Yellowstone Grizzly Bear Investigations 1994

Annual Report of the Interagency Study Team

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1994

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INTRODUCTION

The Interagency Grizzly Bear Study Team (IGBST) was initiated in 1973 and is a cooperative effort of the National Biological Service, National Park Service, U.S. 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. IGBST annual reports are intended to facilitate the timely transfer of research results and perspectives to management 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 (Mattson et al. 1991), population parameters (Knight and Eberhardt 1985), and growth patterns (Blanchard 1987).

Distribution of grizzly bears within the study area (Basile 1982, Blanchard et al. 1992), movement patterns (Blanchard and Knight 1991), food habits (Mattson et al. 1991), and habitat use (Knight et al. 1984) have been largely determined 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 indicate 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 (cf. Blanchard and Knight 1991). Population trend indices appear to be more meaningful and measurable than a number estimate (Eberhardt et al. 1986). Research is ongoing in the attempt to document a sensitive and reliable trend index.

Data analyses and summaries presented in this report supersede all previously published data. Study methods are reported by Blanchard (1985) and Mattson et al. (1991). The study area has been described in detail by Blanchard and Knight (1991) and Mattson et al. (1991).

RESULTS AND DISCUSSION

Monitoring/Population Trend

Marked Animals

Forty-three individual grizzly bears were captured and marked during 1994 (Table 1), including 18 females (12 adult) and 25 males (13 adult). Twenty-six of the 43 had not been marked previously. Twenty-five captures were a result of research efforts and the bears were released on-site. Thirty-one captures resulted from management actions involving conflicts on private land (24), campground-trailhead conflicts (5), livestock depredation (1), and conflict in a development (1); and 28 were transported to release sites within the Yellowstone ecosystem. This was the largest number of transports since 1981 when 35 management captures and 31 transports occurred (Table 2).

A total of 60 grizzly bears were monitored for varying intervals during 1994, including 21 adult females. A maximum of 18 adult females were monitored consecutively during October and 17 were wearing active transmitters at denning.

Since 1975, 239 grizzly bears have been radio-marked (Table 3).

Unduplicated Females

One method of monitoring population trend is recording the number of unduplicated females with cubs-of-the-year (COY) each year. A summary of procedures used to determine whether or not observations are duplicates were reported by Knight et al. (1989) and Knight et al. (1995).

Twenty unduplicated females with 47 COY were observed in 11 Bear Management Units (BMUs) within the Recovery Zone during 1994 (Fig. 1). The current running 6-year average (1989-94) for the entire study area is 21 females/year with an average litter size of 2.16 cubs (Table 4). This 6-year average has steadily increased from 12 females/year with 1.85 cubs/litter during the period of 1973-78.

Table 1. Grizzly bears captured during 1994.

Bear	Sex	Age	Date	Location[a]	Release site	Trapper
220	M	11	05/12	Mormon Cr, SNF	on site	IGBST
136	F	11	05/17	Kitty Cr, SNF	on site	IGBST
124	F	14	05/18	Mormon Cr, SNF	on site	IGBST
221	F	2	05/18	Kitty Cr, SNF	on site	IGBST
222	M	2	05/18	Mormon Cr, SNF	on site	IGBST
223	M	2	05/19	Taylor's Fork, MT, private (mgt)	Bechler, YNP	MT
			05/29	Pinehaven, ID, private (mgt)	Charcoal Bay, YNP	ID
			06/15	Grant Village campground, YNP (mgt)	to zoo	YNP
224	M	6	06/09	Eynon Draw, BTNF	on site	WY
225	M	1	06/17	Skull Cr, BTNF	on site	WY
			06/28	Spread Cr, BTNF	on site	WY
209	M	7	06/18	Spread Cr, BTNF	on site	WY
201	M	4	06/23	Pelican Valley, YNP	on site	IGBST
206	M	20	06/25	Mesa Pit, YNP	on site	IGBST
166	F	11	06/24	Skull Cr, BTNF	on site	WY
G52	F	1	06/28	Spread Cr, BTNF	on site	WY
140	M	15	07/10	Mesa Pit, YNP	on site	IGBST
			08/21	Mesa Pit, YNP	on site	IGBST
182	F	5	07/12	Flat Mountain Arm, YNP	on site	IGBST
34	M	22	07/09	Preacher's Park, BTNF	on site	WY
			07/18	Spread Cr, BTNF	on site	WY
			09/06	N Fork Spread Cr, BTNF	on site	WY
203	M	Ad	07/08	Grizzly Cr, BTNF	on site	WY
226	M	12	07/21	S Fork Shoshone, WY, private (mgt)	Blacktail Cr, YNP	WY
			11/08	Sunlight, WY, private (mgt)	mgt removal	WY
227	M	2	07/24	Chick Cr, TNF	on site	IGBST
228	M	4	07/30	Mesa Pit, YNP	on site	IGBST
174	M	8	08/07	Dunoir Cr, SNF (mgt)	Blacktail Cr, YNP	WY
229	M	11	07/28	Squaw Basin, BTNF	on site	WY
			08/28	Split Rock Cr, BTNF	on site	WY
230	M	SAd	08/14	Taylor's Fork, MT, private (mgt)	Buck Cr, GNF	MT
			08/17	Taylor's Fork, MT, private (mgt)	Tom Miner, GNF	MT
			08/24	Big Sky, MT, private (mgt)	to zoo	MT
231	M	2	08/16	S Fork Shoshone, WY, private (mgt)	Sunlight, SNF	WY
			08/25	Wapiti Valley, WY, private (mgt)	Blacktail, YNP	WY
			08/29	Mammoth, YNP (mgt)	Wrong Cr, YNP	YNP
			10/05	Gardiner, MT, private (mgt)	to zoo	MT
207	M	13	08/10	S Fork Shoshone, WY, private (mgt)	Hoodoo Cr, SNF	WY
112	M	21	08/24	Boulder River, GNF (mgt)	Six Mile Cr, GNF	MT
163	F	10	08/29	Absaroka Lodge, SNF (mgt)	N of Dubois, WY	WY
101	F	12	09/02	Rainbow Point, GNF (mgt)	Buffalo Plateau, BTNF	MT/IGBST
232	F	1	09/02	Rainbow Point, GNF (mgt)	Big Game Ridge, YNP	MT/IGBST
233	M	1	09/02	Rainbow Point, GNF (mgt)	Big Game Ridge, YNP	MT/IGBST

Table 1. continued.

Bear	Sex	Age	Date	Location[a]	Release site	Trapper
234	F	9	09/07	S Fork Shoshone, WY, private (mgt)	Wrong Cr, YNP	WY
235	F	4	09/11	S Fork Shoshone, WY, private (mgt)	Portal Cr, GNF	WY
236	F	14	09/12	S Fork Shoshone, WY, private (mgt)	Trapper Cr, GNF	WY
237	F	11	09/12	Spring Cr, WY, private (mgt)	Blacktail, YNP	WY
238	M	1	09/12	Spring Cr, WY, private (mgt)	Blacktail, YNP	WY
G53	M	1	09/12	Spring Cr, WY, private (mgt)	Blacktail, YNP	WY
239	M	Ad	09/18	S Fork Shoshone, WY, private (mgt)	Six Mile Cr, GNF	WY
128	F	9	09/20	Dubois, WY (mgt)	Hoodoo Cr, SNF	WY
240	F	SAd	09/21	Gardiner, MT, private (mgt)	Charcoal Bay, YNP	MT
241	F	cub	09/19	S Fork Shoshone, WY, private (mgt)	Newton Cr, SNF	WY
242	F	13	10/05	S Fork Shoshone, WY, private (mgt)	Hominy Peak, TNF	WY
106	F	18	10/20	Wapiti, WY, private (mgt)	Otter Cr, YNP	WY
G54	M	1	10/20	Wapiti, WY, private (mgt)	Otter Cr, YNP	WY

	Females	Males
Adult	12	13
Subadult	6	12

	Females		Males	
	Ad	SAd	Ad	SAd
Research	4	2	13	6
Management	8	4	5	14

NEW BEARS: 26
TOTAL INDIVIDUAL BEARS: 43
TOTAL CAPTURES = 56

[a] BTNF = Bridger-Teton National Forest, GNF = Gallatin National Forest, SNF = Shoshone National Forest, YNP = Yellowstone National Park, (mgt = management action).

Table 2. Grizzly bears monitored, captured, and transported, 1980-94.

Year	Number monitored	Individual bears captured	Total captures		Transports
			Management	Research	
1994	60	43	31	23	28
1993	43	21	8	13	6
1992	41	16	1	15	0
1991	42	27	3	28	4
1990	35	15	13	4	9
1989	40	15	3	14	3
1988	46	36	21	23	15
1987	30	21	10	15	8
1986	29	36	31	19	19
1985	21	4	5	0	2
1984	35	33	22	20	16
1983	26	14	18	0	13
1982	46	30	25	27	17
1981	43	36	35	30	31
1980	34	28	0	32	0

Table 3. Status of radio-marked grizzly bears, 1994. (Age when died or age in 1994).

Known dead			Suspected dead		
Man-caused		Natural	Unknown	Man-caused	Natural or unknown
3 (7)	105 (Ad)	1 (28[a])	77 (9)	7 (5)	13 (25[a])
4 (5)	110 (5)	12 (25[a])	108 (4)	11 (7)	16 (27[a])
5 (14)	113 (2)	56 (1)		24 (2)	36 (25[a])
6 (8)	120 (3)	65 (3)		32 (4)	51 (26[a])
8 (17)	121 (6)	145 (2)		75 (1)	54 (1)
9 (17)	122 (3)	161 (20)		102 (2)	55 (1)
10 (12)	127 (1)	187 (5)		147 (10)	68 (25[a])
14 (12)	134 (8)	180 (5)			84 (31[a])
15 (12)	150 (5)	200 (11)			109 (7)
17 (2)	154 (4)				
18 (3)	158 (7)				
20 (14)	160 (5)				
22 (9)	176 (5)				
25 (5)	177 (12)				
26 (22)	183 (4)				
27 (2)	186 (4)				
28 (16)	198 (Ad)				
29 (1)	202 (4)				
30 (2)	223 (2)				
31 (C)	226 (12)				
34 (22)	230 (SAd)				
38 (13)	231 (2)				
39 (3)	235 (4)				
45 (6)					
46 (5)					
47 (2)					
49 (3)					
58 (2)					
59 (8)					
60 (6)					
62 (3)					
63 (4)					
67 (4)					
69 (3)					
76 (6)					
81 (4)					
83 (19)					
88 (7)					
90 (2)					
93 (2)					
94 (1)					
95 (11)					
97 (16)					
	66 Total	9 Total	2 Total	7 Total	9 Total

[a] Suspected died of old age.
[b] Known alive in 1991.
[c] Known alive in 1992.
[d] Known alive in 1993.
[e] Known alive in 1994.

Table 3. Continued.

Off air						Active			
2	(23)	100	(11)	164[b]	(10)	101	(12)	234	(9)
19	(24)	103	(20)	165[b]	(16)	104	(12)	236	(14)
21	(21)	107	(15)	167	(19)	106	(18)	237	(11)
23	(18)	111	(11)	168[d]	(8)	112	(21)	238	(1)
33	(19)	114	(12)	169[c]	(8)	124	(14)	239	(Ad)
35	(19)	115	(18)	170	(13)	125	(11)	240	(SAd)
37	(16)	116	(20)	171	(13)	128	(9)	241	(C)
40	(19)	117[b]	(11)	172	(7)	136	(11)	242	(13)
41	(16)	118	(11)	173[b]	(Ad)	140	(15)		
42	(23)	119	(13)	175[b]	(Ad)	148	(11)		
43	(17)	123	(10)	178[b]	(8)	163	(10)		
44	(unk)	126	(22)	179[d]	(5)	166	(11)		
48	(16)	129	(13)	181[b]	(5)	174	(8)		
50	(20)	130	(12)	184[d]	(13)	182	(5)		
57	(23)	131	(13)	185[c]	(8)	191	(17)		
61	(18)	132	(11)	188[b]	(6)	205	(10)		
64	(16)	133	(13)	189[d]	(12)	206	(20)		
70	(16)	135	(13)	190	(9)	207	(13)		
71	(16)	137	(14)	192	(7)	208	(7)		
72	(17)	138	(16)	193	(8)	209	(7)		
73	(15)	139	(15)	194	(18)	210	(11)		
74	(13)	141[b]	(8)	195[c]	(7)	211	(4)		
78	(15)	142[c]	(13)	196[e]	(9)	212	(3)		
79	(20)	143	(15)	197[d]	(10)	214	(2)		
80	(14)	144	(8)	199[e]	(5)	217	(10)		
82	(18)	146	(14)	201[e]	(4)	218	(5)		
85	(18)	149	(Ad)	203[e]	(Ad)	220	(11)		
86	(24)	151	(14)	204[e]	(4)	221	(2)		
87	(14)	152[d]	(21)	213[e]	(2)	222	(2)		
89	(13)	153	(14)	215[e]	(Ad)	224	(6)		
91	(13)	155[d]	(8)	216[e]	(8)	227	(2)		
92	(15)	156	(12)	219[e]	(4)	229	(11)		
96	(unk)	157	(Ad)	225[e]	(1)	232	(1)		
98	(unk)	159	(Ad)	228[e]	(4)	233	(1)		
99	(13)	162	(20)						
				104 Total				42 Total	

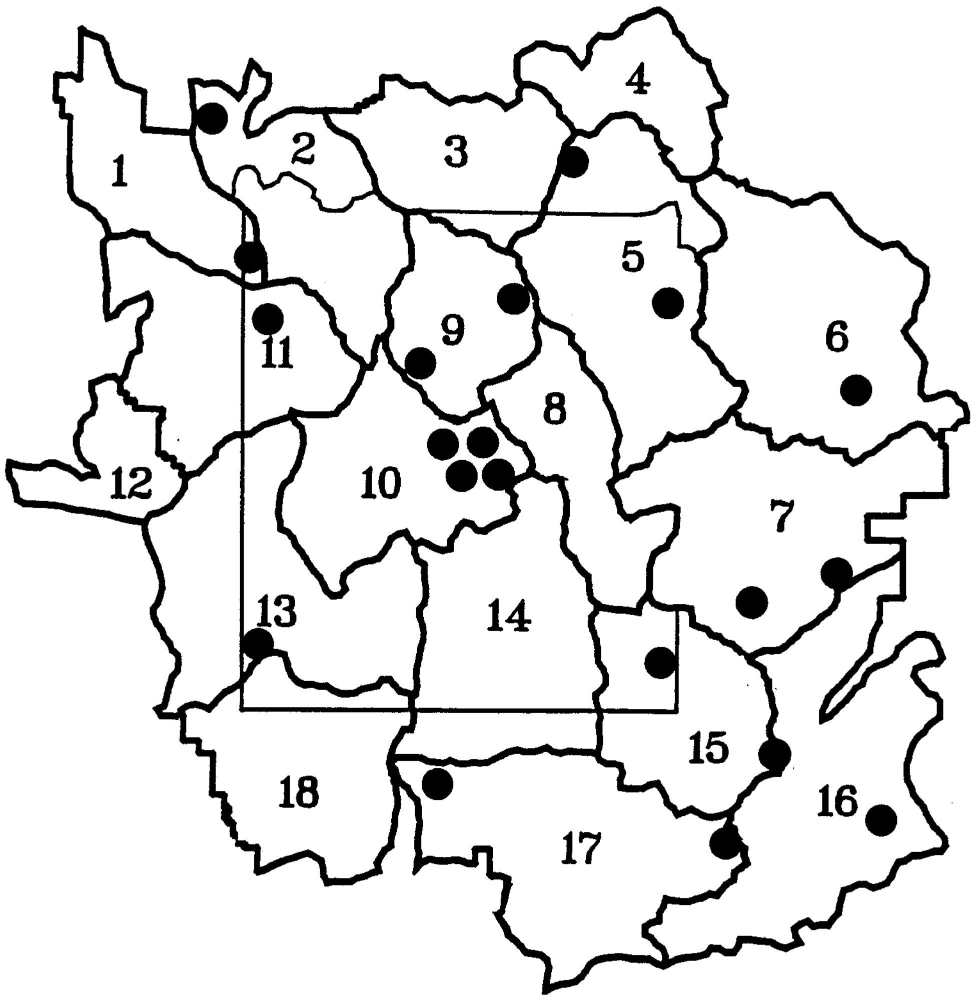


Fig. 1. Locations of initial observations of 20 unduplicated females with cubs-of-the-year within Bear Management Units inside the Recovery Zone during 1994.

Table 4. Annual unduplicated female grizzly bears with cubs-of-the-year and adult female deaths, 1973-94.

Year	Females	Cubs	Mean litter size	Adult female deaths (known and probable)
1973	14	26	1.86	4
1974	15	26	1.73	4
1975	4	6	1.50	1
1976	16	30	1.88	1
1977	13	25	1.92	6
1978	9	18	2.00	1
1979	13	29	2.23	2
1980	12	23	1.92	1
1981	13	24	1.85	5
1982	11	20	1.82	4
1983	13	22	1.69	2
1984	17	30	1.76	2
1985	9	16	1.78	2
1986	25	48	1.92	2
1987	13	29	2.23	2
1988	19	40	2.11	2
1989	16	30	1.88	0
1990	24	57	2.38	4
1991	24	43[a]	1.87	0
1992	23	56	2.43	0
1993	20	41	2.05	3
1994	20	47	2.35	3
Total	343	686		51
Mean	15.38	30.44	1.99	2.29

[a] Number of cubs for 23 females; litter size for 1 female unknown.

Observation Flights

During 1994, 60% of the unduplicated females with COY were seen on IGBST observation flights (Table 5). Observation flights accounted for an average 42% of the unduplicated observations during 1986-94 when methodology was similar; 11% were recorded incidentally on observation flights made by other researchers over the study area, 32% from ground sightings, and 15% from IGBST trapping efforts and radio-tracking flights only.

Table 5. Annual unduplicated female grizzly bears with cubs-of-the-year by prioritized method of observation, 1986-94.

	Observation flights		Ground	Radio	
Year	IGBST	Other	sightings	flights/trap	Total
1986	9	2	10	4	25
1987	5	1	4	3	13
1988	7	1	7	4	19
1989	7	2	5	2	16
1990	8	0	12	4	24
1991	17	2	2	3	24
1992	10	4	6	3	23
1993	3	4	10	3	20
1994	12	4	2	2	20

The 18 BMUs were flown at least once between 5 July and 2 September for an average 2.01 hours each. Grizzly bear observation rate was 1.75 bears/hour on 32 observation flights (Table 6) compared to 0.15 unmarked bears/hour on 69 radio-tracking flights. Females with COY were seen an average of 0.186/hour on observation flights and 0.016/hour on radio-tracking flights. Radio-marked bears were seen 23% of the time on radio-tracking flights (0.11 bears/hour).

Table 6. Unmarked grizzly bears observed during observation flights, 1973-94.

Year	Number flights	Number hours	Total bears	Bears/ hour	Unduplicated females with COY per hour
1973	24	75.90	59	0.78	0.03
1974	47	146.30	128	0.87	0.06
1975	24	47.20	20	0.42	0.02
1976	5	18.50	30	1.62	0.05
1977	0				
1978	0				
1979	7	23.00	14	0.61	0.13
1980	6	22.30	27	1.21	0.18
1981	4	16.00	13	0.81	0.25
1982	6	23.70	23	0.97	0.13
1983	41	124.30	36	0.29	0.03
1984	11	29.00	27	0.93	0.24
1985	16	30.50	21	0.69	0.07
1986	24	52.00	29	0.56	0.17
1987	20	47.20	35	0.74	0.11
1988	17	33.87	62	0.66	0.21
1989	37	88.71	87	0.98	0.08
1990	39	86.01	81	0.94	0.09
1991	46	99.24	257	2.59	0.17
1992	31	68.73	204	2.97	0.15
1993	29	58.42	43	0.74	0.05
1994	32	64.46	112	1.75	0.19

Mortalities

Eleven mortalities were recorded during 1994 (Table 7), including 10 human-caused and 1 from natural causes.

Table 7. Grizzly bear mortalities recorded during 1994.

Bear	Sex	Age	Date	Type	Location[a]	Cause
Unm	?	1	Spring	Probable	Hayden Valley, YNP	Natural: cub of #205 lost den-12 July
223	M	2	June	Known	Grant campground, YNP	Human-caused: 3rd mgt capture, to zoo
230	M	SAd	8/24	Known	Big Sky, MT (private)	Human-caused: 3rd mgt capture, to zoo
Unm	F	Ad	9/6	Probable	Thorofare, BTNF	Human-caused: hunter self-defense, possible yearling
Unm	M	1	9/12	Known	Spring Cr, WY (private)	Human-caused: cub of #237, handling accident
Unm	M	2	9/12	Known	N Fork Shoshone, WY	Human-caused: roadkill
34	M	22	9/16	Known	Davis Hill, BTNF	Human-caused: hunter self-defense
Unm	F	Ad	9/17	Known	Bull Cr, GNF	Human-caused: hunter self-defense, 2 COY
231	M	2	10/5	Known	Gardiner, MT (private)	Human-caused: 4th mgt capture, to zoo
235	F	4	10/27	Known	Deer Cr, GNF	Human-caused: black bear hunter
226	M	12	11/8	Known	Sunlight, WY (private)	Human-caused: 2nd mgt capture

[a] BTNF = Bridger-Teton National Forest, GNF = Gallatin National Forest, YNP = Yellowstone National Park.

Grizzly bear mortalities from 1973-94 are depicted in Table 8. These deaths include known and probable mortalities as defined by Craighead et al. (1988).

Table 8. Known and probable grizzly bear deaths, 1973-94.

	All bears		All adult females	
Year	Human-caused	Other[a]	Human-caused	Other
1973	14	3	4	0
1974	15	1	4	0
1975	3	0	1	0
1976	6	1	1	0
1977	16	1	6	0
1978	7	0	1	0
1979	8	0	1	0
1980	6	4	1	0
1981	10	3	3	2
1982	14	3	4	0
1983	6	1	2	0
1984	9	2	2	0
1985	6	7	2	0
1986	9	2	2	0
1987	3	0	2	0
1988	5	8	0	2
1989	2	1	0	0
1990	9	0	4	0
1991	0	0	0	0
1992	4	4	0	0
1993	3	2	2	1
1994	10	1	3	0

[a] Includes deaths from natural and unknown causes.

Population Trend Estimates from Reproductive and Survival Data

by
L. L. Eberhardt

Population trend has been estimated for the Yellowstone population by using an approximation to Lotka's equation with reproductive and survival data (Eberhardt et al. 1994). The model used is:

[1]

$$\lambda^{a} - s\,\lambda^{a-1} - l_{a}\, m\, [1 - (s/\lambda)^{w-a+1}] = 0$$

Here, λ denotes the "finite population multiplier" ($\lambda = e^{r}$), *s* is a constant rate of survival for adults, l_a is survival to age of first parturition (a), *w* denotes the maximum age considered and *m* is reproductive rate, calculated as female cubs per adult female. The model is based on replacing the reproductive curve by a rectangular function (Eberhardt 1985), using an initial (*a*) and maximum (*w*) age. A maximum age of 20 was used, to compensate for likely lowered reproduction and survival rates in the older age classes. Calculations from eq. (1) are not very sensitive to the maximum age (*w*) used (Eberhardt 1990). The oldest female bear examined in the present study was 25 years of age, dying at that age after having had a cub. Solutions of the model for λ are obtained by iteration.

In the earlier report (Eberhardt et al. 1994) we used survival data based on bear-years of observation, the method used in prior annual reports. A bias in that approach is that radiocollars may be lost (or transmitters fail) and the individual is later recaptured and a new transmitter attached. In the earlier reports, we used the total length of time that an individual was known to be alive (i.e., the intervening time period when a transmitter was inactive was included in the period of observation). This tends to overestimate survival rates, inasmuch as other bears that lose transmitters may die shortly after "going off the air" and thus not be recorded again. Here, we use only those days of life in which a bear was actually observed by telemetry, and survival is calculated on a daily basis, and then adjusted to an annual rate, using the equation:

$$annual\ survival = \left(1 - \frac{deaths\ recorded}{bear\text{ - }days\ observed}\right)^{365}$$

Data on adult female survival from bears captured before 1983 is not used here due in part to the disruption and substantial losses of bears associated with closure of garbage dumps in and near Yellowstone National Park in the early 1970s (Knight and Eberhardt 1985). More importantly, there was a substantial focus on reduction of human-caused mortalities after it became apparent that the population trend was negative (Knight et al. 1983). The survival data used for trend estimates is based on trapping conducted throughout the area by IGBST staff for the purpose of trend estimation. A number of bears caught for "management" purposes are not included in these estimates, because they belong to a high risk group. That is, they were not captured until they had become such a nuisance (by entering campgrounds, private property, etc.) that they had to be relocated. It should be noted that bears caught in "research" trapping often were caught later for "management" purposes, and these bears are included in the survival calculations.

Adult female survival was estimated as 0.943, based on 31,222 bear-days (and 5 deaths). The small sample of adult females caught initially for management purposes (7,999 bear-days) had a survival rate of 0.726 (7 deaths). Survival for subadult females caught from 1983 to date was 0.803 (8,332 bear-days; 5 deaths). Survival for all subadults caught was virtually identical (0.799). Survival for bears caught in research trapping was somewhat higher than the "management" bears, but only small samples are available if the data are broken down into subcategories, so data on all bears caught in 1983 or later is used here. Blanchard and Knight (1995) have shown that subadult females caught in management situations and relocated do not return or repeat the offense as often as adult females.

Cub survival was calculated for litters seen after emergence from the den and again as yearlings, or for cases where the adult female was observed alone the next year. Data on a total of 69 individual cubs observed in 1983 or later were used here, with 58 surviving to become yearlings for a survival rate of 0.840. The survival rate for cubs born prior to 1983 appeared to be a little higher, but is based on a smaller sample.

Survival records on adult females first caught in management operations were not included because including such high-risk bears would bias the survival estimates, so we have used only bears that were caught before they had initiated this kind of behavior. Very few bears in the Yellowstone population die of natural causes. Just 10 (11%) of 92 recorded deaths for which a cause was known died naturally. The remainder were killed by people for one reason or another, and 40% of these died in the course of management activities. Six bears died of unknown causes.

Although management activities are a major cause of mortalities, only a relatively small fraction of adult females are at high risk to death from such activities in any given year. There were 20 "management" bears in the adult female data base from 1983 through 1994, averaging less than 2 such bears caught in each year. None were radioed in 5 years, 1 in each of 3 years, 3 in 1 year, and 6 in 2 years (1986 and 1994). From the "distinct families" data (Knight et al. 1995), there is good reason to believe that the minimum number of adult females in the population each year exceeds 60, so that the average annual number of "management" bears in the population was quite surely less than 3%.

It could be argued that we should stratify the population for survival calculations, thus using the data on bears first caught in a management situation. The few bears classed as management bears each year would constitute 1 stratum and all other bears a second stratum. The problem with this is that some of the "other" bears (caught in "research" trapping) also get into management situations and are killed. Three of the 5 deaths recorded for research bears occurred in just this way. Consequently, any stratified calculation would have to be somehow adjusted for such bears, which seems very difficult to do. As noted earlier, we believe the "research" bears constitute a representative sample of the population. Nine (23%) of 39 adult females initially caught in research trapping were later caught in "management" situations. Overall mortality for management bears was 27%, so that we can calculate an expected death rate of 0.23(0.27) = 0.06, very much the same as the mortality rate of all adult female bears first caught in research trapping.

Reproductive rates in the present report are based on females aged 4 and older. This change from our earlier approach of using females aged 5 and older was instituted because it has become apparent that the Yellowstone bears do begin to have cubs at age 4. There were 20 females that were observed continuously from age 4 to the time of first parturition. The records of age of first reproduction for these bears were 5 at age 4, 4 at age 5, 6 at age 6, and 5 at age 7.

Reproductive rates can be estimated by 3 methods; (1) number of cubs born per year of observation, (2) averaging reproductive rates for individual adult females (which compensates for the fact that some females are observed for longer periods than others), (3) the average interval between parturitions divided by mean litter size. Due to the fact that individual adult bears are usually observed for only 1 or 2 such intervals, this estimate is likely to be biased because the short overall observation period makes it unlikely that the longer intervals between parturitions are observed (radiocollars are lost or transmitters fail before the next parturition). Inasmuch as all 3 methods have been used in practice, results are reported here for the 3 methods. A total of 204 bear-years of observation are available on 48 individual adult females.

Due to the prospect of some disruption of reproduction in earlier years associated with closure of garbage dumps, data for 1981 to date have been examined separately. We used 1981 rather than 1983 as cut-off date here in order to increase sample size. Results for the 3 methods are as follows:

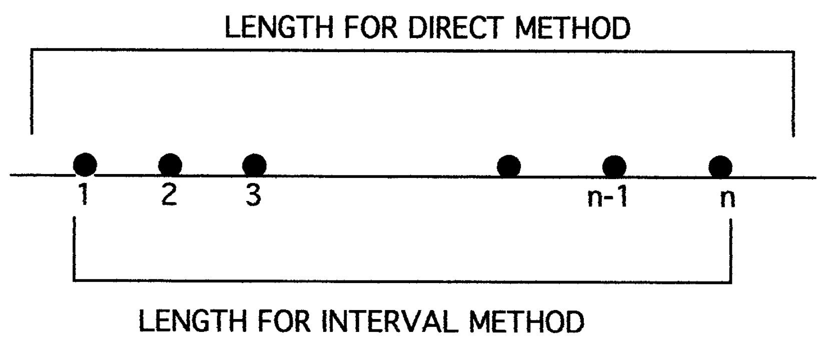
	Female cubs per bear-year	Averaging rates for individual bears	Mean interval/mean litter size
All data	0.36	0.35	0.40
1981 and later	0.35	0.35	0.40

If, instead of the mean interval between parturitions, we use the modal (most frequent) interval of 3 years, then the rate for the interval method becomes 0.37, and thus is in better agreement with the other methods. Using the modal interval reduces the bias in estimating the average interval, inasmuch as the longer intervals do not have much influence on the mode.

Unfortunately, there is no way to be sure that the sample of bear-years obtained is representative of the population. The fact that the 3 methods of estimation appear to agree is encouraging. However, another check can be made by using only data in which the interval of observation begins and ends with a parturition. The smaller sample (76 bear-years from 23 adult females) thus obtained gives the following results:

	Female cubs per bear-year	Averaging rates for individual bears	Mean interval/mean litter size
All data	0.40	0.41	0.39
1981 and later	0.40	0.42	0.40

These rates seem consistently higher than those for the full data set. A difficulty here is that the data largely encompass only a single reproductive interval per bear. Using only a few intervals can result in a bias (Eberhardt and Schneider 1994:Fig. 3). The basis for such a bias can be illustrated by the following diagram (Eberhardt and Schneider 1994:Fig. 2):



The solid points represent parturition events over time, while the length of the upper interval is l_1, and that of the lower interval is l_2. If we consider n intervals, then the basis for an estimate by the interval method consists of dividing number of cubs produced in the first n-1 litters by the overall interval length (l_2) in the diagram. To consider the source and nature of the bias, one needs to review the basis for an unbiased sample, which is a random selection of a fixed observation period (upper interval in the diagram). Random selection of the interval guarantees that location of the endpoints of the observation period is independent of the timing of the events observed (parturitions). The bias is reduced by the use of long intervals, so that l_2 becomes a better approximation to l_1. As mentioned previously, another possible source of bias arises because we may not observe the longer intervals between litters, due to the limitations of collar loss and battery life. The longest observed single interval in the Yellowstone data set is 4 years. For a simulation to illustrate the possible nature of the bias, the observed frequency of interval length has been made symmetrical, as follows:

	Observed frequency	Frequency for simulation	Cumulative distribution for simulation
1	2	2	0.0513
2	9	9	0.2820
3	17	17	0.7180
4	3	9	0.9487
5	0	2	1.0000

The simulation program draws an initial age of parturition at random in the range of ages 4 to 7, and then selects subsequent intervals at random from the above frequency distribution. These intervals can then be used to calculate a mean density of parturitions by using the equation:

$$\hat{D} = \frac{n - 1}{l_2}$$

where n is the number of parturitions and l_2 is the sum of the intervals, as in the diagram above.

The symmetrical distribution of the intervals for the simulations shown above makes it evident that the expected density of parturitions is 0.333, and this is illustrated by 5,000 simulation runs with each run based on 200 intervals, which gives a mean density of 0.3335. If we consider only a single interval, the mean density in 5,000 runs is 0.3783, while using 2 intervals gives a mean density of 0.3502. Note that the data tabulated previously is for female cubs per bear-year, while the simulations only consider <u>parturitions</u> per bear-year. If the litter size were 2 cubs per litter (hence 1 female cub per litter) then the 2 rates would be the same. Because the mean litter size is somewhat higher than 2, one would need to decrease the observed rates somewhat to make them directly comparable to the simulated values.

A bootstrap analysis of the data gives much the same coefficient of variation for lambda (0.0393) as does the delta method (0.0384). Approximate 95% bootstrap confidence limits for λ are 0.97 to 1.12. The delta method approximation indicates that 77% of the overall variance comes from subadult survival (about 2% of that is associated with cub survival), 19% from adult survival and about 4% from reproductive rate. The estimated λ is 1.053, essentially the same rate as that reported by Eberhardt et al. (1994).

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Food Habits

Scat Analysis

Results of 1994 scat analyses were not available when this report was published.

Whitebark Pine Cone Production

Grizzly bears generally consume the seeds of whitebark pine (*Pinus albicaulis*) to the near exclusion of other food items when available in sufficient quantities. These seeds are largely unavailable to bears until cone production approaches 20 cones/tree (Blanchard 1990). Widespread use by bears generally occurs when production exceeds 22 cones/tree (Mattson et al. 1992). Cone production during 1994 averaged <2 cones/tree for the 18 transects in the Yellowstone ecosystem (Fig. 2, Table 9). Only 1 transect in the southeast corner of the study area produced more than 20 cones/tree (Fig. 3). Cone production on the remaining 17 transects averaged less than one-half cone per tree.

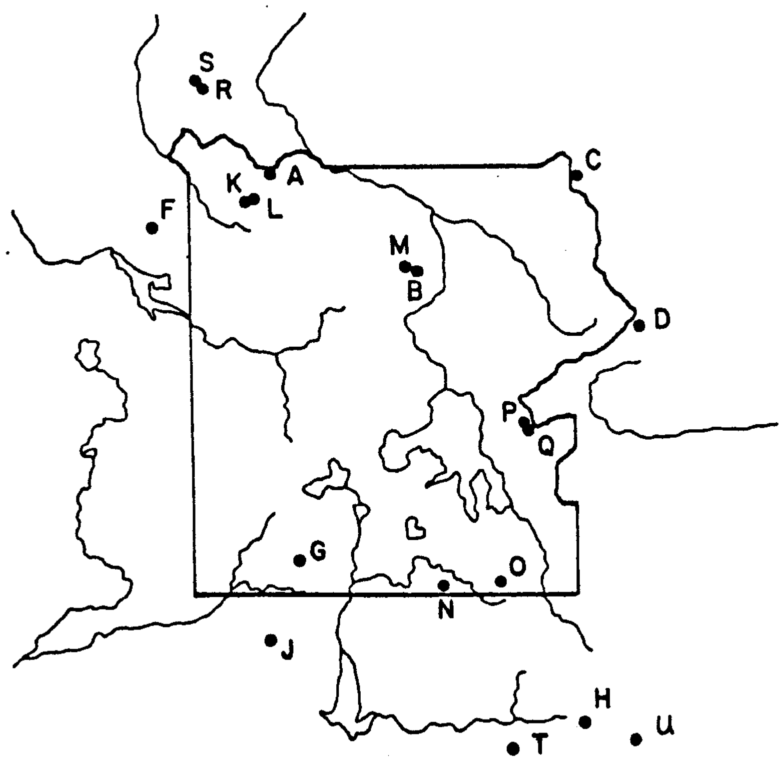

Fig. 2. Locations of whitebark pine cone transects within the study area.

Table 9. Mean annual whitebark pine cone production on study transects, 1980-94.

Year	Total cones	Total trees	Total transects	Mean cones per tree	Mean cones per transect	Cones per transect/year SD	Min.	Max.	Mean Julian date read each year
1980	2,312	90	9	25.69	256.89	122.99	139	562	212
1981	1,191	90	9	13.23	132.33	148.69	8	489	204
1982	1,443	85	9	16.98	160.33	154.18	0	463	229
1983	1,531	88	9	17.40	170.11	88.78	78	372	211
1984	360	56	6	6.43	60.00	41.41	14	124	220
1985	2,312	85	9	27.20	256.89	192.27	17	625	214
1986	103	75	8	1.37	12.88	13.18	0	38	207
1987	394	155	16	2.54	24.63	37.49	0	118	217
1988	406	169	17	2.40	23.88	44.32	0	148	208
1989	10,199	209	21	48.80	485.67	384.27	7	1,473	206
1990	319	207	21	1.54	15.19	51.52	0	243	212
1991	2,744	177	18	15.50	152.44	107.99	7	366	215
1992	2,876	187	19	15.38	151.37	81.67	19	294	209
1993	1,926	189	19	10.19	101.37	114.97	0	456	217
1994	334	178	18	1.72	18.56	52.56	0	224	217

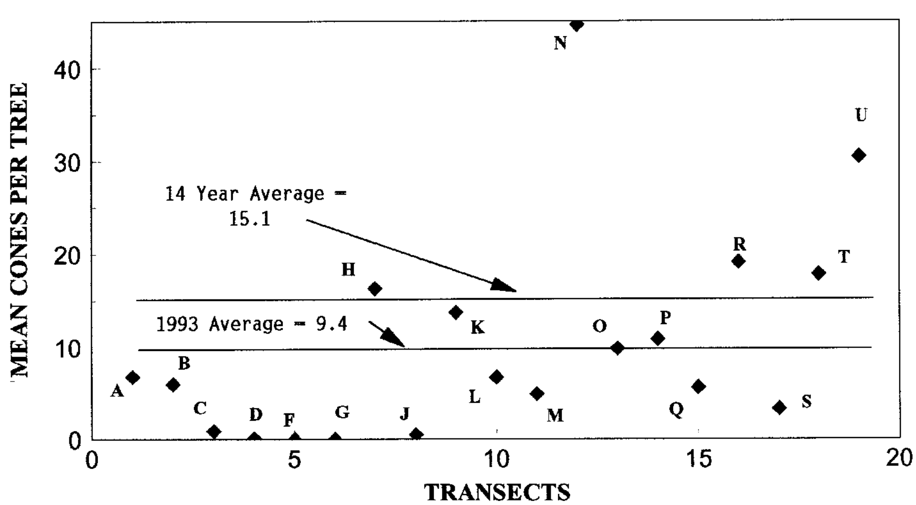

Fig. 3. Whitebark pine cone production on study area transects during 1994.

During years of low whitebark pine seed availability, grizzly bears often seek alternate foods in association with human activities and the number of management actions and mortalities both increase during fall. During August-November, grizzly bears were captured 31 times, 28 of which resulted in transport of the bears away from conflict situations at lower elevations.

Feed Sites

Ground investigation at 110 aerial locations of radio-marked and unmarked grizzly bears from May-October revealed evidence of feeding activity at 24% of the sites. Evidence of activity other than feeding was recorded at an additional 9 sites, and no sign of bear activity was evident at the remaining 75 sites.

Grizzly bear activity was recorded at an additional 32 sites not associated with an aerial location of bear (30 with feeding activity and 2 with other sign recorded). Activities are summarized in Table 10 for those 57 sites with evidence of feeding.

Table 10. Seasonal frequencies of 71 activities at 51 feeding sites during 1994.

Feeding activity	Spring[a] (*n* = 14)	Summer[b] (*n* = 33)	Fall[c] (*n* = 24)	Total (*n* = 71)
Whitebark pine seeds	0	0	0	0
Grazing	0.14	0.24	0	0.14
Digging roots	0.29	0.12	0.20	0.18
Digging rodents/caches	0.07	0.09	0.17	0.11
Large mammals	0.21	0.09	0	0.09
Searching insects	0.21	0.30	0.29	0.28
Miscellaneous[d]	0.07	0.15	0.33	0.20

[a] Spring = May-June.
[b] Summer = July - August.
[c] Fall = September - October.
[d] Miscellaneous = mineral dig, unknown dig, mushrooms, cambium.

The most frequently recorded feeding activity during spring was digging for roots, primarily biscuitroot (*Lomatium cous*) and onion (*Allium* sp.). Large mammal carcasses (elk and bison) and ants were also frequently sought during spring. During summer, searching for insects (primarily ants) and grazing (primarily clover [*Trifolium* sp.]) were the most frequently observed feeding activities. During fall, grizzly bears engaged in a variety of feeding activities in the absence of whitebark pine seeds. They dug for licorice root (*Osmorhiza chilensis*), pondweed rhizomes (*Potamogeton* sp.), and yampa (*Perideridia gairdneri*); searched for ants; dug for pocket gophers and their food caches; stripped tree bark for cambium; and searched for mushrooms.

Movements and Feeding Strategies

Annual range sizes and seasonal rates of movement were not significantly different from the cohort means recorded 1975-87 (Tables 11 and 12). Summer and fall rates of movement were generally greater in 1994 than 1993, a wet year with abundant native foods. Summer and fall of 1994 were dryer than the previous year and whitebark pine seed production was virtually zero. These factors forced bears to range more widely in search of alternate foods. Succulent vegetation was limited and tubers of yampa were much smaller than normal due to low rainfall. Subsequently, management actions escalated from July through October as bears searched for food in association with human activities.

Table 11. Annual range sizes (km^2) of grizzly bears located ≥12 times and during all 3 seasons of 1994.

Cohort	Number of locations	MCP[a]	1975-87 cohort mean MCP	(SD)
Females				
With COY[b]	23	69	231	(136)
	23	189		
	23	177		
	25	53		
With yearlings	24	210	338	(244)
Lone adult	23	250	236	(114)
	19	157		
	18	443		
Subadult	23	239	365	(191)
	14	718		
Males				
Subadults	21	796	698	(598)
	15	77		
	19	444		
Adults	26	379	874	(630)
	18	1,121		
	22	51		
	10	867		

[a] Minimum Convex Polygon.
[b] Cubs-of-the-year.

Table 12. Seasonal rates of movement for radio-marked grizzly bears during 1993 and 1994.

Season	Cohort (number of animals)		Mean km/day/animal 1993	1994	1975-87 mean	(SD)
Spring	adult females with COY	(3)	1.6	0.4	0.7	(0.3)
	females with yearling	(3)	0.6	1.8	1.1	(0.7)
	lone adult females	(5)	1.1	0.8	1.0	(0.6)
	subadult females	(2)		0.9		
	subadult males	(1)	1.0	0.8	1.1	(0.6)
	adult males	(2)	0.2	0.9	1.3	(0.8)
Summer	adult females with COY	(3)	1.3	0.6	1.3	(1.0)
	females with yearling	(4)	0.9	1.7	1.7	(0.9)
	lone adult females	(6)	0.5	1.1	1.3	(0.7)
	subadult females	(2)		1.2		
	subadult males	(3)	0.9	0.9	1.1	(0.9)
	adult males	(6)	0.5	1.6	1.9	(1.1)
Fall	adult females with COY	(2)	0.9	0.6	1.2	(1.0)
	females with yearling	(5)	0.7	1.4	1.6	(0.9)
	lone adult females	(5)	0.7	1.0	1.0	(0.7)
	subadult females	(2)		0.7		
	subadult males	(3)	0.8	0.9	1.1	(0.8)
	adult males	(5)	0.4	1.3	1.4	(0.8)

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