YELLOWSTONE GRIZZLY BEAR INVESTIGATIONS

ANNUAL REPORT OF THE
INTERAGENCY STUDY TEAM
1989

National Park Service
U.S. Forest Service
Montana Fish, Wildlife and Parks Department
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INTRODUCTION

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

Objectives of the study are to determine the status and trend of the grizzly bear population, the use of habitats and food items by the bears, and the effects of land management practices on the bear population. Earlier research on grizzlies within Yellowstone National Park provided data for the period 1959-67 (Craighead et al. 1974). However, changes in management operations by the National Park Service since 1967 - mainly the closing of open pit garbage dumps - have markedly changed some food habits (Mattson et al. 1990), population parameters (Knight and Eberhardt 1985), and growth patterns (Blanchard 1987).

Distribution of grizzly bears within the study area (Basile 1982; Blanchard and Knight, in prep.*a*), movement patterns (Knight et al. 1984, Blanchard and Knight in prep.*b*), food habits (Mattson et al. 1990), 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 indicates that the existence of semi-autonomous population segments is unlikely and that the determination of population size will be difficult due to the average home range sizes of individual bears. Population trend indices appear to be more meaningful and measurable than a number estimate (Eberhardt et al. 1986). Research is ongoing in the attempt to document a sensitive and reliable trend index.

Data analyses and summaries presented in this report supersede all previously published data. Study methods are reported by Blanchard (1985) and Mattson et al. (1990).

RESULTS AND DISCUSSION

MONITORING/POPULATION TREND

Marked Animals

Fifteen individual grizzly bears were captured and marked during 1989 (Table l), including 8 females (7 adult) and 7 males (3 adult). One adult male was recaptured twice. Ten of the 15 had not been marked previously. Twelve captures were a result of research efforts and released on-site. Three captures resulted from management actions and these bears were transported to 2 sites within Yellowstone National Park.

Table 1. Grizzly bears captured during 1989.

Bear	Sex	Age	Date	Location[a]	Release site	Trapper[b]
164	M	5	5/16	Little Horse Cr, SNF	On-site	WY
			5/20	Little Horse Cr, SNF	On-site	WY
			6/27	Little Horse Cr, SNF	On-site	IGBST
165	F	11	5/21	Gibbon Meadows, YNP	On-site	IGBST
126	F	17	5/23	Sentinel Cr, YNP	On-site	IGBST
117	F	6	5/24	Sunlight, SNF	On-site	WY
134	F	7	6/6	Lake, YNP (mgt)	Outlet Cr, YNP (air)	YNP
G47	M	Cub	6/6	Lake, YNP (mgt)	Outlet Cr, YNP (air)	YNP
166	F	6	6/20	Box Cr, BTNF	On-site	IGBST
167	M	14	6/26	Crandall, SNF	On-site	WY
168	M	3	8/13	Pacific Cr, BTNF	On-site	WY
169	F	3	8/15	Two Ocean Pass/BTNF	On-site	WY
170	M	8	8/15	Jay Cr/BTNF	On-site	WY
171	M	8	8/21	Jay Cr, BTNF	On-site	WY
155	M	3	9/9	Tepee Cr, TNF (mgt)	Blacktail, YNP	IGBST/ID
101	F	7	9/17	Cabin Cr/Red Canyon, GNF	On-site	IGBST
172	F	2	10/17	Fox Cr, BTNF	On-site	WY

	Females	Males
Adult	7	3
Subadult	1	4

	Females		Males		Retraps Females		Retraps Males	
	Ad	SAd	Ad	SAd	Ad	SAd	Ad	SAd
Research	6	1	3	2	-	-	2	-
Management	1			2	-	-	-	-

New bears = 10 (3 adult females, 1 subadult female, 3 adult males, 3 subadult males)
Total individual bears = 15

[a] BTNF = Bridger-Teton National Forest, GNF = Gallatin National Forest, SNF = Shoshone National Forest, TNF = Targhee National Forest, YNP = Yellowstone National Park.
[b] IGBST = Interagency Grizzly Bear Study Team, YNP = Yellowstone National Park.

A total of 40 grizzly bears were monitored for varying intervals during 1989, including 24 adult females. A maximum of 19 adult females were monitored consecutively during May and June (Figure 1). Fourteen adult females were wearing active transmitters at denning; however, 2 had not been accurately aged when trapped (i.e., premolars were not collected) and ages as "adult" were estimated in the field.

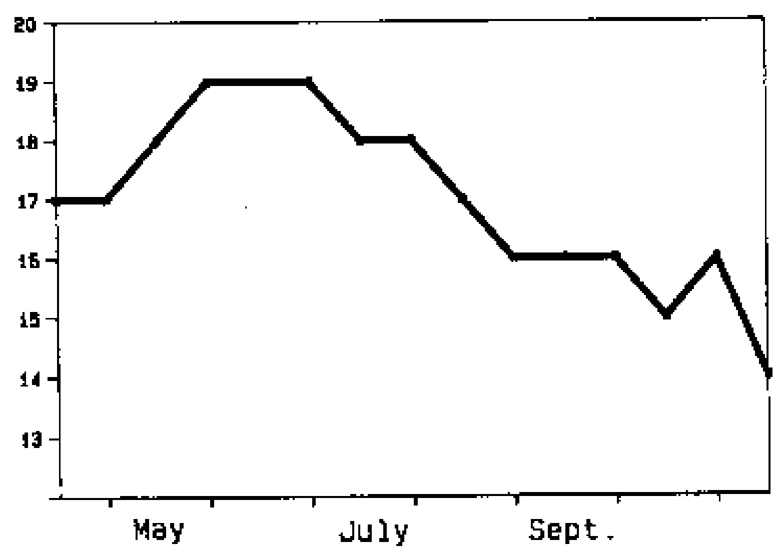

Figure 1. Adult female grizzly bears radio-monitored by 2-week intervals during 1989.

Unduplicated Females

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

Fifteen unduplicated females with 27 COY were observed in Bear Management Units (BMU'S) within the Recovery Zone during 1989 (Figure 2). An additional female with 3 COY was seen in BMU 27 outside the Recovery Zone. The current running 6-year average for the entire study area is 17 females per year with an average litter size of 1.95 cubs (Table 2). This average has steadily increased from an average 12 females per year during the running 6-year period of 1973-78 (Figure 3) to 17 during the period 1984-89.

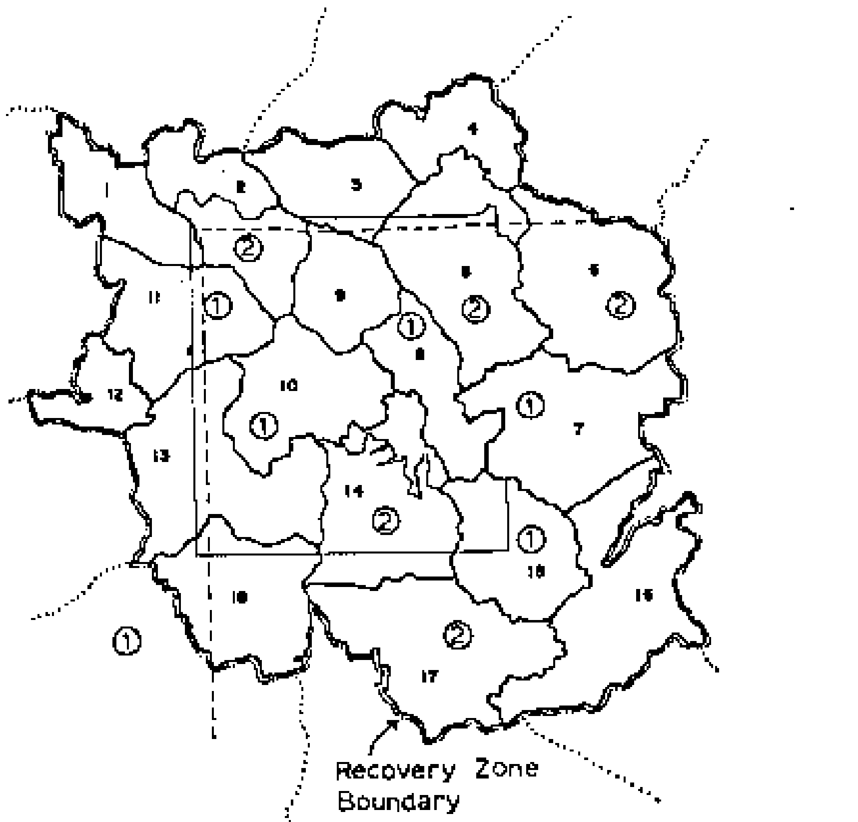

Figure 2. Locations of initial observations of unduplicated females with cubs-of-the-year within Bear management Units during 1989. Number of females is circled.

Table 2. Annual unduplicated female grizzly bears with cubs-of-the-year and adult female deaths, 1973-89.

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
Total	232	442		41
Mean	13.65	26.00	1.91	2.41

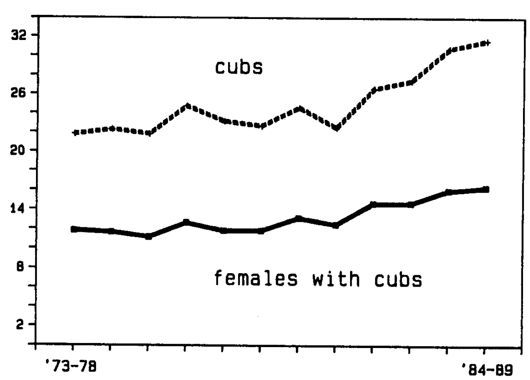

Figure 3. Average annual number of unduplicated females with cubs-of-the-year observed during running 6-year periods, 1973-89.

During 1989, 47% of the unduplicated females with COY were seen on IGBST observation flights (Table 3). Observation flights accounted for an average of 39% of the unduplicated observations during 1986-89 when methodology was similar; 8% were recorded incidentally on observation flights made by other researchers over the study area, 35% from ground sightings, and 18% from IGBST trapping efforts and radio-tracking flights only. Greater effort was expended in 1989 to observe females with COY on observation flights compared to the previous 3 years; however, rate of observation was the lowest recorded since 1986 (Table 4). This poor rate was probably due to good year-long natural food availability (see Food Habits) and normal precipitation levels during 1989. Grizzly bears typically range more widely in search of food during years of below-normal precipitation (Blanchard and Knight in prep.*b*). Bears generally did not have to spend large amounts of time in search of food, thereby decreasing their visibility during daylight hours. This year was in contrast to 1988, a drought year, when the female with COY observation rate was the highest recorded since 1984.

Table 3. Annual unduplicated female grizzly bears with cubs-of-the-year by prioritized method of observation, 1973-89.

	Observation flights		Ground		
Year	IGBST	Other	sightings	Radio flights	Total
1973	2	5	7		14
74	9		6		15
75	1	2	1		4
76	1	3	9	3	16
77		1	8	4	13
78			6	3	9
79	3		7	3	13
1980	4		4	4	12
81	4		2	7	13
82	3		5	3	11
83	4		5	4	13
84	7		10		17
85	2		5	2	9
86	9	2	10	4	25
87	5	1	4	3	13
88	7	1	7	4	19
89	7	2	5	2	16

Table 4. Unmarked grizzly bears observed during observation flights, 1973-89.

Year	Number of flights	Total hours	Total bears	Bears per hour	Unduplicated females with cubs-of-the-year per hour
1973	24	75.90	59	0.78	0.03
74	47	146.30	128	0.87	0.06
75	24	47.20	20	0.42	0.02
76	5	18.50	30	1.62	0.05
77	0				
78	0				
79	7	23.00	14	0.61	0.13
1980	6	22.30	27	1.21	0.18
81	4	16.00	13	0.81	0.25
82	6	23.70	23	0.97	0.13
83	41	124.30	36	0.29	0.03
84	11	29.00	27	0.93	0.24
85	16	30.50	21	0.69	0.07
86	24	52.00	29	0.56	0.17
87	20	47.20	35	0.74	0.11
88	17	33.87	62	0.66	0.21
89	37	88.71	87	0.98	0.08

Each of the 16 observation flight areas was flown twice between 26 June and 12 September (although data were not received for the first flight over Area 4). Average hours per flight were 2.39 and the observation rate of unmarked females with COY was 0.088 per hour (compared to 0.011 per hour on radio-tracking flights). Observation rate of unmarked females with other young was 0.077 per hour on observation flights and 0.027 per hour on radio-tracking flights.

POPULATION PARAMETERS

Reproductive Rate

Reproductive rates were calculated using data from marked females only. Twenty complete cycles were recorded for 17 individuals for which COY litter size was known (Table 5). Reproductive rate was lower during the 8-year period of 1973-80 compared to the 9-year period of 1981-89, even though the mean cycle length was shorter during the earlier period. Larger litters during the later period were responsible for the increased reproductive rate.

Table 5. Completed reproductive cycles of adult females for which entire cub litter size was known.

Year COY[a] produced	Individual females	Litters	COY	Mean litter size	Mean cycle length	Reproductive rate
1973-80	8	11	21	1.91	2.45	0.778
1981-89	9	9	20	2.22	2.78	0.800
Total	17	20	41	2.05	2.60	0.789

[a] Cub-of-the-year.

Mortalities

Only 2 known mortalities were recorded during 1989: an adult male and a female cub-of-the-year. The male was illegally shot during spring along the highway north of Hebgen Lake, Gallatin National Forest. No body parts were taken from the carcass. The cub died naturally in Pelican Valley, Yellowstone National Park, from wounds apparently inflicted by a larger bear.

No adult females were known to die in 1989. That was the only year during this study (1973-89) that this occurred. The total number of mortalities was also the lowest recorded during that 17-year period.

FOOD HABITS

Scat Analysis

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

During 1989, 610 scats were collected and analyzed for content, including 92 deposited in spring, 365 in summer, 142 in fall, and 11 of unknown age (Table 6). Twenty known black bear scats were analyzed, but contents are not reported here due to the small sample size. Foraging strategies in 1989 reflected relatively large numbers of winter-killed and weakened ungulates available during spring (Singer et al. 1989), a substantial yampa crop during summer, and better than normal production of whitebark pine seeds during fall. Ungulates comprised 42%, 33%, and 13% of the volume of April, May, and June scats, respectively, compared to the 1977-87 average of 49%, 17%, and 6% for those 3 months (Mattson et al. 1990). During July, yampa tubers accounted for 20% of scat volume compared to the 10-year average of 2%. Whitebark pine seeds comprised 10%, 62%, and 80% of the August, September, and October scat volumes compared to 18%, 39%, and 39% for the 10-year average.

Sixty-seven percent of the scats were collected in timbered habitats, 23% in the open, and 4% in shrublands. Scats were most frequently found in the timber during June (0.80), September (0.79), and October (0.86), and in the open during May (0.34) and August (0.32).

Table 6. Seasonal grizzly bear scat contents for 1989.

	Spring[a] (*n* = 92)		Summer[b] (*n* = 365)		Fall[c] (*n* = 142)	
	% freq.	% vol.	% freq.	% vol.	% freq.	% vol.
Pine nuts			5.57	4.75	68.18	64.51
Berries			0.27	0.19	0.65	0.13
Sporophytes			6.90	4.50	0.65	0.65
Equisetum			6.11	4.22	0.65	0.65
Foliage:						
Graminoids	54.83	46.07	50.92	31.72	24.03	16.10
Forbs	5.37	1.81	27.03	20.42	5.19	2.98
Claytonia	1.08	0.11	6.10	5.41	0.65	0.65
Epilobium			3.45	2.52		
Cirsium	1.08	0.54	4.51	2.75	0.65	0.26
Taraxacum			2.39	1.83		
Heracleum			3.45	2.79		
Trifolium			5.84	2.40	1.95	0.88
Lomatium	1.08	0.09				
Roots:			17.54	11.73	1.95	1.53
Lomatium	3.23	2.28	1.06	0.64		
Melica	1.08	0.97	0.27	0.03		
Perideridia			14.59	10.13	1.95	1.53
Mammals	60.22	33.55	15.12	6.22	5.19	1.20
Elk	26.88	13.60	10.34	4.44	2.60	2.60
Bison	31.18	18.44	3.98	1.54		
Insects	5.38	0.70	27.06	8.89	18.18	7.92
Ants	5.38	0.70	18.30	2.79	8.44	2.18
Moths			6.63	5.25	9.74	5.75
Trout	1.08	0.05	4.51	1.59		
Debris	39.78	35.50	36.34	9.93	12.34	4.97
Miscellaneous (birds, eggs, garbage)	1.08	0.16	0.27	0.03		

[a] March, April, May.
[b] June, July, August.
[c] September, October.

Whitebark Pine Production

Average whitebark pine cone production throughout the study area was the highest recorded since transects were established in 1980 (Table 7). Mean number of cones per tree was nearly twice that recorded during the 2 previous "best" years, 1980 and 1985. Sixteen of the 21 transects read in 1980 exceeded the 1980-89 average of 18 cones per tree. The five transects below this average were A, C, H, P, and Q (Figure 4).

Table 7. Mean annual whitebark pine cone production on study transects.

Year	Total cones	Total trees	Total transects	Mean cones per tree	Mean cones per transect	Cones/transect/year STD	Cones/transect/year Min.	Cones/transect/year Max.	Mean Julian date read each year
1980	2,312	90	9	25.69	256.89	122.99	139	562	212
81	1,191	90	9	13.23	132.33	148.69	8	489	204
82	1,443	85	9	16.98	160.33	154.18	0	463	229
83	1,531	88	9	17.40	170.11	88.78	78	372	211
84	360	56	6	6.43	60.00	41.41	14	124	220
85	2,312	85	9	27.20	256.89	192.27	17	625	214
86	103	75	8	1.37	12.88	13.18	0	38	207
87	394	155	16	2.54	24.63	37.49	0	118	217
88	406	169	17	2.40	23.88	44.32	0	148	208
89	10,199	209	21	48.80	485.67	384.27	7	1,473	206

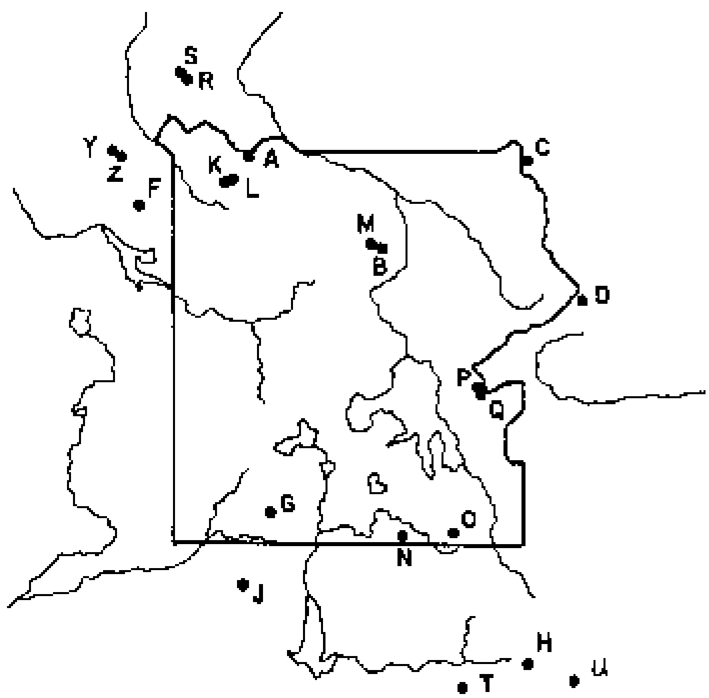

Figure 4. Locations of whitebark pine cone production transects.

Feed Sites

Ground investigation at 200 aerial locations of instrumented bears from April-October revealed evidence of feeding activity at 42% of the sites compared to 60% of the sites investigated during 1988. Least success at finding sign of feeding activity occurred during May and June when such activity was recorded at only 21% of the investigated sites. Evidence of activity other than feeding was recorded at an additional 43 sites, and no sign of bear activity was observed at the remaining 73 sites. Feeding activity was recorded at an additional 156 sites not associated with an aerial location of an instrumented bear. Activity at the 246 total feeding sites is summarized in Table 8. The most frequently recorded feeding activities were scavenging and preying on large mammals (mostly elk) during spring, digging roots (mostly yampa) during summer, and feeding on *Pial* seeds during fall (Table 9).

Table 8. Activities recorded at grizzly bear feeding sites, April-October 1989.

Month	# of feed sites	Types of feeding activities						
		Large mammals	Grazing	Insects	Roots	Small mammals	*Pial* nuts	Misc.[a]
April	21	20	1	0	0	0	0	0
May	27	9	17	0	0	2	0	3
June	21	4	13	0	5	1	0	0
July	56	1	12	22	29	2	0	5
August	66	1	8	14	18	4	11	11
September	46	0	0	1	1	0	38	4
October	9	0	0	0	0	1	8	0
Total	246	35	51	37	53	10	57	23

[a] Miscellaneous = berries, mushrooms, unknown digs, foods associated with human activity.

Table 9. Seasonal frequency of feeding activities at 246 feed site examinations during 1989.

Feeding activity	Spring[a] (n = 48)	Summer[b] (n = 143)	Fall[c] (n = 55)	Total (n = 246)
Digging pine nuts	0	0.077	0.836	0.232
Grazing graminoids and forbs	0.375	0.231	0	0.207
Digging roots	0	0.364	0.018	0.216
Digging small mammals	0.042	0.049	0.018	0.041
Scavenging/preying large mammals	0.604	0.042	0	0.142
Searching insects	0	0.252	0.018	0.150
Miscellaneous[d]	0.063	0.112	0.073	0.094

[a] April, May.
[b] June, July, August.
[c] September, October.
[d] Unknown diggings, berries, mushrooms, foods associated with human activity.

EFFECTS OF THE 1988 WILDFIRES ON YELLOWSTONE GRIZZLY BEARS

Preliminary Report

by
Bonnie M. Blanchard
and
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INTRODUCTION

Wildfires during 1988 burned approximately 12% of the 4.8 million-ha Greater Yellowstone Area which includes Yellowstone National Park and contiguous portions of 6 national forests, 2 national parks, 2 national wildlife refuges, state land, and land in private ownership (Schullery 1989). The burned area was entirely contained within the study area of the Interagency Grizzly Bear Study Team (IGBST) which was initiated in 1973 to determine the status and trend of the resident grizzly bear population.

The primary immediate effect of the fires on grizzly bears was increased availability of some food items, such as elk, during the fall of 1988 through fire-related deaths (Blanchard and Knight 1990). Study plans were formulated to determine long-term effects of the fires on the grizzly population and individuals. This report documents preliminary analyses of data collected during 1989.

METHODS

The working hypothesis to be tested was:

> H_o = The 1988 wildfires had no significant effect upon the subsequent movements and foraging strategies of the Yellowstone grizzly bear population.

Three data sets were used in the analysis:

1. Revisits during 1989 to female grizzly bear aerial radio-telemetry locations examined on the ground 1975-87.
2. Aerial radio-telemetry locations of instrumented grizzly bears during 1989.
3. Grizzly bear feeding site examination records and scat content analysis documented during 1989.

Radio-telemetry techniques and feed-site examination methods are described by Blanchard (1985), and Mattson et al. (1990) have detailed scat analysis procedures. Sites to which bears were transported during management actions were excluded as were subsequent movements induced by transports. Seasons were: spring (March-June), summer (July-August), and fall (September-November). Adults were 4 and older.

RESULTS

Revisits

Fifty-six percent of the 517 revisited aerial radio-location sites had not been burned during the 1988 fires; 206 sites were burned and 22 could not be located. Average intensity of fire at the 206 burned sites was light or light-moderate at 59% of the sites, moderate or moderate-heavy at 26%, and heavy or intense at 15% (see Appendix for intensity definitions).

Vegetative cover at the burned sites was significantly lower than that present during the original examination ($P < 0.037$, paired-t)(Table 10). Live forest cover was reduced by 43% at the 151 forested revisited sites which burned; whitebark pine cover was reduced by 54%. However, mean height of foliage (forbs and graminoids) at forested sites and mean height of shrubs at nonforested sites were not significantly reduced at the burned sites.

Table 10. Comparison of mean vegetative cover and height at original feeding sites recorded 1975-87, with revisited sites in 1989 which were burned during 1988.

	Forest sites (n = 151)		Nonforest sites (n = 55)	
	Original	Revisit	Original	Revisit
Foliage[a] height (cm)	18.36	16.65	25.42	19.17
Shrub height (dm)	2.65	0.92	4.57	7.58
Graminoid cover (%)	30.60	5.93	41.88	12.66
Forb cover (%)	20.28	6.31	28.27	11.77
Shrub cover (%)	23.11	2.10	13.83	3.09
Forest cover (%)	47.82	5.27	4.53	0.85
Deadfall cover (%)	4.73	7.36	0.11	0.36

[a] Foliage = graminoids and forbs.

1989 Telemetry

During 1989, 78% of the 40 grizzly bears radio-monitored were located all or portions of the year within the fire perimeter, including 20 females (18 adult) and 11 males (7 adult). Five of these 31 bears were never located at a burned site.

All cohorts were most often located in burned areas during summer ($P < 0.032$, paired-t). Twenty-one percent of all locations were at burned sites during spring, 32% during summer, and 10% during fall. These differences in frequencies of occurrence among seasons were all statistically significant when both paired-t and Chi-square goodness of fit tests were made ($P < 0.090$). During fall, the majority of grizzly bears were located in unburned whitebark pine forests consuming the abundant whitebark seeds being harvested by red squirrels (see Food Habits section).

During spring, females with cubs-of-the-year (COY), lone adult females, and males were found at burned sites less often than females with yearlings or 2-year-olds and subadult females ($P = 0.001$, $t = 3.734$, $df = 24$). No significant difference among cohorts was apparent during summer or fall.

Annual range sizes were smaller in 1989 for 5 grizzly bears whose ranges in 1987 were also known (Mann-Whitney U, $P = 0.006$, $Z = 2.507$) (Table 11). Females generally have smaller annual ranges when with COY (Blanchard and Knight, in prep.*b*), and 1 of these 5 did have COY in 1989 (Bear 134). However, annual ranges were still significantly smaller in 1989 for the other 4 ($P = 0.015$, $Z = 2.165$).

Table 11. Annual range sizes of 5 adult grizzly bears radio-monitored, 1987-89. Locations associated with management transports are not included and range sizes are minimum convex polygons.

		1987			1988			1989		
Bear	Sex	km^2		*n*	km^2		*n*	km^2		*n*
118	F	204	(alone)	24	---	(COY)	6	155	(yearlings)	22
125	F	221	(alone)	35	167	(alone)	27	70	(alone)	30
126	F	209	(alone)	35	348	(COY)	29	82	(yearlings)	22
134	F	271	(alone)	30	88	(alone)	24	147	(COY)	40
140	M	815		18	25		18	343		23

1989 Feed-Site Examinations

Twenty-five percent of the 390 grizzly bear activity sites examined in 1989 occurred at burned sites. Average fire intensity at the burned sites was light to moderate. Greatest frequency of burned site use was during May, June, and July, accounting for 18% of the total feed sites (Table 12).

Table 12. Grizzly bear feeding site examinations during 1989 at burned and unburned sites. Frequencies are given in parentheses.

Month	Burned		Unburned		Total
April	3	(0.03)	25	(0.09)	28
May	17	(0.18)	34	(0.12)	51
June	25	(0.26)	50	(0.17)	75
July	27	(0.28)	62	(0.21)	89
August	18	(0.19)	63	(0.21)	81
September	6	(0.06)	51	(0.17)	57
October	0		9	(0.03)	9
Total	96		294		390

No sign of feeding activity could be found at 71% of the radio-location sites which had burned and were investigated on the ground compared to 46% at unburned sites (paired-t, $P = 0.023$, $t = -2.627$). Least sign of feeding activity was found in May and June while most was observed in August at both burned and unburned sites. Frequencies of feeding sites examined by month were not statistically different between burned and unburned sites (Chi-square goodness of fit test).

The most frequently observed types of feeding at burned sites were grazing on succulent vegetation and digging for root crops, whereas feeding on *Pial* seed, ants and large mammals was the most common feeding activity in unburned sites (Table 13). These differences were statistically significant for roots (paired-t, $P = 0.090$, $t = -1.557$) and ants (paired-t, $P = 0.098$, $t = 1.494$). Although paired sample sizes were too small to statistically test frequencies of *Pial* seed feeding between burned and unburned sites, no instances of this activity were noted at burned sites compared to 57 instances at unburned sites.

Table 13. Types and frequencies of feeding activity recorded at burned and unburned sites during 1989.

		Total	No feeding sign	Large mammals	Grazing	Ants	Roots	*Pial* seeds	Misc.[a]
Apr	b[b]	3	2	1	0	0	0	0	0
	u[c]	25	5	19	1	0	0	0	0
May	b	17	9	2	7	0	0	0	1
	u	34	15	7	10	0	0	0	4
Jun	b	25	21	1	2	0	2	0	1
	u	50	33	3	11	0	3	0	0
Jul	b	27	10	0	6	0	12	0	1
	u	62	23	1	6	22	17	0	6
Aug	b	18	5	0	6	1	6	0	2
	u	63	10	1	2	13	12	11	13
Sept	b	6	4	0	0	0	0	0	2
	u	51	7	0	0	1	1	38	2
Oct	b	0							
	u	9	0	0	0	0	0	8	1

[a] Miscellaneous: berries, mushrooms, pocket gophers, unknown digs, human foods.
[b] b = burned sites.
[c] u = unburned sites.

SUMMARY

No evidence was found to support the theory that the 1988 wildfires affected foraging strategies or movements of grizzly bears in 1989. Smaller annual range sizes were more likely a result of good foraging opportunities unrelated to the fires. The fires apparently affected foraging strategies by:

1. Contributing to the availability of carrion during spring through reduction of forage on winter ranges (Singer et al. 1989).
2. Reducing or eliminating grazing opportunities at some sites and enhancing them at others.
3. Severely reducing future opportunities for use of whitebark pine seeds in burned forests where whitebark occurred.

EFFECTS OF FIRE ON CUTTHROAT TROUT SPAWNING STREAMS AND ASSOCIATED BEAR USE

by

Daniel P. Reinhart

INTRODUCTION

The fires that burned over the Greater Yellowstone Area (GYA) during 1988 are the largest fire complex recorded for that area (Christensen et al. 1989), and were unprecedented in the fire history of Yellowstone National Park since the early 1700's (Romme and Despain 1989). These fires affected many ecological systems including 20 river and 4 large lake watershed drainages (Minshall et al. 1989). Among the drainages affected by the GYA fires of 1988 are tributary streams of Yellowstone Lake in Yellowstone National Park.

The influences of fire on stream systems and their aquatic biota are predominantly changes in the hydrologic responses of drainage systems and associated changes in stream habitat. Fire-related changes in water quantity and quality, altered timing and intensity of peak discharges, and alterations of stream physical characteristics can affect the aquatic biology of affected stream systems (Novak 1988, Fisheries Assessment Team 1989).

Yellowstone Lake has the largest inland population of cutthroat trout *(Oncorhynchus clarki*)(Varley and Gresswell 1988). Each year from May through July, cutthroat trout migrate up tributary streams of Yellowstone Lake to spawn. While in these streams, they are vulnerable to numerous predators including bears (*Ursus* spp.). Cutthroat trout constitute an important high quality food for Yellowstone grizzly bears (*Ursus arctos*) (Reinhart and Mattson 1987). Bear use of spawning cutthroat trout was studied by the Interagency Grizzly Bear Study Team (IGBST) in the 1970's (Hoskins 1975) and from 1985 through 1987 (Reinhart 1988).

As part of a fire-related assessment of the GYA, the IGBST initiated research in 1989 to determine changes in movements and habitat use of grizzly bears after the 1988 fires. This paper addresses effects of fire on cutthroat trout spawning runs and associated bear use. Information was gathered from: (1) previous studies of bear-cutthroat trout relationships and fire impacts on stream systems; (2) assessment of Yellowstone Lake drainage burns from Geographical Information System maps; (3) data collected in 1989 from an IGBST reconnaissance survey of all Yellowstone Lake spawning streams during the cutthroat trout spawning run; and (4) weekly spawner surveys of tributary streams in the Lake and Grant Village developments conducted by the Yellowstone National Park resource management staff.

FIRES OF 1988

The 1988 fires originating from both lightning and human causes burned 570,627 ha (11%) of the GYA, including 989,000 ha (45%) of Yellowstone National Park (Christensen et al. 1989). Three fire complexes burned extensive portions of the Yellowstone Lake drainage basin (Figure 5). The Snake River complex burned drainages of the west and south shores of Yellowstone Lake including streams in the West Thumb, Flat Mountain Arm, South Arm, and Southeast Arm. The Mink fire burned the Two Ocean-Thorofare area southeast of Yellowstone Lake and affected drainages of the Yellowstone River Inlet which enters Yellowstone Lake in the Southeast Arm. The Clover-Mist fire burned northwest of Yellowstone Lake and burned portions of the Pelican Creek drainage north of Yellowstone Lake.

The Yellowstone Lake drainage is an estimated 261,590 ha (Benson 1961). Twenty-eight percent of this drainage basin burned to some extent in 1988 (Minshall et al. 1989). In Yellowstone National Park the Yellowstone Lake drainage comprises 174,709 ha; of this, 38,740 ha or 22% burned in 1988. Areas of the drainage not included in Yellowstone National Park are the south and east portions of the Yellowstone Inlet tributaries in the Shoshone and Bridger-Teton National Forests. Burned areas of the drainage basin in Yellowstone Park are classified as: 50% mixed canopy-surface burn, 40% canopy burn, 4% nonforested burn, and 6% unclassified burn (Geographical Information Systems Division, Yellowstone National Park).

HYDROLOGIC RESPONSES

Large fires can significantly alter the hydrological characteristics of a drainage system and cause dramatic effects to their fish population (Novak 1988, Fisheries Assessment Team 1989). Immediate effects of fire can be increased stream temperatures (Helvey et al. 1976) and changes in water chemistry (Tiedemann et al. 1979). However, because of the high specific heat of water and replenishment from ground water sources, it is unlikely that increased water temperatures from Yellowstone fires caused stress to the fish population (Helvey et al. 1976, Albin 1979, Minshall et al. 1989). Moreover, at the time of the 1988 fires around Yellowstone Lake, the cutthroat trout spawning runs were completed and post-spawners had returned to the lake. Possible stress to trout eggs or emerging fry is unknown. Changes in water chemistry from fire were probably not severe enough to adversely affect the fish population (Albin 1979, Tiedemann et al. 1979, Minshall et al. 1989).

Longer term effects of stream systems from fires caused by the opening of the forest canopy include increased variation of water temperatures, more intense runoff from hill slopes, higher stream sediment loads, and alteration of stream channel morphology. Removal of vegetation and litter on watershed hill slopes causes decreased interception of rainfall, reduced infiltration of soil moisture, and more rapid runoff of overland waterflow (Tiedemann et al. 1979, Swanston 1980).

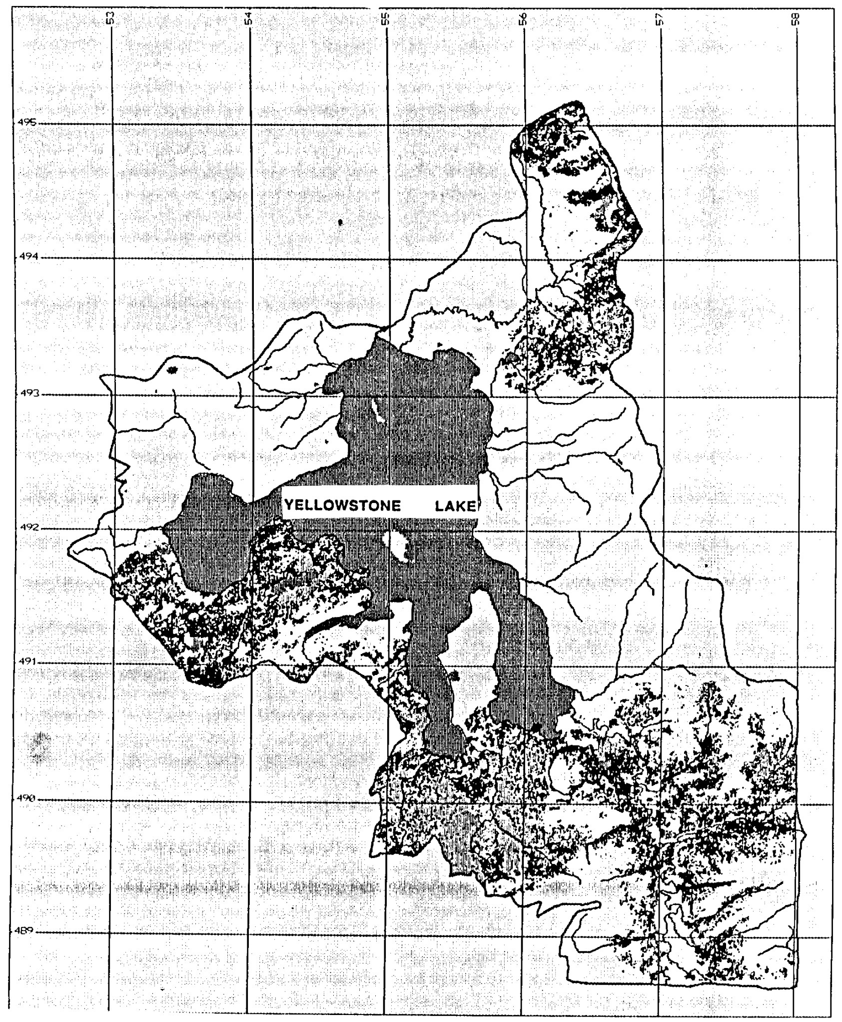

Figure 5. Map of Yellowstone Lake and its drainage basin; extent of 1988 fires shown in dark shading.

Similarly, spring snowmelt of watersheds following severe fires are more rapid because of the loss of canopy shading and from increased longwave radiation from the blackened landscape (Tiedemann et al. 1979). Increased runoff can also result from a water repellent layer of ash formed after a fire (Swanston 1980). These events usually lead to earlier and flashier peak streamflows which can increase surface erosion of hill slopes and cause higher stream sediment loads and turbidity. This may alter stream channel morphology and substrate composition (Tiedemann et al. 1979, Swanston 1980, Minshall et al. 1989).

CUTTHROAT TROUT SPAWNING STREAMS

Of 124 tributaries of Yellowstone Lake, 58 streams or 47% had evidence of a cutthroat trout spawning run (Reinhart 1988). Of these streams, 34 or 59% were located partially or wholly within burns. Eight of these streams were burned on the upper drainage hill slopes, and 4 streams on the west shore and West Thumb were severely burned down to the streambed (Table 14). Most stream bottoms were characterized by open riparian corridors that were not burned intensely and acted as a buffer between the forest canopy burn and the stream channel. Consequently, there was no apparent increase in streambank erosion or change in substrate composition of most spawning streams.

Stream drainages most severely burned occurred on the west and south shores of Yellowstone Lake. These were predominantly first- and second-order streams on the West Thumb, the west shore near Delusion Lake, and the southern portions of the South and Southeast Arms (Figure 5). Most tributaries of the Yellowstone River Inlet were burned extensively. These streams had previous evidence of a cutthroat trout spawning run (IGBST unpublished data) but were not surveyed in an IGBST post-burn assessment in 1989. Portions of the upper Pelican Creek drainage also burned but did not appear severe enough to affect stream features.

Potential post-fire effects on cutthroat trout spawning streams include changes in timing and duration of spawning runs as a result of altered runoff characteristics. Timing of salmonid spawning runs is primarily controlled by streamflows and water temperatures (Hynes 1970). These are influenced by winter snowpack and spring weather. Altered snowmelt characteristics from the burned landscape can cause earlier and shorter spawning runs because of earlier and more intense stream discharges from the changed watershed landscape (Tiedemann et al. 1979, Christensen et al. 1989).

Timing variation of spawning runs on burned streams is illustrated by weekly spawner counts of burned streams near Grant Village and unburned streams near Lake (Figure 6). Spawner use of Grant Village streams peaked on 4 June 1989 and lasted approximately 29 days. This is compared to pre-burn peak spawning activity on 25 May 1987 and 19 June 1986. Spawning duration for 1987 and 1986 were 46 and 42 days, respectively.

Table 14. Tributary streams of Yellowstone Lake; spawning and bear activity survey results, 1985-87 and post-burn 1989; post-burn classification included.

Area	Stream[a]	Results[b,c] 1985-87	1989	Burn[d,e]
West Shore	Solution Cr	S,B	S	1
	1158	S,B,F	B	5*
	1157	S,B,F	B,F	3
Flat Mountain Arm	Flat Mountain Cr	S,B,F	S,B,F	1
	1150	S,B,F	B,F	U
	1147	S,B	B	U
	1146	S,B,F	S,B,F	U
	1144	S,B	B	U
	1143	S,B	B	U
	1141	S,B	B	U
South Arm	1139	S,B	B	2
	1138	S,B,F	S,B	1
	1137	S,B	S,B	2
	1134	S,B	B	2
	1132	S,B	B	1
	1131	S,B	B	1
	1127	S,B,F	S,B	2
	1126	S,B,F	S,B,F	3
	Grouse Cr	S,B	S,B	2
	1123	S,B,F	B	2
	1122	S,B,F	B	2
	Chipmunk Cr	S,B	S	3
	1119	S	-	0
	1118	S,B	B	0
Southeast Arm	1115	S	-	0
	1114	S,B	S,B	3
	1113	S,B	S,B	3
	1111	S,B,F	S,B,F	2
	Trail Cr	S,B	B	2
	Yellowstone Inlet	S,B	-	3
	Beaverdam Cr	S,B,F	S,B	U
	1103	S,B,F	S,B,F	0
	Columbine Cr	S,B	S,B	0
	Meadow Cr	S,B	S	0
	Clear Cr	S,B,F	S,B,F	0
	1094	S,B	B	0
	Cub Cr	S,B,F	S,B,F	0
	1091	S,B,F	S,B	0

Table 14. Continued.

Area	Stream[a]	Results[b,c] 1985-1987	1989	Burn[d,e]
North Shore	Pelican Cr	S,B,F	S,B	0
	Lodge Cr	S,B,F	S,B,F	0
	Hotel Cr	S,B,F	-	0
	Hatcher Cr	S,B,F	S,B	0
	1200	S,B	-	0
	1199	S,B,F	S,B	0
	1198	S,B,F	S,B	0
	Bridge Cr	S,B,F	S,B,F	0
	Weasel Cr	S,B,F	S,B,F	0
West Thumb	Arnica Cr	S,B,F	S	0
	Little Arnica Cr	S,B,F	S	0
	1180	S,B,F	B	0
	1179	S,B,F	S,B,F	0
	1177	S,B,F	S,B,F	2
	Little Thumb Cr	S,B,F	S,B,F	1
	1169	S,B,F	S	4*
	Thumb Cr	S,B	S	2
	1167	S,B,F	S,B	3
	Sandy Cr	S,B,F	S,B,F	3*
	Sewer Cr	S,B,F	S,B,F	3*

[a] Streams designated by name or SONYEW number.
[b] Stream survey results: S = spawners present, B = bear sign, F = bear fishing.
[c] Stream survey results 1985-87 from Reinhart (1988).
[d] Burn classification described by Swalley (this volume).
[e] Burned streams: U = burn in upper drainage only; * = burn to streambed.

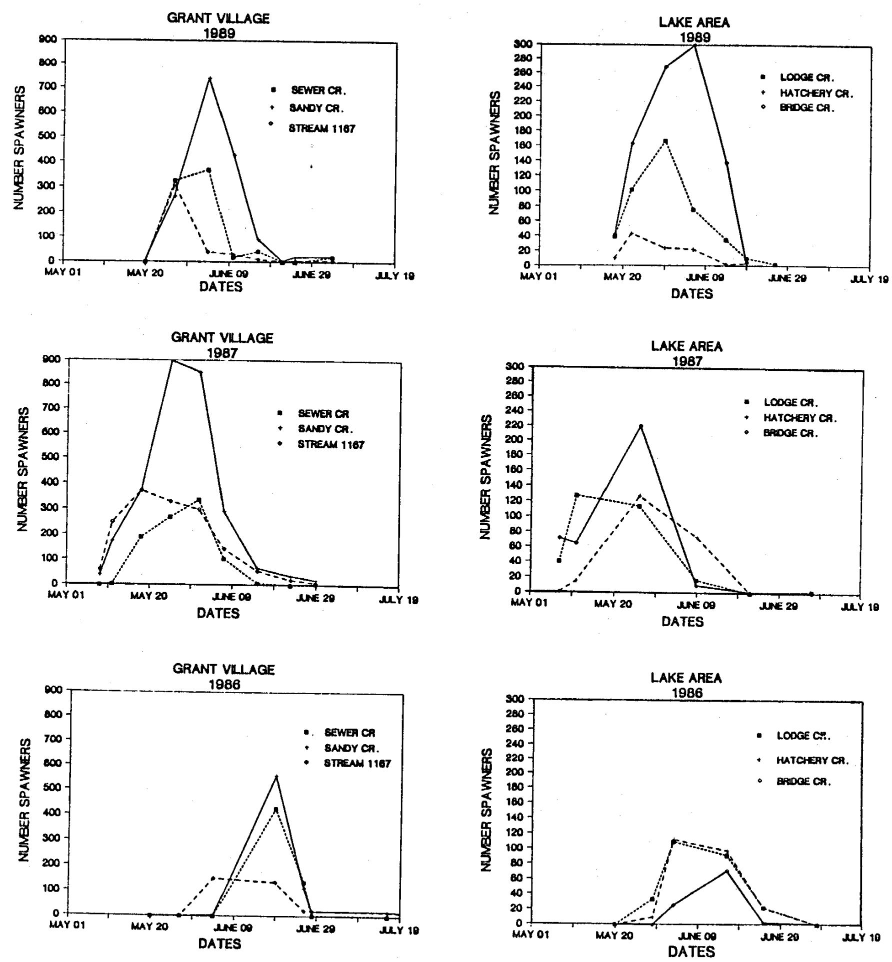

Figure 6. Temporal spawning activity levels for Grant Village and Lake area streams in 1986, 1987, and post-burn 1989.

Peak spawning dates for unburned Lake streams were comparable to Grant Village dates; duration of spawning runs for 1989, 1987, and 1986 were 32, 33, and 27 days, respectively. Snowmelt runoff was considered low for 1987 and high for 1986. The 1989 snowpack was near to above normal (Soil Conservation Service Snotel Data). Peak spawning dates for burned Grant Village streams were within the range of normal yearly variation. However, spawning run duration on burned streams was apparently shorter than in previous years.

Comparison of 1989 levels of cutthroat trout spawning runs for all Yellowstone Lake spawning streams with previous study years show some variation between burned and unburned streams. Differences in spawner numbers between 1989 and the mean of 1985-87 levels on similar dates were marginally significant between burned and unburned streams ($P = 0.08$, Wilcoxon). This tendency was more clearly expressed when comparing volumetric density of spawners (cf. Reinhart and Mattson 1987) between burned and unburned streams ($P = 0.05$, Wilcoxon). These relationships do not confirm, but suggest that variation in levels of cutthroat trout spawning runs between 1989 and previous years' levels could be a result of burn characteristics.

BEAR USE

Bear use of all cutthroat trout spawning streams was not apparently different from previous study years. Comparisons of 1989 bear activity levels (cf. Reinhart and Mattson 1987) with similar dates of previous study years show no difference between burned and unburned streams ($P = 0.96$, Wilcoxon). Bear fishing indices (cf. Reinhart and Mattson 1987) also were not significantly different between 1989 and previous study years on burned versus unburned streams ($P = 0.49$, Wilcoxon). These relationships suggest that, whether or not variation of cutthroat trout spawning runs occurred on burned streams, measured levels of bear use did not change.

Bear use of spawning streams was not measured for the duration of the 1989 spawning run. If spawning run duration was shorter on burned streams than expected on previous pre-burn years, the temporal availability of trout to bears may have been diminished by some degree.

CONCLUSIONS

The aquatic biota or fauna responses associated with fluvial habitats from fires or other natural disturbances have not been well studied (Tiedemann et al. 1979, Minshall et al. 1989). Impacts of spawning cutthroat trout and associated bear use were assessed in 1989 after the 1988 GYA fires. Tributary streams of Yellowstone Lake were surveyed and compared with previous study years to determine possible changes in spawning runs and bear use. Although more work is needed to more clearly describe effects of fire on trout and bears, some observations can be made.

Over half of all spawning streams of Yellowstone Lake were affected by the 1988 fires. Most streams, however, were not burned severely enough to alter their channel morphology or substrate composition and consequently affect spawning capabilities. Changes in timing and magnitude of snowmelt runoff from the loss of canopy shading and the blackened landscape probably affected stream temperatures and flow characteristics. This may have altered the timing and duration of cutthroat trout spawning runs on burned streams by making them earlier and shorter than expected. However, temporal variation of spawning runs on burned streams were within the range of spawning runs of previous study years.

Bear use of spawning streams was apparently not different from previous years' levels on burned and unburned streams. Although bear use was not fully measured for the duration of spawning runs, bear access to fish may have been shortened on burned streams compared to unburned or pre-burned streams.

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Appendix

BURN CATEGORIES FOR THE YELLOWSTONE ECOSYSTEM

Developed for the Interagency Grizzly Bear Study Team
by
Roger Swalley

Methods: Categories apply during year following fire
Scale = 0 to 9

FOREST

1. Light Burn

   Majority of trees in plot are alive.

   Most dead trees have retained brown needles.

   Ground deadfall is lightly charred.

   Regrowth of graminoids, forbs, and shrubs is continuous where continuous vegetation ground layer existed before fire.

2. Light-Moderate Burn

   Majority of trees in plot are dead.

   Most dead trees have retained brown needles.

   Ground deadfall nearly all charred, but intact and solid.

   Regrowth of graminoids, forbs, and shrubs is mostly continuous, however some breaks in ground layer may exist.

3. Moderate Burn

   All trees in plot are dead.

   Majority of dead trees have not retained brown needles.

   Small twigs in crown are present, or mostly present.

   Ground deadfall completely charred, with possibly some burned through.

   Regrowth of graminoids and forbs patchy, with little to no regeneration of shrubs.

4 . Moderate-Heavy Burn

All trees in plot are dead.

Dead trees have not retained brown needles.

Almost no small twigs in crown are present.

Ground deadfall completely charred; some completely burned leaving orange and/or white patches in soil.

Some spalling of rocks present.

Regrowth of graminoids and forbs patchy, with no, or nearly no regeneration of shrubs.

5. Heavy Burn

All trees in plot are dead.

Dead trees have not retained brown needles.

Only larger branches of trees remain; no twigs present.

Deadfall completely burned with little to none remaining.

Spalling of rocks common.

Little to no regrowth of graminoids or forbs.

No shrub regrowth.

Large patches of barren ground common.

6. Intense Burn

All trees in plot are dead, and the majority were uprooted during the fire.

No regrowth of ground vegetation apparent.

Extensive patches of bare mineral soil apparent.

Spalling of rocks frequent.

NONFOREST

7. Light Burn

   Noncontinuous burn with majority of area unburned.

   Revegetation prevalent throughout area.

   Shrubs, if previously present, mostly unburned.

8. Light-Moderate Burn

   Burn fairly continuous encompassing majority of area.

   Revegetation patchy with small areas of blackened bare soil.

   Shrubs, if previously present, mostly burned with some possible basal regrowth.

9. Moderate Burn

   Burn continuous encompassing most of total area.

   Revegetation sparse to nonexistent with large areas of blackened soil exposed.

   Shrubs, if previously present, mostly burned with no regrowths.