of Old Faithful that had been virtually untouched by large vertebrate scavengers, primarily bears (Ursus spp.) and coyotes (Canis latrans). This is remarkable given that 50% of carcass biomass was expected to be consumed, on the average, by 6 days beyond 5 km and by 18 days within 5 km of Old Faithful (Fig. 17).

The increasingly large standard deviation of mean carcass depletion with progressively less time since death reflected the nature of carcass use by larger scavengers. Once encountered, coyotes and bears apparently ate at a carcass until it was nearly all consumed. Thus a dichotomy in carcass condition was evident within a short time after death; a carcass would be either essentially intact or nearly totally consumed. This dichotomy gradually disappeared among carcass "cohorts" with passage of time and was reflected in a diminishing coefficient of variation; given sufficient time all carcasses were near 100% consumed.

Rapid consumption of carcasses in the area beyond 5 km of Old Faithful very likely reflected a relatively large scavenger fauna. Given that

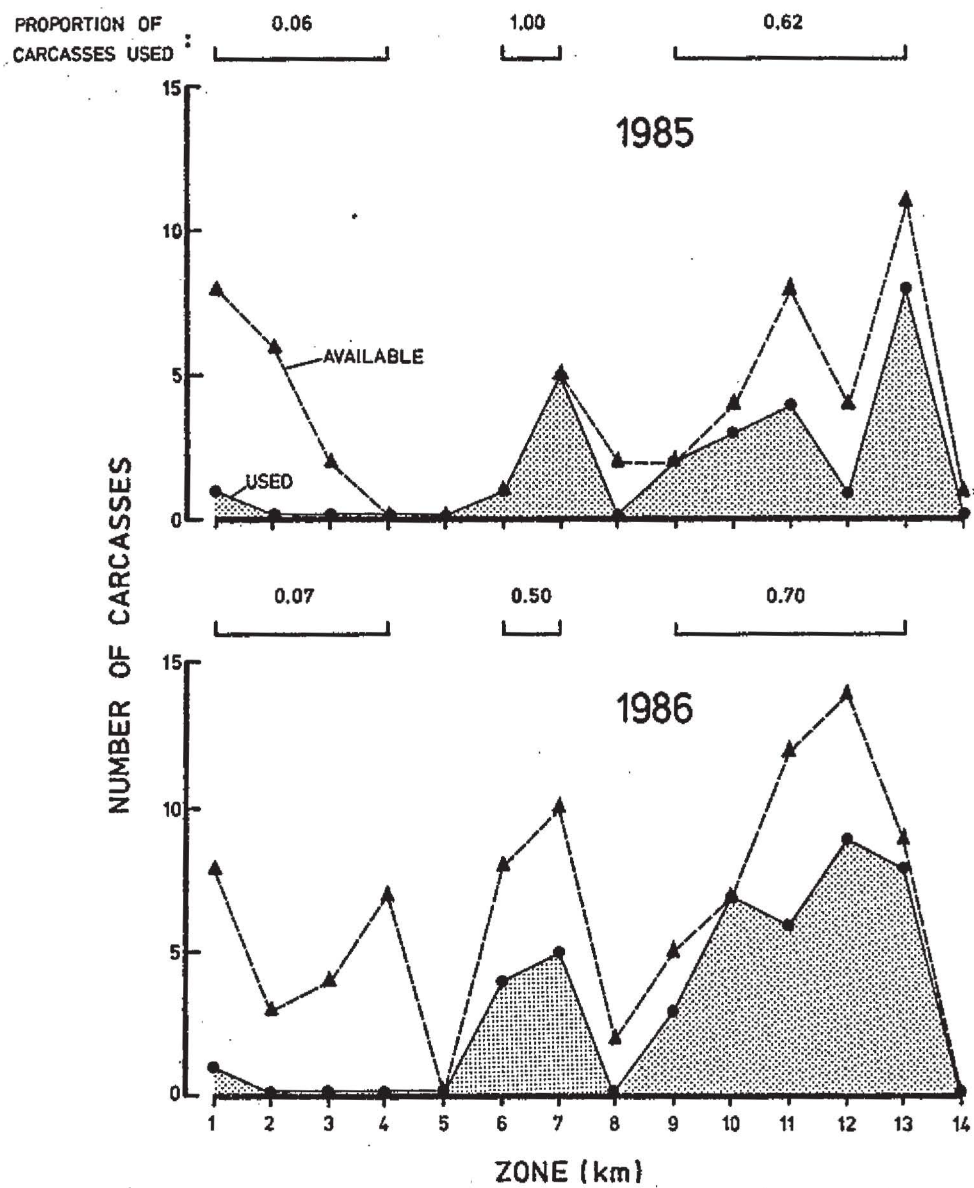


Fig. 15. Ungulate availability and use (n and proportion) with respect to kilometer-wide zones concentric to and progressively farther from the Old Faithful development (1985 and 1986 data).

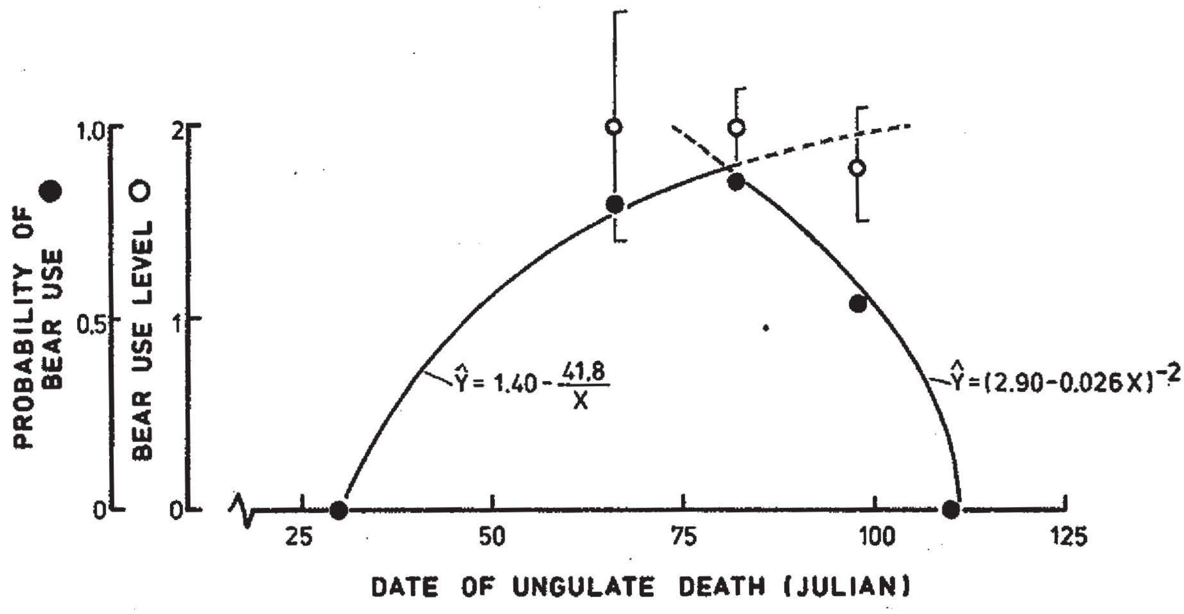


Fig. 16. Probability and level of ungulate carcass use by bears as a function of carcass age (1985 data); for carcasses farther than 5 km from the Old Faithful development.

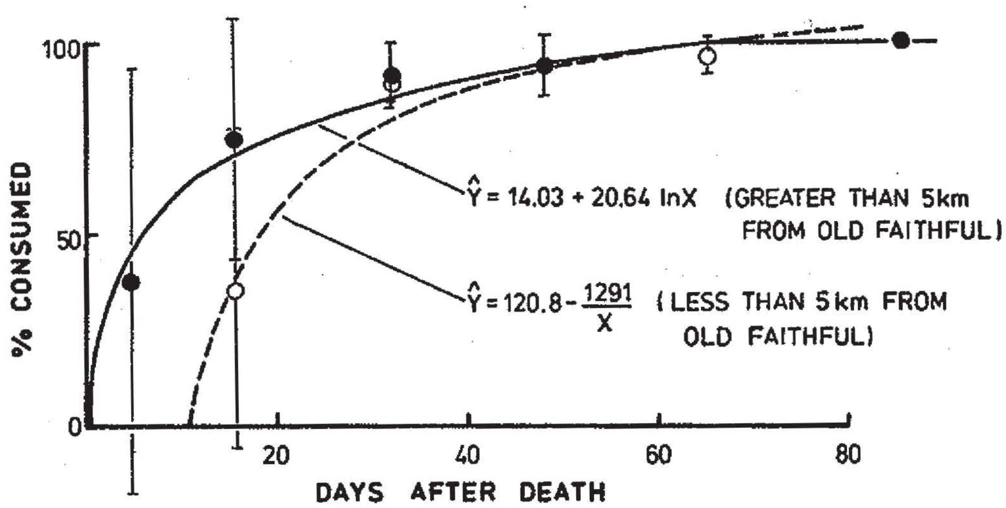


Fig. 17. Mean level and standard deviation of ungulate carcass depletion as a function of time and distance from the Old Faithful development.

maximum probability of encounter with and use of carcasses by bears did not occur until a carcass had been available around 32 days, other scavengers had ample time to consume a large portion of carcass biomass. We cannot quantify the degree of competition between bears and other scavengers, but our data strongly suggest that competition was substantial.

After accounting for influences of proximity to Old Faithful and carcass age, our data showed that bears used bison much more heavily than elk carcasses (Fig. 18). Adult bison carcasses were used approximately 3 times as intensively by bears as were adult elk carcasses. This difference probably reflected influences of competition with other scavengers as well as energetics. Adult bison are, on the average, substantially larger than adult elk (average food yield: Bison - 425 kg, elk - 185 kg; from McCabe 1982). Our field observations also suggested that scavengers other than bears had difficulty accessing bison carcasses, apparently due to the large mass and tough hide of bison. Bears probably more often encountered bison compared to elk carcasses with a substantial amount of utilizable biomass.

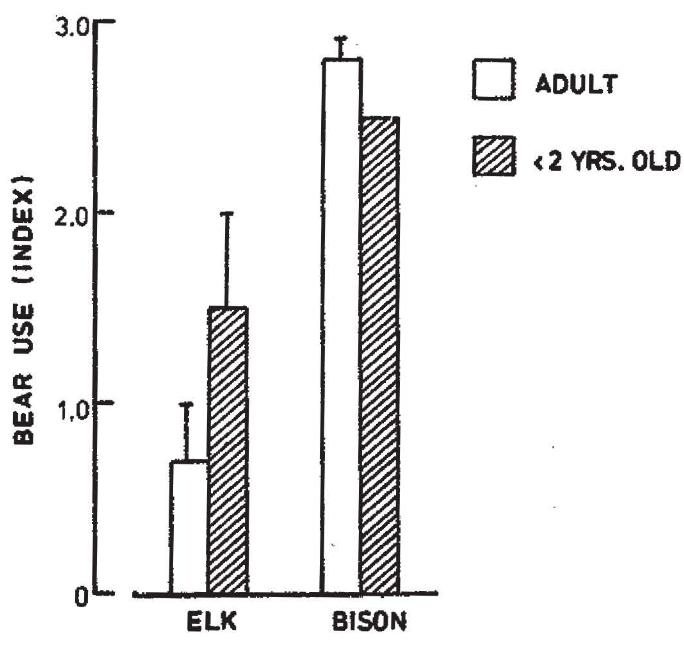


Fig. 18 Level of bear use of elk and bison carcasses, stratified by age class (1985 data); for March dead ungulates farther than 5 km from the Old Faithful development.

SUMMARY AND CONCLUSIONS

This study will be continued for several more years, primarily to document year-to-year variation in carcass availability and use by bears. Our results presented here should be considered tentative; however, our primary conclusions are well supported by data collected to date.

People in residence at or visiting the Old Faithful development had an impact on bear use of ungulate carcasses during springs of 1985 and 1986. Virtually no bear use of carcasses occurred within 5 km of the development. This lack of use is even more remarkable given the disproportionately large representation of bison carcasses (62% of the total) in the near vicinity of Old Faithful.

Bears more intensively used bison compared to elk carcasses, probably as a consequence of different carcass sizes and competition with other scavengers. Increased numbers of over-wintering bison in the Firehole drainage, albeit at a probable cost in elk numbers, have very likely increased productivity of this area for bears.

Competition particularly between coyotes and bears was apparently substantial, and reflected in rapid carcass utilization. Bears, in aggregate, were probably at a relative disadvantage due to the extended lag time between ungulate death and maximum probability of encounter and carcass use by a bear. High consumption rates and this comparatively low time-specific probability of bear-carcass encounter suggest a high coyote relative to bear density during spring.

APPENDIX

Annual flight summaries during March through November, 1973-86.

	Total radio flights	Total radio flight hrs.	Total observation flights	Total obs. flight hrs	Unmarked grizzlies per hour		Total radio locations
					Radio flts.	Obs. flts.	
MAR							
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	-	-	-	43
APR							
1974	-	-	3	9.4	-	-	-
1975	-	-	4	9.3	-	0.32	-
1976	7	11.6	-	-	0.35	-	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
1982	3	9.0	-	-	0.44	-	25

Annual flight summaries during March through November, 1973-86 (continued).

	Total radio flights	Total radio flight hrs.	Total observation flights	Total obs. flight hrs	Unmarked grizzlies per hour: Radio flts.	Unmarked grizzlies per hour: Obs. flts.	Total radio locations
APR (cont.)							
1983	7	16.4	-	-	0.12	-	41
1984	5	10.8	-	-	0.65	-	23
1985	5	9.3	-	-	-	-	29
1986	1	1.8	-	-	-	-	4
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	-	-	0.36	-	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
JUN							
1973	-	-	5	19.3	-	0.52	-
1974	-	-	12	38.9	-	0.57	-
1975	1	2.7	2	1.4	1.48	-	1

Annual flight summaries during March through November, 1973-86 (continued).

	Total radio flights	Total radio flight hrs.	Total observation flights	Total obs. flight hrs	Unmarked grizzlies per hour: Radio flts.	Unmarked grizzlies per hour: Obs. flts.	Total radio locations
JUN (cont.)							
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
JUL							
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
1981	8	28.4	4	19.0	0.25	0.68	68
1982	7	33.4	4	16.3	0.21	1.17	69
1983	7	30.9	7	21.1	0.16	0.33	45
1984	13	42.6	8	22.2	0.45	1.22	97

Annual flight summaries during March through November, 1973-86 (continued).

	Total radio flights	Total radio flight hrs.	Total observation flights	Total obs. flight hrs	Unmarked grizzlies per hour: Radio flts.	Unmarked grizzlies per hour: Obs. flts.	Total radio locations
JUL (cont.)							
1985	7	23.1	7	16.8	0.26	0.66	45
1986	8	12.1	10	22.8	1.98	0.66	22
AUG							
1973	-	-	3	9.5	-	-	-
1974	-	-	7	19.9	-	1.86	-
1975	13	36.7	-	-	0.08	-	31
1976	13	43.4	-	-	0.46	-	73
1977	8	35.7	-	-	0.03	-	80
1978	12	59.3	-	-	0.03	-	109
1979	14	75.4	1	3.5	0.15	1.71	131
1980	9	29.7	-	-	0.24	-	72
1981	17	52.5	-	-	0.50	-	142
1982	17	49.1	2	8.8	0.08	0.46	115
1983	12	34.1	6	24.1	0.18	0.25	68
1984	16	42.5	3	6.8	-	-	95
1985	6	17.9	6	11.0	-	0.91	31
1986	12	34.1	4	9.4	0.44	0.43	76
SEP							
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

Annual flight summaries during March through November, 1973-86 (continued).

	Total radio flights	Total radio flight hrs.	Total observation flights	Total obs. flight hrs	Unmarked grizzlies per hour: Radio flts.	Unmarked grizzlies per hour: Obs. flts.	Total radio locations
SEP (cont.)							
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
OCT							
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
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

Annual flight summaries during March through November, 1973-86 (continued).

	Total radio flights	Total radio flight hrs.	Total observation flights	Total obs. flight hrs	Unmarked grizzlies per hour: Radio flts.	Unmarked grizzlies per hour: Obs. flts.	Total radio locations
OCT (cont.)							
1985	7	18.1	-	-	0.11	-	43
1986	8	28.8	-	-	0.04	0	55
NOV							
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

REFERENCES CITED

Aune, K. E. 1981. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. M. S. Thesis, Montana State Univ., Bozeman. 110pp.

_____, and T. Stivers. 1983. Rocky Mountain Front grizzly bear monitoring and investigation. Montana Dep. Fish, Wildl. and Parks, Helena. 180pp.

Ball, O. P., and O. B. Cope. 1961. Mortality studies on cutthroat trout in Yellowstone Lake. U.S. Fish & Wildl. Serv. Res. Rep. 55:1-62.

Banner, A., J. Pojar, R. Trowbridge, and A. Hamilton. 1986. Grizzly bear habitat in the Kimsquit River valley, coastal British Columbia: classification, description, and mapping. Pages 36-49 in Proc. Grizzly Bear Habitat Symposium. U.S. Dep. Agric. Gen. Tech. Rep. INT-207, Intermt. Res. Stn., Ogden, UT.

Benson, N. G. 1961. Limnology of Yellowstone Lake in relation to the cutthroat trout. U.S. Fish & Wildl. Serv. Res. Rep. 56:1-38.

Blanchard, B. 1985. Field techniques used in the study of grizzly bears. USDI, Nat. Park Serv., Interagency Grizzly Bear Study Team Report. 24pp.

_____. In press. Size and growth patterns of the Yellowstone grizzly. Int. Conf. Bear Res. and Manage. 7.

Bromlei. F. G. 1965. Bears of the south far-eastern USSR. Trans. from Russian. Publ. by Indian Natl. Sci. Documentation Centre, New Delhi, and U.S. Dep. Commerce, 1973. 138pp.

Bunnell, F. L., and T. Hamilton. 1983. Forage digestibility and fitness in grizzly bears. Int. Conf. Bear Res. and Manage. 5:179-185.

Camarra, J. J. In press. Measuring the footprints as a tool for censusing the brown bear in the Western Pyrenees. Abstract from presentation at the Int. Conf. Bear Res. and Manage. 7, Williamsburg, VA., 19-26 Feb 1986.

Chatelain, E. F. 1950. Bear-moose relationships on the Kenai peninsula. Trans. of the North Am. Wildl. Conf. 15:224-234

Clark, W. K. 1957. Seasonal food habits of the Kodiak bear. Trans. of the North Am. Wildl. Conf. 22:145-151.

_____. 1959. Kodiak bear-red salmon relationships at the Karluk Lake, Alaska. Trans. of the North Am. Wildl. Conf. 24:337-345.

Craighead, J. J., F. C. Craighead, Jr., R. L. Ruff, and B. W. O'Gara. 1973. Home ranges and activity patterns of nonmigratory elk of the Madison drainage herd as determined by biotelemetry. Wildl. Monogr. 33.

_____, J. Varney, and F. Craighead. 1974. A population analysis of the Yellowstone grizzly bears. Montana For. and Conserv. Exp. Sta. Bull. 40. Univ. Montana, Missoula. 20pp.

Eberhardt, L. L., R. R. Knight, and B. M. Blanchard. 1986. Monitoring grizzly bear population trends. J. Wildl. Manage. 50(4):613-618.

Edwards, R. Y., and D. E. Green. 1959. The measurement of tracks to census grizzly bears. Murrelet 40(2).

Erickson, A. W. 1965. The brown-grizzly bear in Alaska; its ecology and management. Fed. Aid in Wildl. Restoration Proj. Rep. Alaska Dep. Fish & Game, Juneau. 42pp.

Glenn, L. P., and L. H. Miller. 1980. Seasonal movements of an Alaska Peninsula brown bear population. Int. Conf. Bear Res. and Manage. 4:307-312.

Gunther, K. 1986. Grizzly bear activity and interrelationships with backcountry recreational use in the Pelican Valley area of Yellowstone National Park. Unpubl. rep. of the Nat. Park Serv., Bear Manage. Off., Yellowstone National Park.

Hall, J. G. 1981. A field study of the Kaibab squirrel in Grand Canyon National Park. Wildl. Monogr. 75. 54pp.

Hamer, D., and S. Herrero. 1983. Movements, food and habitat of grizzly bears in the Cascade and Panther valleys of Banff National Park. Pp. 9-210 in D. Hamer and S. Herrero, eds. Ecological studies of the grizzly bear in Banff National Park - final report. Parks Canada Contract Report.

Hamilton, A. N., and W. R. Archibald. 1985. Grizzly bear habitat in the Kimsquit river valley, coastal British Columbia; evaluation. Pages 50-56 in Proc. Grizzly Bear Habitat Symposium. U.S. Dep. Agric. Gen. Tech. Rep. INT-207, Intermt. Res. Stn., Ogden, UT.

Hoskins, W. P. 1975. Yellowstone Lake tributary study. Interagency Grizzly Bear Study Team. Unpubl. rep. 31pp.

Jones, R. D., D. G. Carty, R. E. Gresswell, C. U. Hudson, L. D. Lentsch, and D. L. Mahony. 1986. Annual project report, fishery and aquatic management program, Yellowstone National Park, calendar year 1985. U.S. Fish & Wildl. Serv. unpubl. mimeo. 204pp.

Kaal, M. 1976. Ecology, protection and prospect of utilization of brown bear in the Estonian S.S.R. Int. Conf. Bear Res. and Manage. 3:303-306.

Kemp, G. A., and L. B. Keith. 1970. Dynamics and regulation of red squirrel (*Tamiasciurus hudsonicus*) populations. Ecol. 51(5):763-779.

Kendall, K. C. 1983. Use of pine nuts by grizzly and black bears in the Yellowstone area. Int. Conf. Bear Res. and Manage. 5:166-173.

_____. 1986. Grizzly and black bear feeding ecology in Glacier National Park, Montana - progress report. Unpubl. National Park Service Rep. 42pp.

Klein, D. R. 1959. Track differentiation for censusing bear populations. J. Wildl. Manage. 23:361-363.

Knight R. R., and L. L. Eberhardt. 1984. Projected future abundance of the Yellowstone grizzly bear. J. Wildl. Manage. 48(4):1434-1438.

_____, and L. L. Eberhardt. 1985. Population dynamics of Yellowstone grizzly bears. Ecol. 66(2):323-334.

_____, B. M. Blanchard, and D. J. Mattson. 1986. Yellowstone grizzly bear investigations - 1985. Nat. Park Serv. Rep. 58pp.

______, D. Mattson, and B. Blanchard. 1984. Movements and habitat use of the Yellowstone grizzly bear. USDI, Nat. Park Serv., Interagency Grizzly Bear Study Team Rep. 177pp.

Luque, M. H. and A. W. Stokes. Fishing behavior of Alaska brown bear. Int. Conf. Bear Res. and Manage. 3:71-78.

Mattson. D. J. 1986. Population and habitat dynamics of the Yellowstone grizzly bear. Unpubl. class notes prepared for the Yellowstone Inst. 47pp.

_____, and D. P. Reinhart. 1986. Grizzly bear, red squirrels, and whitebark pine: Second year progress report. Pages 30-38 *in* R. R. Knight, B. M. Blanchard, and D. J. Mattson. Yellowstone grizzly bear investigations - 1985. Nat. Park Serv. Rep.

_____, B. Blanchard, and R. Knight. 1986. Food habits of the Yellowstone grizzly bear. Presented at the 7th Int. Conf. Bear Res. and Manage., Williamsburg, VA, Feb 19-26, 1986.

McCabe, R. E. 1982. Elk and Indians: Historical values and perspectives. Pp. 61-123 *in* J. W. Thomas and D. E. Toweill, eds. Elk of North America - ecology and management. Stackpole Books, Harrisburg, PA.

Mealey, S. P. 1975. The natural food habits of free ranging grizzly bears in Yellowstone National Park, 1973-1974. M.S. Thesis, Montana State Univ., Bozeman.

Mechan, W. R. 1961. Observations on feeding habits and behavior of grizzly bears. The Am. Midl Nat. 65:409-412.

Pearson, A. M. 1975. The northern interior grizzly bear, Ursus arctos L. Can. Wildl. Serv. Rep. Ser. No. 34. 86pp.

Reinhart, D., and D. Mattson. 1986. Yellowstone Lake tributary study, 1985 progress report. Pages 39-50 in Yellowstone grizzly bear investigations, annual report of the Interagency Study Team, 1985. USDI-NPS.

Reynolds, H. V. 1980. Characteristics of grizzly bear predation on caribou in the calving grounds of the western Arctic herd. 10pp in Vol. 1. North Slope grizzly bear studies. Alaska Dep. Fish and Game Proj. Prog. Rep.

Russell, R. H., J. W. Nolan, N. A. Woody, and G. Anderson. 1979. A study of the grizzly bear in Jasper National Park, 1975-78. Final Rep., Can. Wildl. Serv. 136pp.

Rusch, D. A., and W. G. Reeder. 1978. Population ecology of Alberta red squirrels. Ecol. 59(2):400-420.

Servheen, C. 1983. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. J. Wildl. Manage. 47(4):1026-1035.

Steele, R., S. Cooper, D. Ondov, D. Roberts, and R. Pfister. 1983. Forest habitat types of eastern Idaho-western Wyoming. USDA, For. Serv. Gen. Tech. Rep. INT-144. 122pp.

Stonorov, D., and A. W. Stokes. 1972. Social behavior of the Alaska brown bear. Int. Conf. Bear Res. and Manage. 1:232-242

Varley, J. D. 1983. The use of restrictive regulations in managing wild salmonids in Yellowstone National Park, with particular reference to cutthroat trout (Salmo clarkii). Pages 145-156 in J. M. Walton and D. B. Houston, eds. Proc. of the Olympic Wild Fish Conf. Sponsored by the Fish. Technology Program and the Nat. Park Serv. Olympic Nat. Park, March 1983.

*U.S. GOVERNMENT PRINTING OFFICE: 1987-0-775-986/65195