Yellowstone Grizzly Bear Investigations

1998

Annual Report of the Interagency Grizzly Bear Study Team

YELLOWSTONE GRIZZLY BEAR INVESTIGATIONS

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1998

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

Charles C. Schwartz and Mark A. Haroldson, Editors

This report is published primarily for the use of the members of the Interagency Grizzly Bear Committee and the Yellowstone Ecosystem Subcommittee. Results are preliminary and not for citation without permission of the editors.

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INTRODUCTION *(Charles C. Schwartz, Interagency Grizzly Bear Study Team; and David Moody, Wyoming Game and Fish Department)*

It was recognized as early as 1973, that in order to understand the dynamics of grizzly bears (*Ursus arctos horribilis*) throughout the Greater Yellowstone Area, that there was a need for a centralized research group responsible for collecting, managing, analyzing, and distributing all data. To meet this need, agencies formed the Interagency Grizzly Bear Study Team (IGBST), a cooperative effort among the U.S. Geological Survey, National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service (USFWS), and the States of Idaho, Montana, and Wyoming. The responsibilities of the IGBST are to: (1) conduct both short and long-term research projects addressing information needs for bear management, (2) monitor the bear population, including status and trend, numbers, reproduction, and mortality, (3) monitor grizzly bear habitats, foods, and impacts of humans, and (4) provide technical support to agencies and other groups responsible for the immediate and long-term management of grizzly bears in the Greater Yellowstone Area.

Quantitative data on grizzly bear abundance, distribution, survival, mortality, nuisance activity, and bear foods are critical to formulating management strategies and decisions. Moreover, this information is critical for evaluating the recovery process. The IGBST promotes data collection and analysis on an ecosystem scale, prevents overlap of effort, and pools limited economic and personnel resources.

Earlier research on grizzlies within Yellowstone National Park (Craighead et al. 1974) provides population data for the period 1959-67. However, closing the open-pit garbage dumps and cessation of the ungulate reduction program in Yellowstone National Park in 1967, markedly changed food habits (Mattson et al. 1991*a*), population demographics (Knight and Eberhardt 1985), and growth patterns (Blanchard 1987) for grizzly bears. Since 1975, the IGBST has produced an annual report summarizing all grizzly bear monitoring and research efforts within the Greater Yellowstone Area. As a result, distribution of grizzly bears within the Greater Yellowstone Area (Basile 1982, Blanchard et al. 1992), movement patterns (Blanchard and Knight 1991), food habits (Mattson et al. 1991*a*), habitat use (Knight et al. 1984), and population dynamics (Knight and Eberhardt 1985, Eberhardt et al. 1994, Eberhardt 1995) have been previously addressed. Nevertheless, monitoring and updating continues so that status can be annually evaluated. This report contains the results of our efforts during 1998. A summary of grizzly bear-human conflicts within the Greater Yellowstone Area will be provided as a separate report (Gunther et al. 1999). Beginning next year, the conflict summary will be included here in an effort to consolidate all data into a single annual report addressing the status of the grizzly bear in the Greater Yellowstone Area.

Continuing IGBST research entails evaluating methods to identify important habitats and the impacts of humans on these habitats. We present initial results from an analysis of open and total road densities and percent secure area by Bear Management Unit (BMU) for the Grizzly Bear Recovery Zone (USFWS 1993). We also began evaluating the application of Resource Selection Functions (Manly et al. 1993) to help quantify habitat value. Movement and home range data (cf. Blanchard and Knight 1991) suggest that the grizzly bears in Yellowstone are a semi-autonomous population. This makes it necessary to monitor population size at an ecosystem scale. We are currently evaluating techniques to monitor population trend (Boyce, M. J., D. I. MacKenzie, B. F. J. Manly, M. A. Haroldson, and D. Moody. In review. Negative binomial models for counts of unique individuals, personal communication) and estimate population size. As in past years, we use the 1998 count of unduplicated females with cubs-of-the-year (COY) to generate an estimate of the minimum population size. Beginning in 1998, the IGBST modified the aerial observation protocol to evaluate the potential of capture-mark-resight to estimate population size. We use radio-collared bears as marks and to determine closure following the protocol described by Miller et al. (1997). We continued to monitor the number of unique grizzlies feeding on cutthroat trout (*Oncorhynchus clarki*) spawning streams of Yellowstone Lake. This study employs the use of DNA fingerprinting from hair samples. We also monitored the numbers of spawning cutthroat trout on selected streams of Yellowstone Lake. These data are compared to historic counts and used to develop an index of fish abundance to aid in tracking cutthroat trout population changes associated with the introductions of exotic lake trout (*Salvelinus namaycush)* and whirling disease. We continued to monitor spring ungulate carcass numbers and cone production of whitebark pine (*Pinus albicaulis*) on selected transects to index food abundance.

The annual reports of the IGBST summarize annual data collection. Because additional information can be obtained after publication data summaries are subject to change. For that reason, data analyses and summaries presented in this report supersede all previously published data. The study area and sampling techniques are reported by Blanchard (1985), Mattson et al. (1991*a*), and Haroldson and Schwartz (1998).

This report truly represents a "study team" approach. Many individuals contributed either directly or indirectly in its preparation. To that end, we have identified author(s). We also wish to thank Chad Dickinson, Mark Lamoreux, Roger Swalley, James Helsley, Mark Biel, Dan Reinhart, Travis Wyman, Jason Hicks, Rick Swanker, Hillary Robison, Kurt Alt, Keith Aune, Kevin Frey, Chuck Anderson, Mark Bruscino, Chris Queen, Craig Sax, Gary Brown, John Emmrich, Larry Roop, Steve Cain, Wendy Clark, Sue Consolo-Murphy, Bonnie Gafney, Kerry Gunther, Kerry Murphy, Tom Olliff, Dave Price, Doug Smith, Peter Gogan, Ted Chu, Jeff Copeland, Kim Barber, J.T. Stangl, Mark Hinschberger, Brian Aber, Adrian Villaruz, Connie King, Bill Chapman, Doug Chapman, Rich Hyatt, Gary Lust, Stan Monger, Jerry Spencer, Dave Stradley, Roger Stradley, Randy Arment, Kim Keating, and Steve Cherry for their contributions to data collection, analysis, and other phases of the study. Thanks also to Jeff Henry and Kim Keating for permission to use the photos on the cover. Without the collection efforts of many, the information contained within this report would not be available.

Yellowstone Grizzly Bear Investigations for 1995-1998 are now available at http://www.nrmsc.usgs.gov/research/igbst-home.htm

RESULTS AND DISCUSSION

Bear Monitoring and Population Trend

Marked Animals *(Mark Haroldson, Interagency Grizzly Bear Study Team; and Mark Ternent, Wyoming Game and Fish Department)*

During the field season of 1998, we captured and handled 35 individual grizzly bears on 40 occasions (Table 1). We captured 13 females (6 adult) and 22 males (8 adult); 25 individuals were new bears not previously marked.

We captured 32 bears during our research trapping efforts; all were handled and released on site. We trapped 721 trap days (1 trap day = 1 trap set for 1 day) in 11 BMUs or their respective 10-mile outer perimeter area (Figure 1). Trap success was 1 bear for every 22.5 trap days.

Seven bears were captured as a result of direct conflict with humans (management actions). Four of these bears were transported to new locations and released; 1 was moved twice. The actions on these 4 bears were considered preventative in nature since the bears (all subadults) were not causing damage at the time of capture; all were eating apples near human developments. One management capture involved a yearling male that was released on site when its mother, who was the intended target, could not be captured. Two bears were captured and euthanized as a result of second offense sheep depredation. Although Wyoming Game and Fish (WYGF) personnel participated in only 1 management capture; they attempted without success to catch problem bears in 3 additional BMUs and at 2 livestock allotments outside of the 10-mile BMU perimeter area. A more complete narrative of these management actions can be found in Gunther et al. (1999).

We monitored 58 radio-collared grizzly bears during the 1998 field season, including 17 adult females (Tables 2 and 3). Thirty-eight bears entered their winter dens wearing functional transmitters.

Unduplicated Females *(Mark Haroldson, Interagency Grizzly Bear Study Team)*

Knight et al. (1995) detail the procedures used to determine whether or not observed females with COY are unique. Appendix F of the Grizzly Bear Recovery Plan (USFWS 1993) provides "Revised reporting rules for Recovery Plan Targets, July 12, 1992." Rule 1 states that "unduplicated females with cubs will be counted inside or within 10 miles of the Recovery Zone line." Here we report data for unduplicated counts following this revised rule.

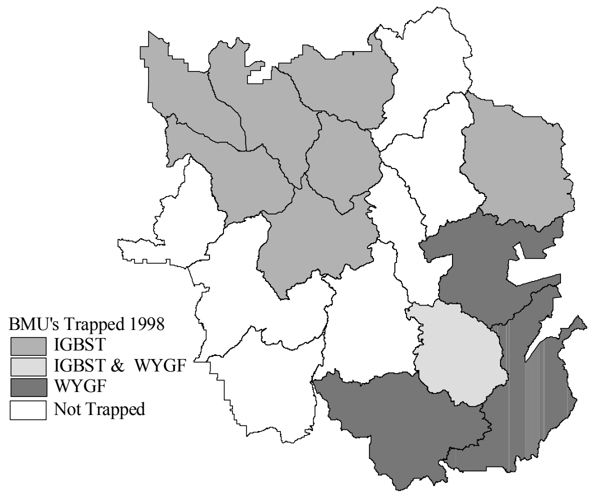
During 1998, we identified 35 unique females accompanied by 70 COY in the Greater Yellowstone Area (Figure 2). Average observed litter size was 2.0. The current running 6-year average (1993-98) for unduplicated females with COY is 26 with a 6-year average litter size of 2.1 cubs (Table 4). We observed unique females with COY in 12 of 18 BMUs within the Recovery Zone (Figure 2). Four were initially observed outside the Recovery Zone, but well within 10-mile perimeter area of the Recovery Zone boundary.

Table 1. Grizzly bear capture records for 1998.

Bear	Sex	Age	Date	General location[a]	Capture type	Release site	Trapper/handler[b]
302	Male	Adult	5/6/98	Burroughs Cr, SNF	Research	On site	WYGF
			5/19/98	Cartridge Cr, SNF	Research	On site	WYGF
303	Female	Adult	5/11/98	Long Cr, SNF	Research	On site	WYGF
304	Male	Subadult	5/12/98	Long Cr, SNF	Research	On site	WYGF
305	Female	Subadult	5/14/98	Horse Cr, SNF	Research	On site	WYGF
			5/28/98	Horse Cr, SNF	Research	On site	WYGF
291	Male	Subadult	5/16/98	Brent Cr, SNF	Research	On site	WYGF
306	Male	Subadult	5/20/98	Gas Cr, SNF	Research	On site	IGBST
307	Male	Subadult	5/21/98	Painter Cr, SNF	Research	On site	IGBST
128	Female	Adult	5/26/98	Horse Cr, SNF	Research	On site	WYGF
308	Female	Adult	6/3/98	Cartridge Cr, SNF	Research	On site	WYGF
G63	Male	Yearling	6/3/98	Cartridge Cr, SNF	Research	On site	WYGF
309	Male	Adult	6/12/98	Gravelbar Cr, SNF	Research	On site	IGBST
310	Male	Subadult	6/14/98	Beam Gulch, SNF	Research	On site	IGBST
311	Female	Adult	6/15/98	Gas Cr, SNF	Research	On site	IGBST
251	Male	Adult	6/18/98	N Fork Buffalo, BTNF	Research	On site	WYGF
312	Male	Yearling	6/29/98	S Fork Shoshone, Pr-WY	Management	On site	WYGF
301	Male	Subadult	7/1/98	Madison Co., Pr-MT	Management	Mgt removal	WS/MTFWP
213	Female	Adult	7/12/98	Wapiti Cr, GNF	Research	On site	IGBST
313	Male	Subadult	7/14/98	Cottonwood Cr, BTNF	Research	On site	WYGF
			7/20/98	Cottonwood Cr, BTNF	Research	On site	WYGF
314	Male	Adult	7/14/98	Eldridge Cr, GNF	Research	On site	IGBST
315	Female	Subadult	7/19/98	Moccasin Cr, BTNF	Research	On site	WYGF
289	Female	Subadult	7/24/98	Deadhorse Cr, GNF	Research	On site	IGBST
316	Female	Subadult	7/28/98	Mormon Cr, SNF	Research	On site	WYGF
295	Female	Adult	8/21/98	Canyon Cr, YNP	Research	On site	IGBST
286	Male	Adult	8/23/98	Fiddler Cr, Pr-MT	Management	Mgt removal	WS/MTFWP
317	Male	Adult	8/27/98	Coyote Cr, YNP	Research	On site	IGBST
318	Male	Subadult	8/28/98	Coyote Cr, YNP	Research	On site	IGBST
			8/31/98	Coyote Cr, YNP	Research	On site	IGBST
319	Male	Subadult	9/8/98	N of Gardiner, Pr-MT	Management	Chipmunk Cr, YNP	MTFWP
			9/29/98	Parker, Pr-ID	Management	Trapper Cr, GNF	IDFG
320	Male	Subadult	9/17/98	Cascade Cr, YNP	Research	On site	IGBST
321	Female	Adult	9/22/98	Cascade Cr, YNP	Research	On site	IGBST
322	Female	Subadult	9/24/98	N of Gardiner, Pr-MT	Management	Sunlight Cr, SNF	MTFWP
323	Male	Subadult	10/4/98	Trout Cr, YNP	Research	On site	IGBST
103	Male	Adult	10/5/98	Cascade Cr, YNP	Research	On site	IGBST
324	Male	Subadult	10/14/98	Miller Cr, Pr-MT	Management	Spirea Cr, YNP	WS/MTFWP
260	Male	Adult	10/18/98	Antelope Cr, YNP	Research	On site	IGBST
325	Female	Subadult	11/10/98	N of Gardiner, Pr-MT	Management	Otter Cr, YNP	MTFWP

[a] BTNF = Bridger-Teton National Forest, GNF = Gallatin National Forest, SNF = Shoshone National Forest, YNP = Yellowstone National Park, Pr = private land.
[b] IDFG = Idaho Fish and Game; IGBST = Interagency Grizzly Bear Study Team, USGS; MTFWP = Montana Fish, Wildlife and Parks; WS = Wildlife Services–AHPIS; WYGF = Wyoming Game and Fish.

a)



b)

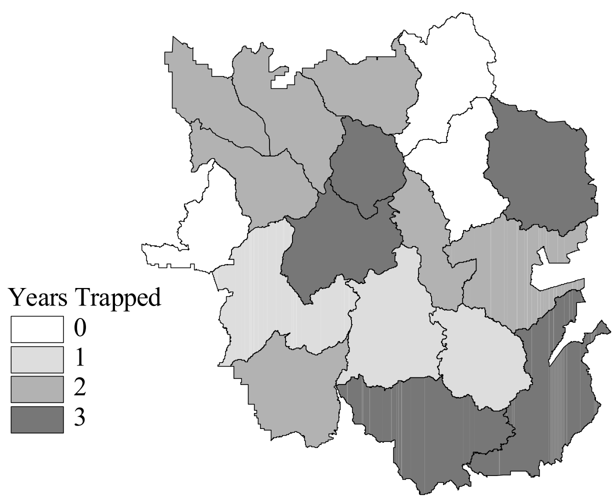


Figure 1. Bear Management Units (BMUs) in which research trapping efforts were conducted during 1998 (a), and within the last 3 years (b). Trapping efforts by the Wyoming Game and Fish Department that occurred just outside the Recovery Zone boundary but were immediately adjacent to the recovery zone were considered part of the adjacent BMUs for this figure.

Table 2. Bear identification number, sex, age, offspring, and status of grizzly bears monitored in the Greater Yellowstone Area during 1998.

				Monitored			
Bear	Sex	Age	Offspring	Out of den	Into den	Status	Transported
103	M	adult		no	yes	active	
128	F	adult	unknown, but lactating	no	yes	active	
179	F	adult	unknown	yes	no	cast collar	
205	F	adult	2, 2-year-olds weaned	yes	no	battery failed	
206	M	adult		yes	no	dead (old age)	
211	M	adult		yes	yes	active	
212	M	adult		yes	?	missing	
213	F	adult	none	no	yes	active	
214	F	adult	none	yes	yes	active	
219	M	adult		yes	no	cast collar	
239	M	adult		yes	no	collar on mortality [a]	
251	M	adult		yes	yes	active	
260	M	adult		no	yes	active	
264	F	adult	none	yes	yes	active	
267	F	adult	unknown	yes	no	cast collar	
271	F	adult	none	yes	no	collar on mortality [a]	
276	F	adult	none	yes	yes	active	
278	M	adult		yes	yes	active	
279	F	adult	1 cub of year	yes	yes	active	
281	M	adult		yes	yes	active [c]	
282	M	adult		yes	no	cast collar	
284	F	adult	2 cubs of year	yes	yes	active	
286	M	adult		yes	no	dead (mgt removal)	
289	F	subadult		yes	yes	active	
290	M	subadult		yes	yes	active	
291	M	subadult		yes	yes	active	
292	M	adult		yes	?	missing	
294	F	adult	unknown	yes	no	battery failed	
295	F	adult	none	yes	yes	active	
296	F	subadult		yes	yes	active	
298	F	adult	none	yes	yes	active	
299	M	adult		yes	yes	active	
300	F	subadult		yes	no	battery failed	
301	M	subadult		yes	no	dead (mgt removal)	
302	M	adult		no	?	missing	
303	F	adult	1 yearling	no	yes	active	
304	M	subadult		no	yes	active	
305	F	yearling		no	no	cast collar	
306	M	adult		no	no	cast collar	
307	M	subadult		no	no	collar on mortality [b]	
308	F	adult	1 yearling	no	yes	active	
309	M	adult		no	yes	active	

Table 2. Continued.

Bear	Sex	Age	Offspring	Monitored: Out of den	Monitored: Into den	Status	Transported
310	M	adult		no	yes	active [c]	
311	F	adult	3 cubs of year	no	yes	active [c]	
312	M	yearling		no	no	cast collar	
313	M	subadult		no	yes	active	
314	M	adult		no	yes	active [c]	
315	F	subadult		no	yes	active	
316	F	subadult		no	yes	active	
317	M	adult		no	yes	active [c]	
318	M	adult		no	no	cast collar	
319	M	subadult		no	?	missing (dispersing)	Yes (2)
320	M	subadult		no	yes	active	
321	F	adult	none	no	yes	active	
322	F	subadult		no	yes	active [c]	Yes
323	M	subadult		no	yes	active	
324	M	subadult		no	yes	active [c]	Yes
325	F	subadult		no	yes	active	Yes

[a] These collars were not retrieved in 1998, the sites will be visited as soon as possible in 1999 to determine status.
[b] This collar could not be retrieved due to cliffs. It remains unknown whether it is a cast transmitter or a dead bear.
[c] These bears were not located just prior to denning. They should be re-acquired upon emergence if not before.

Table 3. Annual record of grizzly bears monitored, captured, and transported since 1980.

Year	Number monitored	Individuals trapped	Total captures Management	Research	Transports
1980	34	28	0	32	0
1981	43	36	35	30	31
1982	46	30	25	27	17
1983	26	14	18	0	13
1984	35	33	22	20	16
1985	21	4	5	0	2
1986	29	36	31	19	19
1987	30	21	10	15	8
1988	46	36	21	23	15
1989	40	15	3	14	3
1990	35	15	13	4	9
1991	42	27	3	28	4
1992	41	16	1	15	0
1993	43	21	8	13	6
1994	60	43	31	23	28
1995	71	39	28	26	22
1996	76	36	15	25	10
1997	70	24	8	20	6
1998	58	35	8	32	5

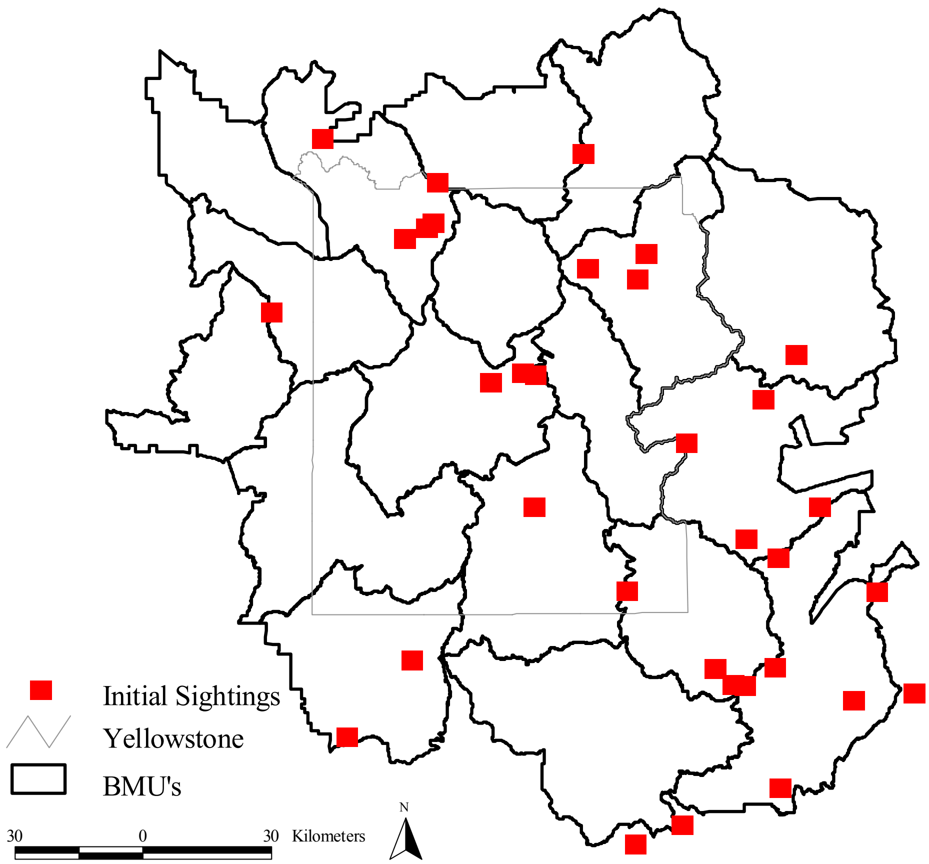


Figure 2. Distribution of initial observations of unduplicated female grizzly bears with cubs-of-the-year in the Greater Yellowstone Area, 1998.

Table 4. Number of unduplicated females with cubs-of-the-year (COY), number of COY, average litter size, and 6-year running averages for the years 1973-1998, in the Greater Yellowstone Area.

		Total #	Mean litter	6-Year running averages		
Year	F w/COY	cubs	size	F w/COY	Cubs	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	19	2.1	12.0	22.3	1.8
1979	13	29	2.2	11.8	22.8	1.9
1980	12	23	1.9	11.3	22.3	1.9
1981	13	24	1.8	12.8	25.3	2.0
1982	11	20	1.8	11.8	23.3	2.0
1983	13	22	1.7	11.8	22.8	1.9
1984	17	31	1.8	13.2	24.8	1.9
1985	9	16	1.8	12.5	22.7	1.8
1986	25	48	1.9	14.7	26.8	1.8
1987	13	29	2.2	14.7	27.7	1.9
1988	19	41	2.2	16.0	31.2	1.9
1989[a]	16	29	1.8	16.5	32.3	2.0
1990	25	58	2.3	17.8	36.8	2.0
1991[b]	24	43	1.9	20.3	41.3	2.1
1992	25	60	2.4	20.3	43.3	2.1
1993[a]	20	41	2.1	21.5	45.3	2.1
1994	20	47	2.4	21.7	45.8	2.1
1995	17	37	2.2	21.8	47.2	2.2
1996	33	72	2.2	23.2	49.5	2.1
1997	31	62	2.0	24.3	52.7	2.2
1998	35	70	2.0	26.0	54.8	2.1

[a] One female with COY was observed outside the 10-mile perimeter area.
[b] One female with unknown number of cubs. Average litter size was calculated using 23 females.

Of the 35 females with COY classified as unduplicated, 15 (42.9%) were initially sighted during observation flights (Table 5). This was slightly higher than the 1986-97 average of 38%; the number of initial sightings recorded during telemetry relocation flights decreased from 42% in 1997 to 20% in 1998.

Table 5. Numbers of sightings of unduplicated female grizzly bears with cubs-of-the-year (COY) by method of observation, 1986-98.

	Observation flights		Ground	Radio	
Year	IGBST & WY	Other [a]	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
1995	2	2	12	1	17
1996	13	1	10	9	33
1997	9	0	9	13	31
1998	15	1	12	7	35

[a] Female with COY seen during non-IGBST research flights by qualified observers.

The protocols used to determine unduplicated females with COY are conservative (Knight et al. 1995), and become more so at higher bear densities. This is due to the criteria used to distinguish unmarked unique females. For example, if 2 or more similarly colored females with the same number of similarly colored cubs are using locales within 30 km of each other, they are not considered unique unless both are seen on the same day at different locations. At high bear densities, it is difficult to differentiate females living in close proximity to each other. With more effort, more unique females with COY can be differentiated. Mattson (1997*a*) has pointed out that yearly totals are also influenced by effort.

Counts of unique females with COY observed in Yellowstone National Park have been fairly constant during the years 1973-1998 (Figure 3). The park has also received the most consistent effort throughout this time period, both from ground and aerial observations. Since about 1986, the total number of unduplicated females identified annually in the Greater Yellowstone Area has increased (Figure 3). This increase is likely due to a combination of factors. Increased effort has undoubtedly contributed. Aerial searches outside Yellowstone National Park, primarily in Wyoming, increased during 1986 but have remained fairly consistent since that year. Our efficiency at finding females with COY has likely increased as our knowledge of bear use of insect aggregation sites has increased (see Insect Aggregation Sites). Finally, it is plausible that the number of reproductive age females in the ecosystem may be increasing.

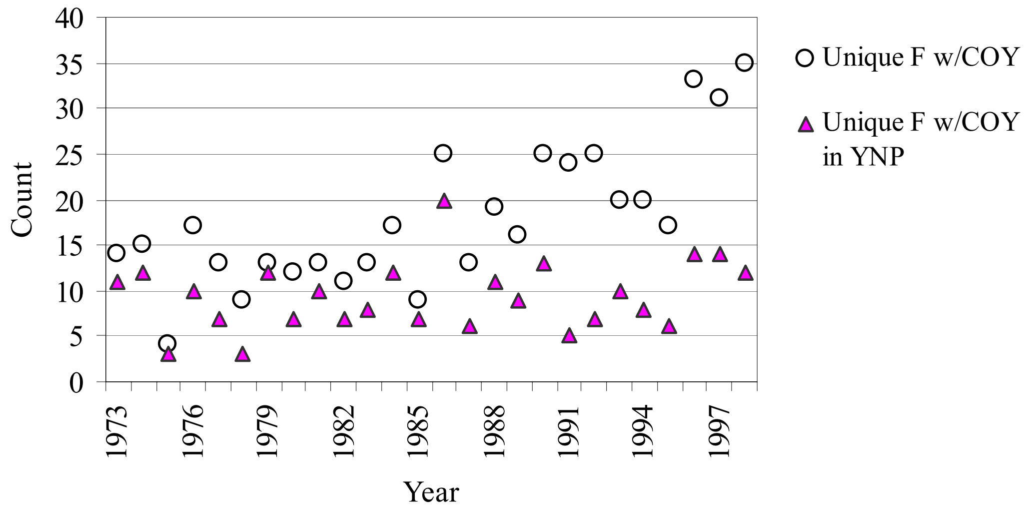


Figure 3. Annual count of unique female grizzly bears with cubs of the year in the Greater Yellowstone Area, and the number occurring within Yellowstone National Park (YNP), 1973-1998.

These counts best represent an estimate of the minimum number of females with COY in the Greater Yellowstone Area (Knight et al. 1995). As stated by Knight et al. (1995) estimates of rate of change based on reproductive and survival data are likely more reliable than those obtained from trend in the number of distinct family groups. However, techniques that use these cumulative counts to estimate the total number of females with COY annually are being investigated (Boyce, M. J., D. I. MacKenzie, B. F. J. Manly, M. A. Haroldson, and D. Moody. In review. Negative binomail models for counts of unique individuals, personal communication; Keating, K. A., M. A. Haroldson, D. Moody, and C. C. Schwartz. In review. Estimating the number of females with cubs-of-the-year in the Yellowstone grizzly bear population: are maximum-likelihood estimates that assure equal sightability conservative?, personal communication).

Evaluation of a Capture-Mark-Recapture Estimator to Determine Grizzly Bear Numbers and Density in the Greater Yellowstone Area *(Charles C. Schwartz, Interagency Grizzly Bear Study Team)*

Estimates of abundance of grizzly bears have been the subject of considerable research (Craighead et al. 1974; Shaffer 1978; Knight and Eberhardt 1984, 1985; Sucky et al. 1985; Dennis et al. 1991; Eberhardt et al. 1994; Foley 1994; Eberhardt 1995; Knight et al. 1995; Boyce 1995) and disagreement (Pease and Mattson 1999). The ability to produce an unbiased estimate of bear numbers in the ecosystem is critical to understanding the recovery of this threatened population. Accurate and precise estimates could document trends in population numbers and ultimately be linked to anthropogenic activities. The cryptic habits of grizzly bears, coupled with their low density and forested habitats make complete counts nearly impossible. In such circumstances, estimates of abundance have been made using capture-mark-recapture (CMR) techniques.

As described by White (1996), more technologically advanced approaches to CMR estimation have incorporated animals marked with radio transmitters. The initial sample of animals is captured and marked with radios, but recaptures of these animals are obtained by only observing them, not actually recapturing them. The limitation of this procedure is that unmarked animals are not marked on subsequent occasions. The advantage of this procedure is that resighting occasions are cheaper to acquire than physical captures of animals. The mark-resight procedure has been tested with known populations of mule deer (Bartmann et al. 1987), and used with white-tailed deer (Rice and Harder 1977), mountain sheep (Furlow et al. 1981, Neal et al. 1993), black and grizzly bears (Miller et al. 1987, Schwartz and Franzmann 1991), and coyotes (Hein 1992). Here we test the applicability and accuracy of a CMR technique developed for bears in Alaska (Miller et al. 1997).

Methods

We followed the basic methods described by Miller et al. (1987, 1997). The Recovery Zone for the Yellowstone grizzly bear (USFWS 1993), previously subdivided into 18 BMUs plus a 10-mile perimeter around this zone containing 9 additional units, represented our "study area" (Figure 4). Annually, the IGBST attempts to maintain a sample of about 35-40 radio-marked bears within the ecosystem. In 1998, we had 39 marked bears within the Recovery Zone boundaries and the 10-mile perimeter area. We used these bears as our sample of marked individuals (M_i) within the population.

We used fixed-wing aircraft to systematically survey the search area. We repeated these searches twice, here referred to as "survey rounds". Searches were constrained to an area in size to permit the pilot and observer adequate time to visually inspect most open habitats during about a 2-hour survey flight. Search areas were generally confined to the existing BMUs within the recovery zone plus the 9 additional search areas in the 10-mile perimeter. Search areas were split into 2 subunits where the BMUs and perimeter units were too large to meet this criterion; we used subunits (BMUs [#] = Crandall/Sunlight [6] , Shoshone [7], Firehole/Hayden [10], Pleateau [13],

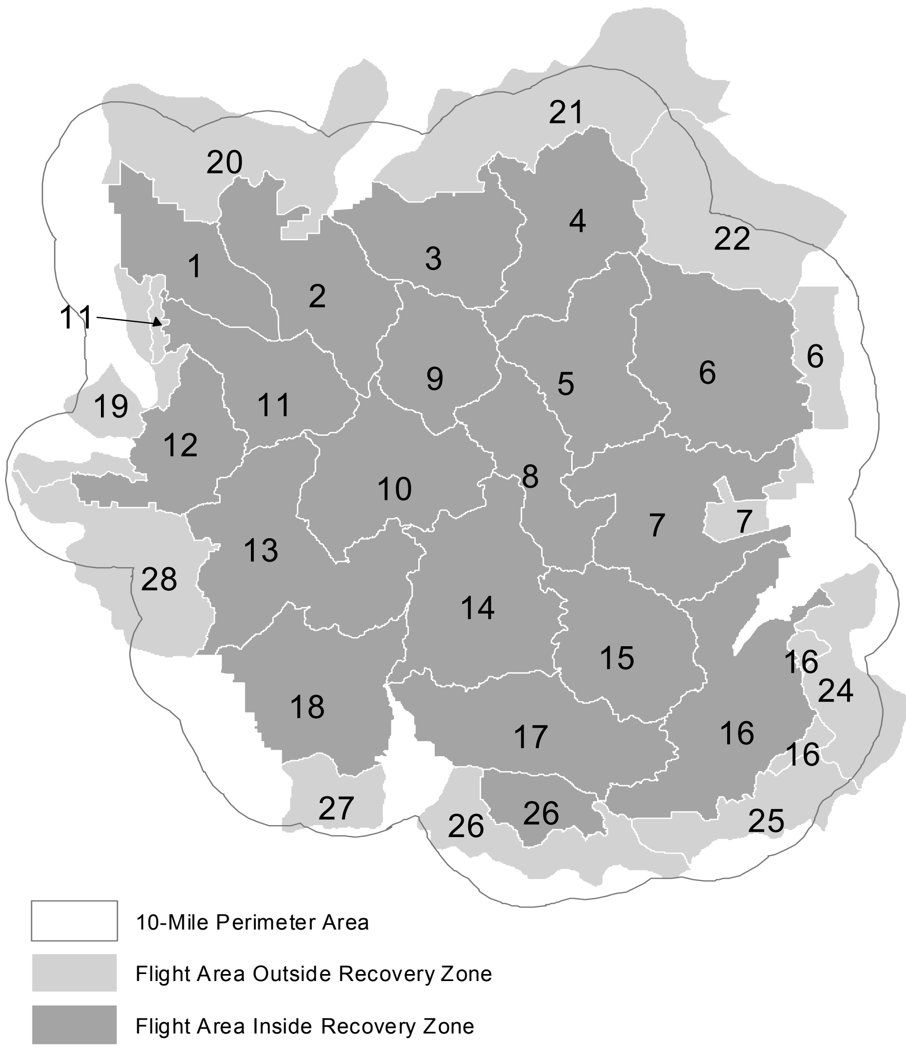


Figure 4. Observation flight areas within the Greater Yellowstone Area, 1998. Numbers 1-18 correspond to the Bear Management Units (BMU) within the primary Recovery Zone. Numbers 19-28 (no 23) represent additional survey units within the 10-mile perimeter area. Because of their large size, areas 6, 7, 10, 13, 14, 15, 16, 17, 21, and 26 were divided into 2 search areas. Because observation areas did not conform exactly to BMU boundaries, we refer to them as bear observation areas (BOAs).

Two Ocean/Lake [14], Thorofare [15], South Absaroka [16], Buffalo/Spread Creek [17], Livingston [21], and Gros Ventre [26]). In some cases, search area boundaries differed slightly from BMU and subunit boundaries. Because of the slight difference in boundary configuration, and to prevent confusion, we will refer to the 18 BMUs plus the 9 additional units for this study as bear observation areas (BOAs). In total there were 37 BOAs including subunits. During a survey round, each BOA was searched once during the early morning. The observer and pilot recorded all bears and groups ($\geq$1) of bears observed during a search. A group of bears was defined as more than 1 individual within 100 m of another. Most often groups >1 were females with dependent young. On some army cutworm moth (*Euxoa auxiliaris*) sites multiple bears were closely spaced and considered a single group. For each bear sighted, the observer recorded location, vegetation type, group size, and whether the bear was in sunshine or shade when observed. For each bear spotted, the observer turned on the radio-receiver and determined if the animal was radio-collared. Observed radio-collared bears represented recaptured marks (m_i). Following the completion of a search, the pilot and observer then radio-tracked and located all marked bears in the search area. We used these radio-tracking flights to determine the numbers of marks available (M_i) and account for closure. We tallied observations from all BOAs within a round to generate m_i, $M_{i,}$ and n_i.

Round 1 began on 15 July and ended 6 August 1998. Round 2 began on 4 August and ended on 27 August. Pilots were instructed to fly adjacent areas on subsequent days to minimize movements of marked bears among count areas.

We used the Lincoln-Petersen estimate derived by Chapman (1951) as described by White and Garrot (1990). We used the computer program NOREMARK (White 1996) to generate our estimates. Data are presented for both rounds combined into a single estimate using the hypergeometric maximum likelihood estimate (JHE) (Bartmann et al. 1987, White and Garrott 1990, Neal et al. 1993).

<u>*Assumptions and biases*</u>.--A critical assumption of the CMR estimator is that the number of marked animals in the population is known (White and Garrott 1990). We were able to meet this assumption by following the radio-marking techniques of Miller et al. (1997). We verified the number of marks in the study area during a recapture operation by relocating each marked bear. Second, the CMR estimator we used requires that the population is closed (i.e., no immigration or emigration). It is generally accepted that the Greater Yellowstone Area is closed to bear movements from other ecosystems (USFWS 1993), precluding emigration and immigration. Third, the CMR technique also assumes that the marked sample of bears represents a random sample of the population, and that bears are seen at random (i.e., equal probability of sighting marked and unmarked bears). If marked bears are easier to see than unmarked bears, the population will be underestimated. Likewise, if marked bears are less likely to be seen than unmarked individuals, the estimate is likely to be too large. We violated this assumption. We know in the southeast part of the ecosystem bears feed on army cutworm moths in open alpine scree habitats. These bears have a very high sightability compared to bears elsewhere in the ecosystem, based on observations of radio marked bears. O'Brien and Lindzey (1998) estimated the visibility of bears on moth sites from fixed-wing aircraft was 0.85-0.92 of bears known to have been feeding at the site based on ground observations. Additionally, we had few radio-marked bears that utilized moth sites. The consequence of this uneven distribution of marks is

an overestimation of the population. To evaluate the potential consequences of this sightability bias, we estimated the number of bears and density with and without BOAs that contained moth sites.

When bears are found as groups, observations of each animal are not independent events. This occurs for females with dependent young and occasionally for breeding pairs. It also occurs at army cutworm moth feeding sites. We also know that there is a bias in observability of family groups when compared to single bears. Females with offspring are seen more often (Blanchard and Knight 1991). This could inflate an estimate when extrapolating from a group estimate. We explore these issues by comparing estimates generated for "groups of bears" and by treating each bear as "independent" as recommended by Miller et al. (1997). We used mean group size to extrapolate to total bears.

Results and Discussion

We flew a total of 69.5 hours during round 1 and observed 141 bears in 61 groups. The mean group size was 2.31. Three bears observed were radio-collared and 20 collared bears were determined to be within the search area. Likewise, we flew 71.4 hours during round 2 and observed 52 groups with 125 bears. The mean group size was 2.4. Two bears observed were radio-collared and 27 marks were determined to be within the search area. For our estimate, we used "groups" rather than individuals as total animals seen during searches because of the lack of independence among individuals within a group. Consequently, our estimates are for "groups of bears". We used mean group size to extrapolate to total bear numbers (Table 6).

Our estimate of all bear groups in the entire study area (Recovery Zone plus 10-mile perimeter) was 524 groups. The 95% confidence interval for this estimate ranged from 266-1,391 groups (Table 6).

Because we anticipated a bias in bear numbers observed at moth sites and because we had no bears marked at moth sites, we excluded those survey areas that contained moth sites (BOAs Crandall/Sunlight, Shoshone, Thorofare, and South Absaroka, plus perimeter units Meeteetse and Wind River) from the study area and recalculated our population estimate. By doing this, we reduced the number of unmarked bear groups observed by more than half. The number of marked bears resighted changed in round 2 but not round 1. By eliminating the survey units with moth sites, the group estimate declined to 257, with a 95% CI of 124-776.

We expanded our estimate of bear groups to total bear numbers (Table 6). Clearly, bears observed at moth sites had a significant impact on our estimate of total bears in the ecosystem, nearly doubling the density estimate. This major shift indicates a strong need to (1) conduct the CMR during a time period when bears are not using moth sites, or (2) mark a representative sample of bears that use these sites. Either could eliminate the potential bias associated with bears sighted at moth sites. We are currently working with West, Inc. in Cody, Wyoming, modeling the CMR technique and investigating the implications of this sightability bias.

Table 6. Capture-mark-recapture information collected to determine the applicability of this technique to estimate grizzly bear numbers in the Greater Yellowstone Area. Two survey rounds were flown and combined into a single estimate of bear groups using the hypergeometric maximum likelihood estimator. Total bear numbers were generated from these estimates by multiplying the group estimate by mean group size.

Survey area	Round	Marks available	Marks seen	Unmarked groups seen	Group estimate 95% CI	Group size	Area (km^2)	Total bears
Recovery zone plus 10-mile perimeter area (37 BOAs)	1	20	3	58				
	2	27	2	50				
	1&2				266-1,391	2.31	34,246	614-3,213
Recovery zone plus 10-mile perimeter area (excluding 6 moth BOAs[a])	1	18	3	30				
	2	21	1	20				
	1&2				124-776	1.72	25,650	213-1,334
Recovery Zone (26 BOAs)	1	18	2	54				
	2	21	2	43				
	1&2				231-1,495	2.33	23,406	538-3,483
Recovery Zone (excluding 4 moth BOAs[a])	1	17	2	29				
	2	19	1	19				
	1&2				130-1,145	1.73	17,170	225-1,981

[a] Moth sites included all of the area within BMUs Crandall/Sunlight, Shoshone, Thorofare, and South Absaroka, plus perimeter units of Meeteetse and Wind River.

We also estimated group numbers within the primary recovery zone delineated by the 26 BOAs. This estimate was 488 groups with a 95% CI of 231-1,495. Excluding the 4 BOAs with moth sites (Crandall/Sunlight, Shoshone, South Absaroka, Thorofare), the estimate is reduced to 301 groups with a 95% CI of 130-1,145. Again amplifying the need to evaluate the bias associated with observing bears on moth sites.

We also followed the recommendations of Miller et al. (1997) and treated each bear as "independent" even if it was seen in a group. To do the calculations, we treated offspring of female bears as independent observations. Females that were collared with 2 dependent young were treated as 3 separately marked bears. Likewise an observation of an unmarked female with 2 dependent young was treated as 3 unmarked bears. Bears seen at moth sites were all considered independent individuals. We generated the same series of estimates for the entire ecosystem and the Recovery Zone including and excluding moth sites. Results were similar to those generated for "groups" but somewhat lower (Table 7, Figure 5). This is probably because of the higher probability of seeing a "group" of bears as opposed to single individuals. Thus our mean group size estimate was probably larger compared to the population as a whole.

The CMR technique offers the ability to generate an unbiased estimate of bear numbers if all assumptions are met. We do not think that our first attempt to apply this technique met that criterion. There is clearly a bias in observability of bears at moth sites. This bias could be eliminated by conducting surveys earlier in the season prior to bear's arrival at moth sites.

We experienced some problems the first year with standardization of the technique among pilots and observers. Our previous tracking and collaring efforts indicated that we had 37-39 radio-collared bears in the ecosystem during the 2 survey rounds. However, during radio-tracking flights following searches only 20 and 26 marked bears were located. Some bears were obviously missed. This reduced M_i with the consequence of an underestimation of the population. Some of the problem resulted from confusion about the technique and how it was applied. We therefore recommend that next year, all pilots and observers be briefed on the survey protocol prior to flights.

We also recommend that the IGBST continue for at least 2 more years to evaluate the potential application of this CMR estimator to determine grizzly bear numbers in the Greater Yellowstone Area.

Table 7. Capture-mark-recapture information collected to determine the applicability of this technique to estimate grizzly bear numbers in the Greater Yellowstone Area. Two survey rounds were flown and combined into a single estimate of independent bears using the hypergeometric maximum likelihood estimator.

Survey area	Round	Marks available	Marks seen	Unmarked bears seen	Group estimate 95% CI	Area (km^2)
Recovery zone plus 10-mile perimeter area (37 BOAs)	1	22	5	136		
	2	28	2	123		
	1&2				526-2,083	34,246
Recovery zone plus 10-mile perimeter area (excluding 6 moth BOAs[a])	1	20	5	57		
	2	22	1	30		
	1&2				174-736	25,650
Recovery Zone (26 BOAs)	1	19	3	126		
	2	22	2	105		
	1&2				485-2,549	23,406
Recovery Zone (excluding 4 moth BOAs[a])	1	18	3	56		
	2	19	1	28		
	1&2				192-1,214	17,170

[a] Moth sites included all of the area within BMUs Crandall/Sunlight, Shoshone, Thorofare, and South Absaroka, plus perimeter units of Meeteetse and Wind River.

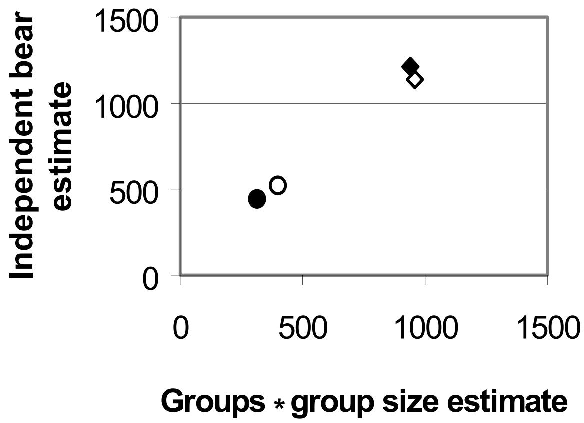


Figure 5. The relationships between total bear numbers generated from capture-mark-recapture estimates using (1) bear groups multiplied by average group size, and (2) by treating each bear as an independent observation. The four data points represent estimates for the recovery zone (open symbols), and the recovery zone plus the 10-mile perimeter area (closed symbols) both including (diamonds) and excluding (circles) cutworm moth sites. See text for details.

Occupancy of BMUs by Females with Young *(Shannon Podruzny, Interagency Grizzly Bear Study Team)*

We monitor and verify reports of female grizzly bears with young (COY, yearlings, 2-year-olds, and/or young of unknown age) to determine distribution throughout the ecosystem. The population recovery criteria (USFWS 1993) require occupancy of 16 of the 18 BMUs by females with young on a running 6-year sum with no 2 adjacent BMUs unoccupied. In 1998, we verified that 14 of 18 BMUs were occupied by female grizzly bears with young (Table 8). Eighteen of 18 BMUs contained verified observations of females with young in at least 1 year of the last 6-year period. The occupancy database was carefully scrutinized in 1998 to verify that record(s) existed for each sighting; data contained in Table 8 have been updated from previous reports.

Table 8. Bear management units occupied by females with young (cubs-of-the-year, yearlings, 2-year-olds, or young of unknown age), as determined by verified reports, 1993-98.

Bear Management Unit	1993	1994	1995	1996	1997	1998	Years occupied
1) Hilgard	X	X	X		X		4
2) Gallatin	X	X	X	X	X	X	6
3) Hellroaring/Bear	X				X		2
4) Boulder/Slough			X	X	X		3
5) Lamar	X	X	X	X	X	X	6
6) Crandall/Sunlight	X		X		X	X	4
7) Shoshone	X	X	X	X	X	X	6
8) Pelican/Clear	X	X	X	X	X	X	6
9) Washburn	X	X		X	X	X	5
10) Firehole/Hayden	X	X	X	X	X	X	6
11) Madison	X	X			X	X	4
12) Henrys Lake			X		X	X	3
13) Plateau		X					1
14) Two Ocean/Lake	X	X	X	X	X	X	6
15) Thorofare	X	X	X	X	X	X	6
16) South Absaroka	X	X	X	X	X	X	6
17) Buffalo/Spread Creek	X	X	X	X	X	X	6
18) Bechler/Teton	X			X	X	X	4
Totals	15	13	13	12	17	14	

***Annual Home Range Size and Movements** (Greg Holm, Wyoming Game and Fish Department)*

During 1998, we located 23 bears (14 females, 9 males) at least once during each of 3 tracking seasons (spring, summer, and fall) and ≥12 times throughout the entire year. Minimum convex polygon home ranges for these bears ranged from 37–1,896 km^2 (Table 9). A lone female (bear #205) displayed the smallest home range size (37 km^2) of any individual, while an adult female with cubs (bear #284) had the largest home range (1,896 km^2). Annual adult male grizzly bear home range sizes were not different ($\bar{x}$ = 397; SD = 231; n = 8) than those reported for 1975-87.

Bear #284 displayed a home range that was dramatically larger than all other bears during 1998. This was primarily due to a long distance movement made during the last 2 weeks of September. She traveled with her cubs from the west side of Grand Teton National Park (GTNP) to an area between the North and South Forks of the Shoshone River. In 1996, bear #284 was trapped in August from the same area on the west side of GTNP and moved to the North Fork of the Shoshone River drainage following a domestic sheep depredation incident. She remained in this area and eventually denned in the North Fork drainage. Following den emergence in 1997, she moved back to her original home range area near GTNP where she remained until 1998. She moved back to the Shoshone in September 1998. Although we do not know why she made this movement, we can speculate that it was food related. Bear #284 likely discovered army cutworm moth aggregation sites following transport. This movement is of special interest because it was made by a female that normally resided in the southwestern portion of the ecosystem, an area without insect (army cutworm moths) aggregation sites. She may be establishing a traditional migration route to these sites. She is also passing on this tradition to her cubs. If bear #284 and her cubs survive, we may see this cultural inheritance of knowledge regarding insect aggregation sites spreading from one portion of the ecosystem to another. Our current movement data suggests that only those female bears that reside near (within the same BMU) insect sites use them as a seasonal food resource.

We calculated the mean distance (km) traveled per day per animal across cohorts during 1998 (Table 10). Greatest mean seasonal movement occurred during the summer ($\bar{x}$ = 1.5; SD = 0.3), followed by the fall ($\bar{x}$ = 1.1; SD = 0.4), and then spring ($\bar{x}$ = 0.9; SD = 0.3). During both spring and summer of 1998, lone females, females of unknown reproductive status, and adult males exhibited the greatest rates of movement. During fall, adult males continued to exhibit large movement rates, followed closely by adult females with offspring (COY and yearlings). Much of the fall movement of females with COY can be attributed to bear #284.

Table 9. Annual range sizes (km^2) of grizzly bears located ≥12 times and during all 3 seasons of 1998 in the Greater Yellowstone Area.

Cohort	Bear No.	Locations	MCP[a]	1975-87 Mean	1975-87 SD
Females					
Adults	-	-	367[b]	281	196
	-	-	254[c]		
With COY	214	21	110	231	136
	279	23	731		
	284	27	1,896		
With yearlings	308	15	129	338	224
Lone adults	205	17	37	236	114
	264	22	148		
	271	23	344		
	276	21	249		
	295	27	457		
	298	23	249		
Unknown status	128	16	79	N/A	N/A
	294	22	261		
Subadults	289	18	253	365	191
	296	17	193		
Males					
Adults	-	-	396[d]	874	630
	211	20	411		
	239	14	221		
	251	24	199		
	278	19	234		
	281	16	865		
	299	24	606		
	309	15	294		
	310	15	342		
Subadult	290	16	626	698	598

[a] Minimum Convex Polygon.
[b] Mean range size for all adult female bears.
[c] Mean range size for adult female bears excluding bear #284.
[d] Mean range size for all adult male bear.

Table 10. Seasonal rates of movement (mean distance between successive locations) for radio-marked grizzly bears during 1995-98.

		Mean/km/day/animal					
						1975-87	
Season	Cohort	1995	1996	1997	1998	Mean	SD
Spring[a]	adult females with COY	0.4	0.6	0.9	0.9	0.7	0.3
	females with yearling	0.4	na	2.2	0.2	1.1	0.7
	lone adult females	0.6	1.2	1.5	1.1	1	0.6
	adult female unknown status	na	0.5	0.1	1.1	na	na
	subadult females	0.8	0.4	2.2	0.7	na	na
	adult males	0.6	0.8	2.3	1.1	1.3	0.8
	subadult males	0.4	0.8	0.3	0.9	1.1	0.6
Summer[b]	adult females with COY	0.5	0.9	0.6	1.6	1.3	1
	females with yearling	0.9	na	2.1	0.9	1.7	0.9
	lone adult females	0.9	0.5	1.1	1.8	1.3	0.7
	adult female unknown status	na	0.6	na	1.7	na	na
	subadult females	0.5	1.2	1.6	1.5	na	na
	adult males	1.3	1.8	2.4	1.7	1.9	1.1
	subadult males	0.7	1.7	1.6	1.5	1.1	0.9
Fall[c]	adult females with COY	na	0.7	1	1.5	1.2	1
	females with yearling	1	na	1.4	1.3	1.6	0.9
	lone adult females	0.7	0.2	2.1	0.8	1	0.7
	adult female unknown status	na	0.5	na	1.1	na	na
	subadult females	0.5	0.7	1.1	0.5	na	na
	adult males	1.7	1	1.1	1.6	1.4	0.8
	subadult males	1.1	0.8	1	1	1.1	0.8

[a] Spring = den emergence to 30 June.
[b] Summer = 1 July to 31 August.
[c] Fall = 1 September to denning.

Mortalities *(Mark Haroldson, Interagency Grizzly Bear Study Team)*

We classify mortality as "known" in those cases where a carcass is physically inspected and as "probable" where strong evidence exists to suggest mortality but no carcass is found (Craighead et al. 1988). We documented 5 known and 1 probable grizzly bear mortalities during 1998 (Table 11). An additional dead grizzly bear was found during the spring of 1998 in Breteche Creek of the Shoshone National Forest. This bear likely died during the fall of 1997 but the cause of death could not be determined; we added this mortality to the 1997 total. Of the 6 grizzly bear mortalities documented during 1998, 3 were human-caused, including 2 management removals of young male bears due to sheep depredations, and the self-defense shooting of an adult female by a hunter (Table 11). The remaining 3 mortalities included 1 cub (probable) that disappeared from its mother (#214), 1 cub whose cause of death is unknown, but remains under investigation, and 1 adult male (#206) that died of natural causes related to old age (Table 11).

Although not clearly stated, Appendix F of the Grizzly Bear Recovery Plan (USFWS 1993) intended that only known mortalities within the Yellowstone Grizzly Bear Recovery Zone and a 10-mile perimeter area counted against the Recovery Plan mortality thresholds. The U.S. Fish and Wildlife Service has clarified this oversight in a memo that will be amended to the Grizzly Bear Recovery Plan (USFWS 1993).

Two of the 3 human-caused mortalities documented during 1998 occurred outside of the 10-mile perimeter area around the Recovery Zone. Both of these instances were management removals of young male bears involved in sheep depredations. Thus only 1 human-caused grizzly bear mortality applies to the calculation of mortality thresholds for 1998. As a result both total man-caused and female mortalities were under the Grizzly Bear Recovery Plan (USFWS 1993) mortality limits for 1998 (Table 12). Table 12 has been corrected from the previous report to include only known mortalites within the Recovery Zone plus the 10-mile perimeter. The locations of past known and probable mortalities, relative to the recovery zone and the 10-mile perimeter area, were also carefully scrutinized during 1998 (Table 13). Data contained in Table 13 have been updated from previous reports.

Table 11. Grizzly bear mortalities recorded in the Greater Yellowstone Area during 1998.

Bear	Sex	Age	Date	Type	Location[a]	Cause
Unmarked	M	Subadult	Fall 97	Known	Breteche Creek, SNF	Unknown cause: carcass found spring of 1998
206	M	Adult	Spring 98	Known	Pelican Creek, YNP	Natural: probably old age
301	M	Subadult	7/1	Known	Near Dillon, MT-Pr	Human-caused: management removal[b]
286	M	Adult	8/23	Known	Fiddler Creek, MT-Pr	Human-caused: management removal[b]
Unmarked	Unknown	Cub	Summer 98	Probable	Gardners Hole, YNP	Natural: bear 214 lost COY
247	F	Adult	9/24	Known	Grizzly Creek, BTNF	Human-caused: Hunter DLP
Unmarked	Unknown	Cub	11/11	Known	Icy Creek, SNF	Unknown cause: under investigation

[a] BTNF = Bridger-Teton National Forest; SNF = Shoshone National Forest; YNP = Yellowstone National Park; DLP = Defense of life and property; Pr = Private land.
[b] Occurred greater than 10 miles outside the Recovery Zone.

Table 12. Grizzly Bear Recovery Plan (USFWS 1993) mortality thresholds 1993-98. Determination is based on annual counts of unduplicated females with cubs-of-the-year, and known man-caused grizzly bear mortality within the Recovery Zone and the 10-mile perimeter area. Calculations of mortality thresholds do not include probable mortalites, or dead bears and unduplicated females with cubs from outside the 10-mile perimeter.

								FWS Grizzly Bear Recovery Plan mortality thresholds				
	Unduplicated females	Man caused mortality			Man caused mortality 6 -year running averages			Min pop	Total man caused mortality		Total female mortality	
Year	w/COY	Total	Total female	Adult female	Total	Female	Adult female	estimate	4% of min pop	Year result	30% of Total mortality	Year result
1990	25	9	6	4	4.8	2.7	1.5	204	8.1		2.4	
1991	24	0	0	0	4.0	2.2	1.2	222	8.9		2.7	
1992	25	4	1	0	3.8	1.8	1.0	259	10.4		3.1	
1993	19	3	2	2	3.8	1.8	1.0	244	9.8	Under	2.9	Under
1994	20	10	3	3	4.7	2.0	1.5	219	8.7	Under	2.6	Under
1995	17	17	7	3	7.2	3.2	2.0	178	7.1	Exceded	2.1	Exceded
1996	33	9	4	3	7.2	2.8	1.8	226	9.0	Under	2.7	Exceded
1997	31	7	3	2	8.3	3.3	2.2	270	10.8	Under	3.2	Exceded
1998	35	1	1	1	7.8	3.3	2.3	344	13.8	Under	4.1	Under

Table 13. Known and probable grizzly bear deaths in the Greater Yellowstone Area, 1973-98.

	All bears				All adult females			
	Human-caused		Other[a]		Human-caused		Other	
Year	In[b]	Out[b]	In[b]	Out[b]	In[b]	Out[b]	In[b]	Out[b]
1973	14	0	3	0	4	0	0	0
1974	15	0	1	0	4	0	0	0
1975	3	0	0	0	1	0	0	0
1976	6	0	1	0	1	0	0	0
1977	14	0	3	0	6	0	0	0
1978	7	0	0	0	1	0	0	0
1979	7	1	0	0	1	0	0	0
1980	6	0	4	0	1	0	0	0
1981	10	0	3	0	3	0	2	0
1982	14	0	3	0	4	0	0	0
1983	6	0	1	0	2	0	0	0
1984	9	0	2	0	2	0	0	0
1985	5	1	7	0	2	0	0	0
1986	5	4	2	0	1	1	0	0
1987	3	0	0	0	2	0	0	0
1988	5	0	7	0	0	0	2	0
1989	2	0	1	0	0	0	0	0
1990	9	0	0	0	4	0	0	0
1991	0	0	0	0	0	0	0	0
1992	4	0	4	0	0	0	0	0
1993	3	0	2	0	2	0	1	0
1994	11	1	1	0	4	0	0	0
1995	17	0	1	0	3	0	0	0
1996	9	0	4	1	3	0	0	0
1997	8	2	10[c]	0	3	0	0	0
1998	1	2	3	0	1	0	0	0

[a] Includes deaths from natural and unknown causes.
[b] In refers to inside the Recovery Zone or within a 10-mile perimeter area around the Recovery Zone. Out refers to more than 10 miles outside the Recovery Zone.
[c] Includes one mortality from the fall of 1997 discovered in 1998.

Key Foods Monitoring

Spring Ungulate Availability and Use by Grizzly Bears in Yellowstone National Park *(Shannon Podruzny, Interagency Grizzly Bear Study Team, and Kerry Gunther, Yellowstone National Park)*

It is well documented that grizzly bears use ungulates as carrion (Mealey 1980, Henry and Mattson 1988, Green 1994, Blanchard and Knight 1996, Mattson 1997*b*) in Yellowstone National Park. Competition with recently reintroduced wolves (*Canis lupus*) for carrion and changes in bison (*Bison bison*) and elk (*Cervus elaphus*) management policies in the Greater Yellowstone Area have the potential to affect carcass availability and use by grizzly bears. For these and other reasons, we continued to survey historic carcass transects in Yellowstone National Park. In 1998, we surveyed 25 routes established by Green (1994) in ungulate winter ranges to monitor the relative abundance of spring ungulate carcasses.

We surveyed each route once for carcasses between April and mid-May. At each carcass, we collected a site description (i.e., location, aspect, slope, elevation, distance to road, distance to forest edge), carcass data (i.e., species, age, sex, cause of death), and information about animals using the carcasses (i.e., species, percent of carcass consumed, scats present). We used the protocol described by Houston (1978) to quantify the amount of edible biomass for each elk carcass. We estimated bison biomass using estimates of mass as follows: 72 kg for calves, 117 kg for yearlings, 207 kg for adult cows, and 360 kg for an adult bull (Turner Ranches, Gallatin Gateway, Montana, personal communication). We were unable to calculate the biomass consumed by bears, wolves, or other unknown large scavengers with our survey methodology.

We are interested in relating the changes in ungulate carcass numbers to potential independent measures of winter die-off. Such measures include weather, winter severity, and forage availability. All are considered limiting factors to ungulate survival during winter (Cole 1971, Houston 1982). Long-term changes in weather and winter severity monitoring may be useful in predicting potential carcass availability. The Winter Severity Index (WSI) developed for elk (Farnes 1991), tracks winter severity, monthly, within a winter and is useful to compare among years. WSI uses a weight of 40% of minimum daily winter temperature below 0° F, 40% of current winter's snowpack (in snow water equivalent), and 20% of June and July precipitation as surrogate for forage production (Farnes 1991).

<u>Northern Range</u>

We surveyed 11 of 13 routes on Yellowstone's Northern Range totaling 208.5 km traveled. One established route was not surveyed due to a closure in effect to protect a wolf denning site. We counted 28 carcasses consisting of 26 elk, 1 bighorn sheep, and 1 bison, which equated to 0.13 carcasses/km. The total observed biomass available to scavengers on these transects totaled 2,589 kg excluding the bighorn sheep. Observed elk biomass equated to 2,382 kg and the observed bison biomass equaled 207 kg (Table 14).

Table 14. Carcasses found, calculated available biomass, and percent of carcasses visited by bears, wolves, and unknown large scavengers along surveyed routes in Yellowstone National Park during spring, 1998.

	Elk				Bison				Totals	
		% Visitation by species				% Visitation by Species				
Survey area (# routes)	No. carcasses (biomass, kg)	Bear	Wolf	Unknown	No. carcasses (biomass, kg)	Bear	Wolf	Unknown	Biomass observed (kg)	Carcass/km
Firehole (7)	10 (606)	10	30	80	3 (774)	0	0	100	1,380	0.17
Norris (4)	1 (111)	0	0	0	1 (207)	0	0	100	318	0.12
Heart Lake (2)	2 (96)	0	100	0	0	0	0	0	96	0.07
Northern Range (11)	26 (2,382)	19	15	92	1 (207)	0	0	100	2,589	0.13

We observed grizzly bear sign at 5 carcass sites located on 4 of the 11 survey routes. We documented no black bear sign or sign from undetermined bear species on any of the 11 routes. We observed wolf sign at 4 carcass sites on 4 of the 11 routes. Percentages of ungulate carcasses visited by bears, wolves, and unknown large scavengers are presented in Table 14.

Firehole River Area

We surveyed 7 of 8 routes in the Firehole River area totaling 76 km. We did not complete 1 survey route. We counted 10 elk and 3 bison on these routes, which equated to 0.17 carcasses/km traveled (Table 14). Total available biomass in the Firehole area equated to 1,380 kg. We observed grizzly bear sign at 1 carcass site. We observed wolf sign at 3 carcasses on 2 different routes.

Norris Geyser Basin

We surveyed 4 routes in the Norris Geyser Basin totaling 17 km. We counted 1 elk and 1 bison carcass, which equated to 0.12 carcasses/km traveled (Table 14). Total available biomass in the Norris area equated to 318 kg. We observed no grizzly, black bear, or wolf sign at these carcass sites. However, 1 of the carcasses was consumed by an unknown large scavenger (Table 14).

Heart Lake

We surveyed 2 of 3 routes in the Heart Lake thermal basin covering 27 km. Due to severe weather conditions, we did not survey 1 route. We counted 2 elk carcasses equating to 0.07 carcasses/km, with a total biomass of 96 kg. Grizzly, black bear, and wolf sign were observed on 1 of the 2 routes surveyed. Both carcasses found had evidence of being killed and consumed by wolves (Table 14).

Winter Severity Index

According to the WSI, the winter of 1997-98 was the mildest recorded since 1980-81, and the third mildest since 1948-49 (Figure 6). There were relatively few ungulate carcasses observed on any of the survey routes and our index of carcass abundance was much lower in 1997-98 compared to the winter of 1996-97 (Figure 7). We found a significant correlation between the WSI and numbers of carcasses found on the Northern Range ($R^2 = 0.78$, $n = 6$, $F = 14.25$, $P = 0.02$) and in the Norris Geyser Basin ($R^2 = 0.72$, $n = 11$, $F = 24.16$, $P < 0.001$). We will continue these surveys for at least 3 more years, in part to determine if the strong relationship between the number of observed carcasses and the WSI persists.

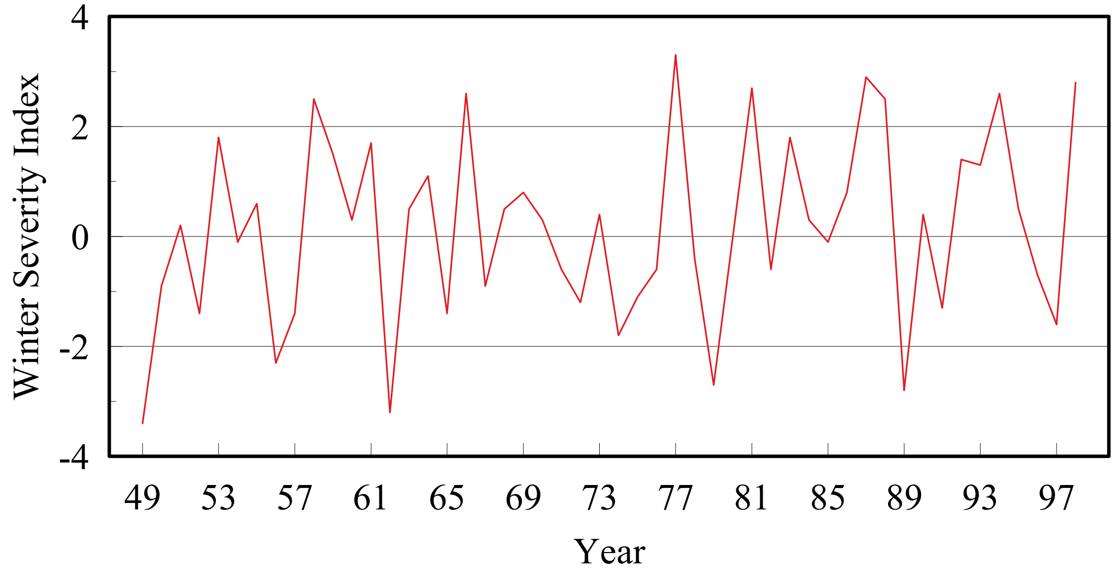


Figure 6. Winter Severity Index (WSI) for elk on the Northern Range, Yellowstone National Park, 1948-98. WSI values of 3 to 4 indicate very mild winters, 0 average, and –3 to –4 very severe winters.

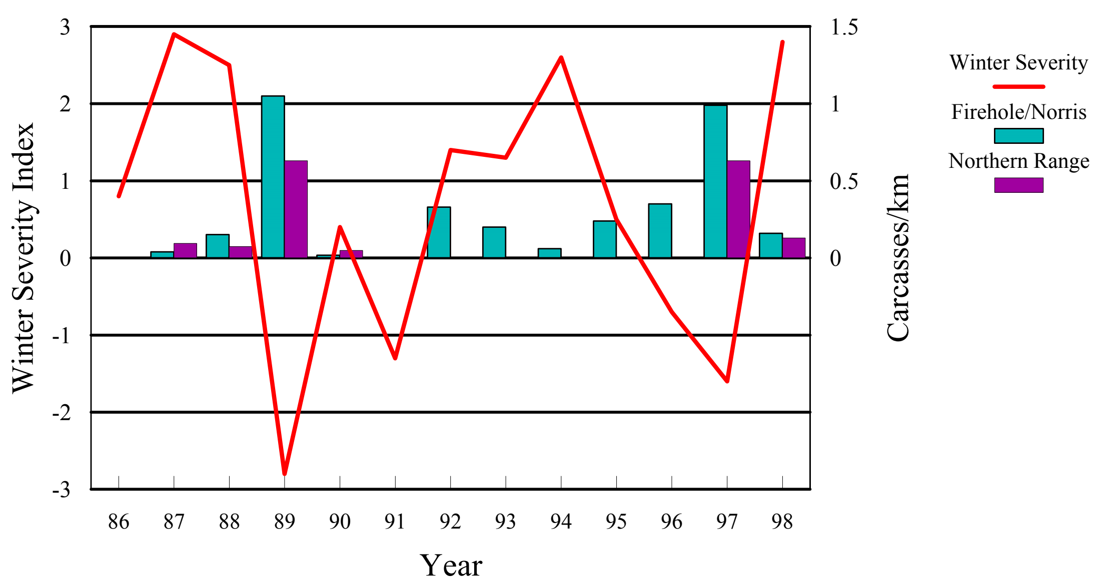


Figure 7. Winter Severity Index (WSI) derived for elk on the Northern Range and ungulate carcasses/km along transects in 2 areas, Yellowstone National Park, 1986-98.

Spawning Cutthroat Trout numbers on tributary streams to Yellowstone Lake and Grizzly Bear use of spawning trout *(Mark Haroldson, Interagency Grizzly Bear Study Team; Dan Reinhart and Kerry Gunther, Yellowstone National Park; Lisette Waits, University of Idaho)*

Grizzly bears fish for spawning cutthroat trout in small tributary streams of Yellowstone Lake; this use is well-documented (Hoskins 1975, Mealey 1980, Reinhart 1990, Mattson and Reinhart 1995). During 1994, non-native lake trout were discovered in Yellowstone Lake. Estimates suggest that lake trout have been in Yellowstone Lake for 10 to 30 years (J. Ruzycki, Aquatic Resources, Yellowstone National Park, personal communication). Lake trout are efficient predators and in the absence of management, have the potential to reduce the native cutthroat trout population by 80-90% (McIntyre 1996). A decline of this magnitude will negatively impact 42 wildlife species that utilize cutthroat trout as food, including the threatened grizzly bear (Schullery and Varley 1996). This is due to the fact that lake trout live and spawn in deep water and are mostly unavailable to avian and terrestrial predators.

Since the early 1990s, resource managers in Yellowstone National Park have observed a downward trend in numbers of spawning cutthroat trout and associated grizzly bear use on some front country streams (Reinhart et al. in press). It is unknown whether these trends are an anomaly associated with increased use by people, an effect of the 1988 fires, or are related to the presence of lake trout. In 1997, the IGBST in cooperation with Yellowstone National Park began a 3-year study to determine if similar trends were evident throughout the Yellowstone Lake tributary system. We were also interested in delineating the minimum number of grizzly bears in the Greater Yellowstone population that feed on cutthroat trout and may be impacted by a decline in their numbers. Reinhart (1990) and Haroldson and Schwartz (1998) have previously described the study area and methods. Results of the 1998 field surveys are presented here. We also summarize results from the DNA analysis to identify individual grizzly bears from hairs collected at hair corrals located adjacent to spawning streams in 1997.

We surveyed 11 front and 11 backcountry streams in 4 different areas of Yellowstone Lake during 1998 (Figure 8). The ice was gone from Yellowstone Lake by 15 May, and we observed the first spawning activity on 17 May (Table 15). The latest spawning activity we observed on surveyed streams occurred on 30 July. We documented the mean peak number of spawning cutthroat trout in the Lake and West Thumb streams on 1 June and 28 May, respectively. East shore streams lagged behind West shore streams by approximately a month; average dates for peak numbers were 6 June and 8 July for east and west shore streams, respectively, excluding Trail creek, an east shore stream. Spawner numbers peaked in Trail Creek on 3 June.

When we averaged peak spawner numbers on east and west shore backcountry streams for the current study (1997-98), they were similar to numbers observed during 1985-87 (Figure 9). We did not detect a difference between spawner numbers on front country streams surveyed in the Lake area when compared to previous studies. However, streams in the West Thumb area continued to show substantial reduction in peak numbers of spawning trout when compared to the previous study period (Figure 9). Although reasons for declines in spawner numbers in the West Thumb area are speculative, these streams are located in an area of known lake trout abundance. Numbers of netted lake trout have grown from 2 in 1994 to 7,792 during 1998.

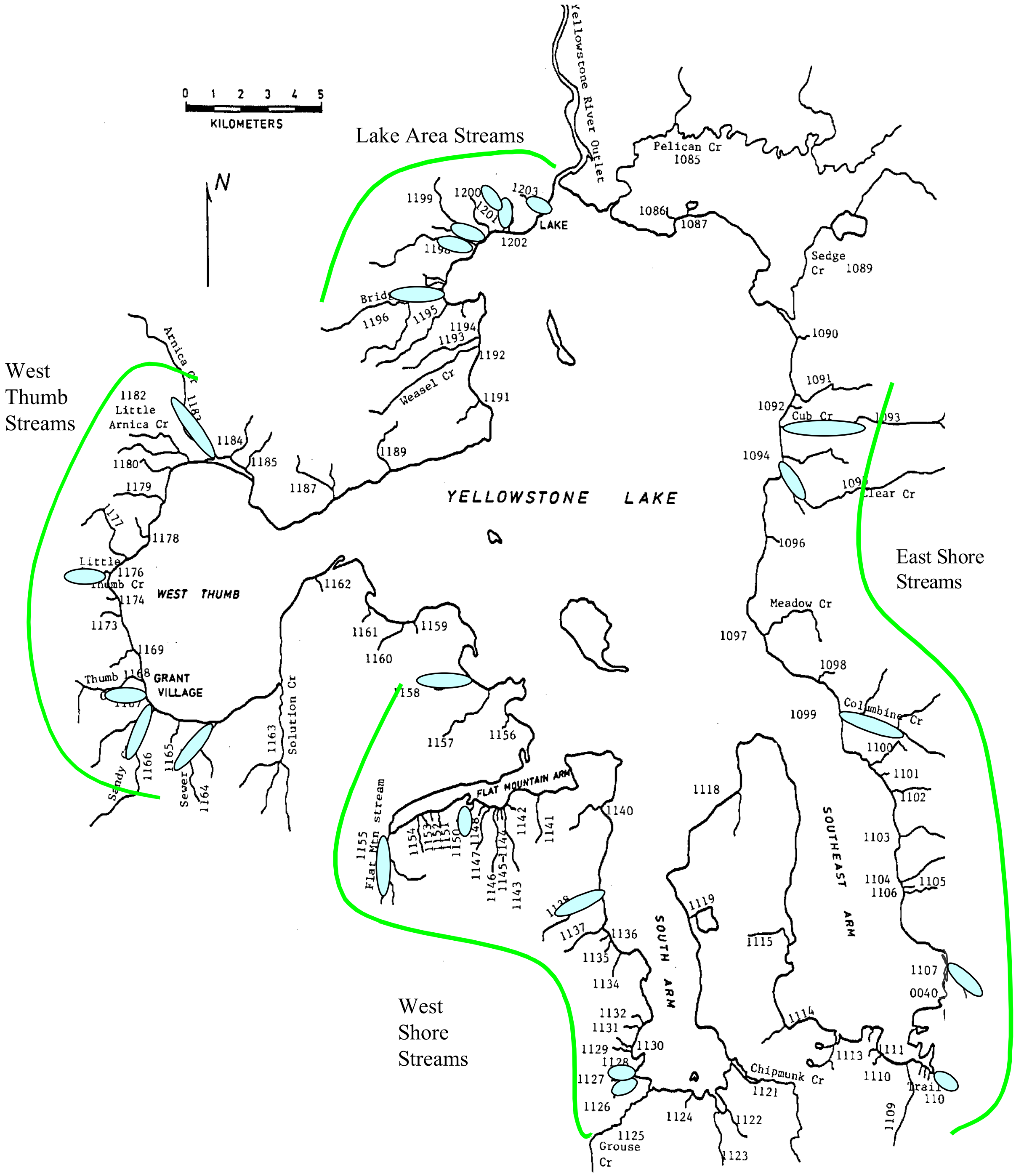


Figure 8. Locations of cutthroat trout spawning streams surveyed (highlighted) during 1998 for fish numbers and grizzly bear use.

Table 15. Beginning, peak, and ending dates and peak number of spawning cutthroat trout observed by stream.

Stream name (SONYEW number)	Beginning date	Peak date	Peak number	End date
Front country streams				
Lake Area streams				
Lodge Creek (1203)	5/17	6/1	200	6/28
Hotel Creek (1202)	no fish observed			
Hatchery Creek (1201)	5/18 [a]	6/1	36	6/8
Incinerator Creek (1199)	5/18 [a]	6/1	47	6/15
Bridge Creek (1196)	5/18 [a]	6/1	657	6/15
Wells Creek (1198)	6/1	6/9	4	6/15
West Thumb Area streams				
Stream 1167 (1167)	5/26 [a]	5/26	57	6/8
Sandy Creek (1166)	5/26 [a]	5/26	34	6/15
Sewer Creek (1164)	5/26 [a]	5/26	54	6/15
Little Thumb Creek (1176)	6/2	6/2 and 6/21	89	7/12
Arnica Creek (1183)	5/18 [a]	6/10	161	unknown[b]
Backcountry streams				
East shore				
Cub Creek (1093)	6/10	7/9	2,986	8/5
Clear Creek (1095)	5/28	7/9	3,071	7/29
Columbine Creek (1099)	6/28	7/15	920	7/29
Foam Creek (1107)	6/28	6/28	6	7/22
Trail Creek (1108)	5/27	6/3	111	6/28
West shore				
East Eagle Creek (1126)	5/20[a]	6/9	138	6/23
West Eagle Creek (1127)	5/20[a]	6/9	27	6/23
Stream 1138 (1138)	5/19[a]	6/2	1,153	6/29
Flat Mountain Creek (1155)	5/20[a]	6/2	1,612	7/30
Stream 1150 (1150)	5/20[a]	6/9	140	6/29
Delusion Lake Outlet (1158)	no fish observed			

[a] Data indicated that the cutthroat spawn had begun prior to initiation of surveys.
[b] Placement of a weir trap to count fish disrupted spawn.

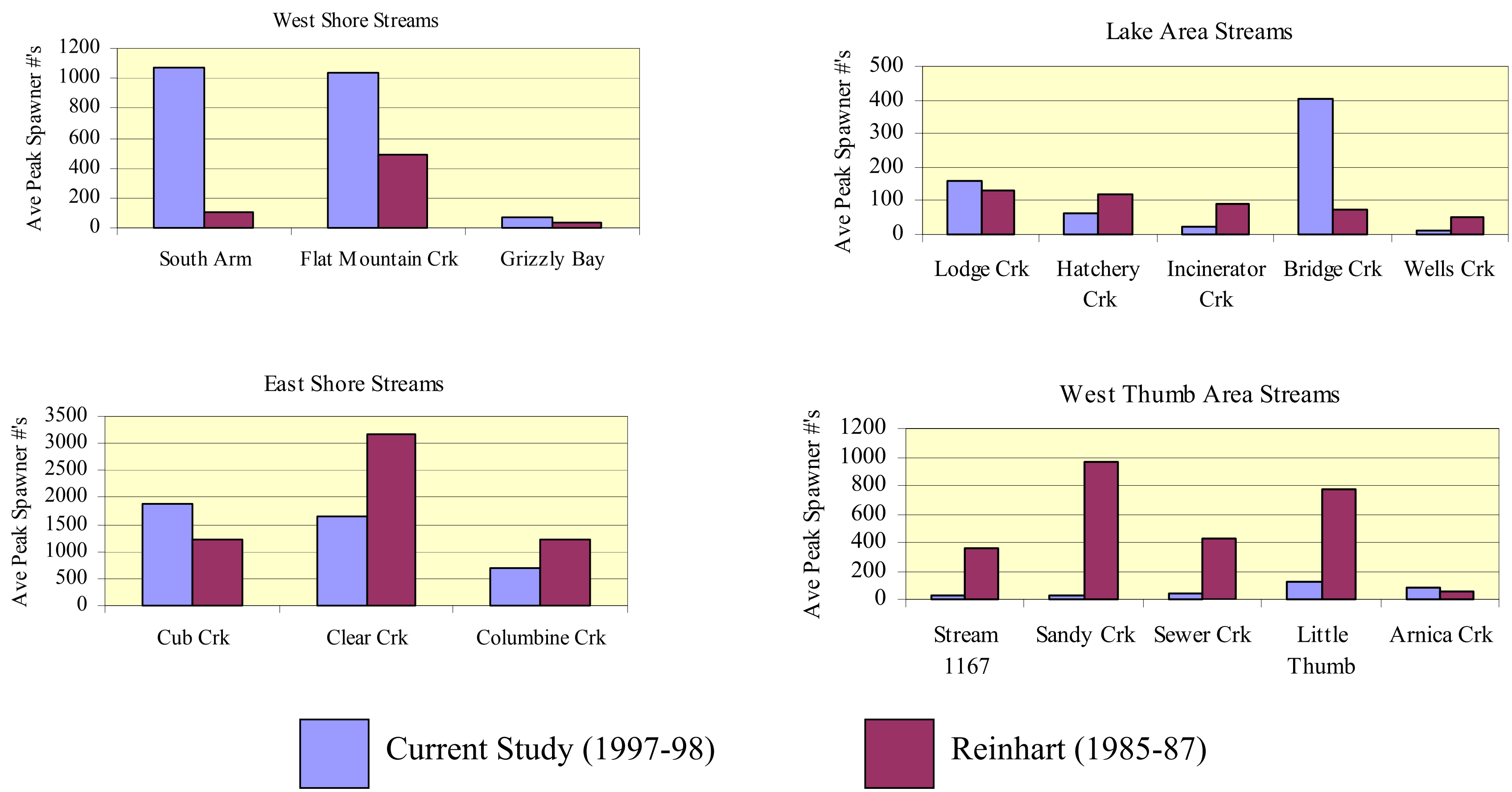


Figure 9. Comparisons of average peak numbers of spawning cutthroat trout between study periods for 4 different areas of Yellowstone Lake.

Most of this netting effort and 90% of these lake trout captures occurred in the West Thumb area. Most deep-water hydro-acoustic targets also point to higher lake trout densities in the West Thumb area (J. Ruzycki, Aquatic Resources, Yellowstone National Park, personal communication). These data suggest that lake trout are a probable cause for the observed declines in numbers of spawning cutthroat trout in the West Thumb area. We are concerned about the potential for similar declines throughout Yellowstone Lake

We measured bear tracks discovered during each stream survey to estimate the minimum number of unique bears that visited and foraged on a particular stream during the spawning period (Table 16). However, these values represent only an index to the number of unique individual bears using surveyed streams because we cannot determine if an individual visits more than 1 stream. Generally, backcountry streams exhibited higher peak numbers of spawning fish and bears visited them more when compared to front country streams, which contained fewer fish.

During 1997, we collected 360 hair samples from 15 hair collection corrals (HCCs) on 10 different spawning streams. Of these 360 samples, 193 contained multiple strands of hair (>10) with follicles. We analyzed these to identify individual grizzly bears. All DNA extraction and Polymerase chain reaction (PCR) set up was performed in a low quantity DNA room dedicated to processing bone, scat, and hair samples to avoid contamination errors. DNA was extracted from all samples with 5 or more visible roots. This minimum number of roots was chosen as a conservative method to provide enough DNA to avoid genotyping errors that are known to occur in microsatellite analysis of samples with low quantities of DNA (Taberlet et al. 1996, 1997, 1999; Goosens et al. 1998). DNA was extracted using 200ul of 5% Chelex solution (Walsh et al. 1991) and further purified with a Geneclean II Kit (Bio101). Species identification was performed by amplifying a 145 - 165 base pair region of the mitochondrial DNA (mtDNA) control region that has a 13 - 20 base pair deletion in brown bears relative to black bears (Shields and Kocher 1991, Waits 1996). PCR primers, reaction conditions, and resolution methods are being described (L. Waits, University of Idaho, personal communication; Woods et al. 1999). This is a very robust method for obtaining non-invasive genetic samples for bears as success rates for obtaining DNA for species identification are above 95% (Woods et al. 1999). Mixed samples containing both black and brown bear hair are observed at a low frequency (<2%) (Woods et al. 1999).

Based on the strength of the mtDNA species ID PCR product, samples were chosen that have sufficient DNA for individual identification. A suite of 6 microsatellite loci of 200 base pairs or less was used for individual identification (Paetkau et al. 1995). Brown bears have been previously surveyed across North America using these loci (Paetkau et al. 1998), and a large number of alleles (5 - 13) have been identified. PCR conditions and ABI gel separation methods are described in Woods et al. (1999). Genotypes for each sample were determined using the Genescan and Genotyper software packages (Perkin Elmer). After genetic analyses are complete, the database is searched for matches to identify unique genotypes, and each genotype receives an individual ID number.

Excluding errors in genetic analysis, a difference in genotypes between individuals is proof that they originate from different animals. However, for samples with identical genotypes, it is
Table 16. Estimated number of bears[a] by species as indicated by detailed track analysis, and

number of hair samples collected using hair collection corrals (HCC) by stream during 1998.

Stream (SONYEW number)	Number of grizzly bears	Number of black bears	Hair samples collected
Front country streams			
Lake Area streams			
Lodge Creek (1203)	1	0	no HCC
Hotel Creek (1202)	0	0	no HCC
Hatchery Creek (1201)	1	1	no HCC
Incinerator Creek (1199)	0	0	no HCC
Bridge Creek (1196)	3	1	8
Wells Creek (1198)	0	0	no HCC
West Thumb Area streams			
Stream 1167 (1167)	0	0	no HCC
Sandy Creek (1166)	0	0	no HCC
Sewer Creek (1164)	1	0	no HCC
Little Thumb Creek (1176)	1	1	18
Arnica Creek (1183)	1	0	no HCC
Backcountry streams			
East shore			
Cub Creek (1093)	4-5	0	23
Clear Creek (1095)	4	1	25
Columbine Creek (1099)	3-4	0	15
Foam Creek (1107)	0	0	no HCC
Trail Creek (1108)	5	0	36
West shore			
East Eagle Creek (1126)	3	2	73
West Eagle Creek (1127)	3-4	1	no HCC
Stream 1138 (1138)	5	1-2	81
Flat Mountain Creek (1155)	6-7	2	22
Stream 1150 (1150)	4-5	1	13
Delusion Lake Outlet (1158)	1	0	7

[a] Number of bears using each stream does not sum to a definite number of bears visiting spawning streams as movements of bears between streams are not considered.

possible that they match for the surveyed loci, but actually represent 2 different individuals that will have different genotypes if more loci are examined. Thus, a statistical basis for match declarations must be used. The probability of a match is generally calculated for each locus using pi^2 for homozygotes and 2 pi pj for heterozygotes (where pi and pj are the frequencies of the *i*th and *j*th alleles), and these single locus values are multiplied across all analyzed loci to give an overall probability of a match (Woods et al. 1999). This calculation makes the assumption that samples are drawn at random from a population, and this is a potential problem for hair-trapping studies of free-ranging mammals due to population substructure and possible sampling of family groups (Waits et al. in press; Woods et al. 1999). Therefore, formulae have been developed to determine the match probability for parent-offspring (Poff) or sibling-pairs (Psib) (Waits et al. in press; Woods et al. 1999). We used these conservative estimators and a statistical criterion of Psib < 0.05 for declaring a match. Based on data from ongoing studies (L Waits, University of Idaho, personal communication), 3-4 and 4-6 loci are required to identify individual black and brown bears, respectively.

All samples that meet the statistical criterion for unique individuals were analyzed to determine gender. This is accomplished by co-amplification of a ZFX/ZFY fragment (X and Y chromosomes) and SRY fragment (Y chromosome) using SRY primers described in Taberlet et al. (1993) and ZFX/ZFY primers described in Woods et al. (1999). One primer of each pair is fluorescently labeled for quick resolution of the 130 bp X chromosome fragment and 120 bp Y chromosome fragment on a 5% acrylamide gel using the ABI 377 fluorescent detection system. All individuals with an X and Y fragment are scored as males, and all individuals with an X fragment only are scored as females.

Of the 193 samples analyzed, we obtained DNA from 143 samples. We typed these as 42 black and 101 grizzly bears. Seventy-three of the grizzly bear samples had enough nuclear DNA to attempt individual identification. We identified 28 individual grizzly bears in 1997 (Table 17).

We established HCCs on 11 streams during 1998; we ran these for the entire cutthroat trout spawning season. In total, we collected 321 hair samples. We obtained an additional 11 hair samples from rub trees and branches along bear trails on streams not containing an HCC. Funding limited the number of samples we could analyze. To maximize our success, we used a systematic approach to select samples for DNA analysis. Basically, we selected all multiple hair (>10 strands) groups that we obtained from different streams on different collection dates. Using this approach, we selected 148 samples for further DNA analysis. We are currently awaiting the results from analysis of these samples.

We will continue spawning stream surveys and grizzly bear hair collection efforts during the 1999 field season, which will be the last year of this 3-year effort. We will expand our grizzly bear hair collection efforts during the final year to include front country streams. It is our intention to try to identify as many individual grizzly bears as possible that potentially use spawning cutthroat trout as a seasonal food.

Table 17. Number of individual grizzly bears identified from DNA techniques that used cutthroat trout spawning streams around Yellowstone Lake during 1997.

Stream (SONYEW #)	Individual grizzly bears identified
Bridge Creek (1196)	2
Clear Creek (1095)	6[a]
Columbine Creek (1099)	4
Cub Creek (1093)	3[a]
Flat Mountain Arm (1155)	7[b]
Little Thumb Creek (1176)	2
South Arm Stream 1138 (1138)	6[b]

[a] One individual was identified on both streams
[b] One individual was identified on both streams

Grizzly Bear Use of Insect Aggregation Sites Documented from Aerial Telemetry and Observations *(Mark Ternent, Wyoming Game and Fish Department, and Mark Haroldson, Interagency Grizzly Bear Study Team)*

Army cutworm moths were first recognized as an important food source for grizzly bears of the Greater Yellowstone Area in the mid-1980s (Mattson et al. 1991*b*, French et al. 1994). Early observations indicated that moths, and subsequently bears, showed specific site fidelity. These sites are typified as high alpine areas dominated by talus and scree adjacent to areas with abundant alpine flowers. Such areas are referred to as "insect aggregation sites". Since their discovery, numerous grizzly bears have been counted on or near these aggregation site due to excellent sightability from a lack of trees and simultaneous use by multiple bears.

Complete tabulation of grizzly use of insect sites is nearly impossible. Not all observations of moth feeding activity are specifically recorded as such. This is particularly the case if use does not occur at known aggregation areas. Also, the exact boundaries of known sites are not clearly delineated and potentially change from year to year with moth abundance. We are constantly learning about new aggregation sites; however, in the past, there was no systematic effort to name each site. Finally, as new sites were named, the historical observations database was not updated to reflect these changes.

Prior to 1997, we delineated insect aggregation sites with convex polygons drawn around locations of observed moth feeding activity and buffered these polygons by 500 m. The problem with this technique was that small sites were overlooked. Ultimately, mapping the unique boundary of each site is preferable, but not possible at this time because we have insufficient knowledge about moth sites characteristics. In fact, only a few sites have been investigated by actual ground reconnaissance.

To help correct these problems, we are exploring new techniques to delineate insect aggregation sites. For this report, we queried the entire location database (telemetry and observations) searching for records associated with moth feeding activity (i.e., the observer indicated that the bear was digging or feeding at a suspected moth site). We plotted these records using Geographic Information System (GIS) technology and identified 43 unique clusters that we labeled as insect aggregation sites. We determined the center of each cluster by averaging the x- and y- Universal Transverse Mercator System coordinates. Using the entire location database, we determined and plotted the cumulative number of points falling within 20 concentric circles at 0.16 km (0.10-mile) increments from the center of each cluster. This curve rose sharply reaching an asymptote at approximately 1 km (0.6 miles). These preliminary analyses suggested that a circle with a radius of approximately 1 km provides a first approximation and possibly an adequate generalized area for identified moth sites. We tested this assumption by plotting the records that either had the words "moth" or "insect" in their description, or those records where the cover type was listed as "high-elevation talus slope" (characteristic of moth sites but no other known bear foods). We determined how many occurred within these 1-km radius circles. Eighty-one percent of these records were contained within our 1-km circles. Moreover, 92% of the records with known moth feeding activity (i.e., the observer indicated that the bear was digging or feeding at a suspected moth site) also fell within these circles. Although preliminary in nature, this allowed us to help quantify bear use of moth aggregation sites.

Although these percentages suggest that using a 1-km radius circle to delineate moth sites may be a close approximation, inevitably some moth-related records may not be included. This is true in cases where moth sites tend to follow linear features like ridges. However, this technique provides a standardized approach to assessing moth site use among years. It tends to exclude points not associated with moth feeding activity (provides a conservative estimate), but includes smaller, potentially overlooked sites.

Annually since 1986, researchers have steadily learned of new moth sites (Table 18). The percentage of known sites used by bears among years has fluctuated, suggesting that some years were better moth-years than others (Figure 10). The years 1993-95 appear to have been poor moth years because the percent of known sites that were used (Figure 10) and the number of locations and observations recorded (Table 18) decreased substantially. These years also had substantially more nuisance management activity than other years. Monitoring bear activity at moth sites only provides an indicator of trend. Additional research is needed to answer other questions, such as what percentage of the bear population uses this resource, is the resource distribution or quantity changing, where do the migrating moths originate, and what are the implications of agricultural moth control efforts.

Table 18. The number of moth sites researchers were aware of each year, the number actually used by bears, and the total number of telemetry relocations and aerial observations of bears recorded at each site during 1986-98.

Year	Number of known moth sites[a]	Number of sites used[b]	Number of relemetry relocations and aerial observations[c]
1986	8	4	7
1987	9	6	22
1988	12	6	45
1989	20	14	52
1990	24	13	84
1991	27	19	178
1992	33	23	155
1993	34	9	75
1994	37	16	88
1995	37	18	84
1996	39	28	124
1997	42	27	85
1998	43	27	145
Total			1,144

[a] The year of discovery was considered the first year a telemetry location or aerial observation was documented at a site. Sites were considered known every year thereafter regardless of whether or not additional locations were documented.
[b] A site was considered used if ≥1 location or observation was documented within the site that year.
[c] May include replicate observations or telemetry relocations.

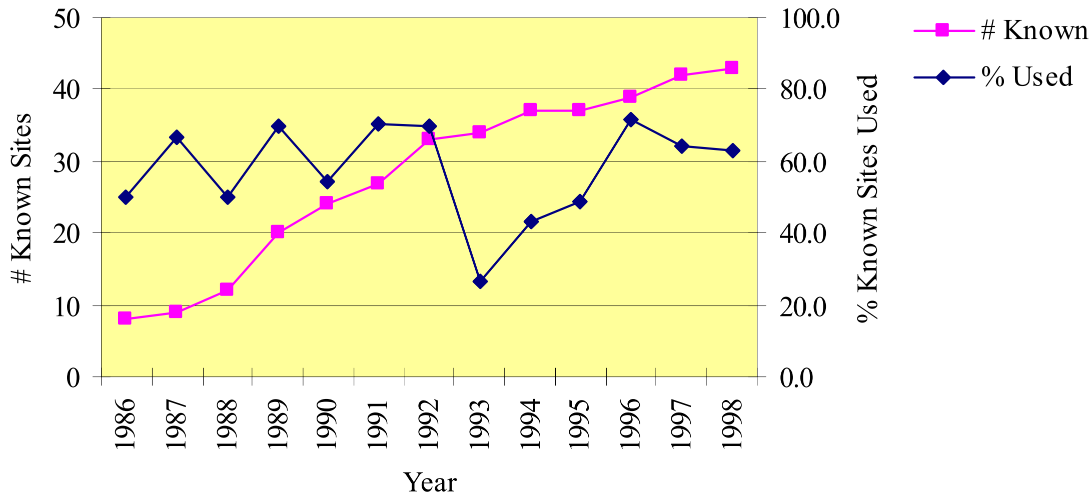


Figure 10. Annual number of known moth sites and percent of known sites at which either telemetry relocations of marked bears or visual observations of unmarked bears were recorded, Greater Yellowstone Area, 1986-98.

The IGBST maintains an annual list of unduplicated females observed with COY (see Table 4). Since 1986, when moth sites were initially included in aerial observation surveys, 304 initial sightings of unduplicated females with COY have been recorded, of which 79 have occurred at (within 1 km, $n = 59$) or near (within about 2 km, $n = 59 + 20$) moth sites (Table 19). Notably, peaks in the number of initial sightings recorded at moth sites corresponded with annual trends in the total number of locations (Table 19) and the percent of moth sites with documented use (Figure 11). This further corroborates that 1993 to 1995 were poor moth years.

Since 1986, 26% of the initial sightings of females with COY were associated with moth aggregation sites (i.e., within about 2 km of a center); of these sightings, most (65%) occurred at 28 sites. Of these 28 sites, only 7 (25%) had initial sightings recorded during at least half of the years (1986-98) once we discovered their use by bears; 13 (46%) have had only 1 initial sighting since 1986. The number of initial sightings during 1986-98 has ranged from 0 to 14, with a per site average of 1.1 (Table 19). Survey flights at insect aggregation sites have annually contributed to counts of unduplicated females with COY (except 1987). If we exclude these sightings, there is still an increasing trend in the annual number of unduplicated sightings of females with COY. This trend is still evident after all sightings within about 2 km of moth site centers are excluded (Figure 11).

Table 19. Number of initial sightings of unduplicated females with cubs of the year that occurred on or near moth sites, number of sites where such sightings were documented, and the mean number of sightings per site.

Year	Unduplicated females with COY[a]	Initial sightings of females at moth sites[b]	Mean initial sightings per moth site[b]	Initial sightings of unduplicated females with COY: Within 1 km of moth site[b]		Within 2 km of moth site[c]	
				N	%	*N*	%
1986	25	1	1.0	1	4.0	2	8.0
1987	13	0	0.0	0	0.0	0	0.0
1988	19	2	2.0	2	10.5	2	10.5
1989	16	1	1.0	1	6.3	1	6.3
1990	25	3	1.0	3	12.0	3	12.0
1991	24	8	1.0	8	33.3	15	62.5
1992	25	6	1.2	6	24.0	11	44.0
1993	20	2	1.0	2	10.0	2	10.0
1994	20	4	2.0	4	20.0	5	25.0
1995	17	1	1.0	1	5.9	3	17.6
1996	33	6	1.0	6	18.2	8	24.2
1997	32	11	1.2	11	34.4	13	40.6
1998	35	14	1.2	14	40.0	14	40.0
Total	304			59		79	
Mean	23.4	4.5	1.1	4.5	16.8	6.1	23.1

[a] Initial sightings of unduplicated females with cubs of the year; see Table 4.
[b] Moth site is defined as a 1 km radius circle drawn around the average coordinates of a cluster of moth-related observations. Forty-three sites have been identified as of 1998.
[c] Twice the distance of what is thought to represent a general moth site size, since some observations could be made of bears traveling to and from moth sites.

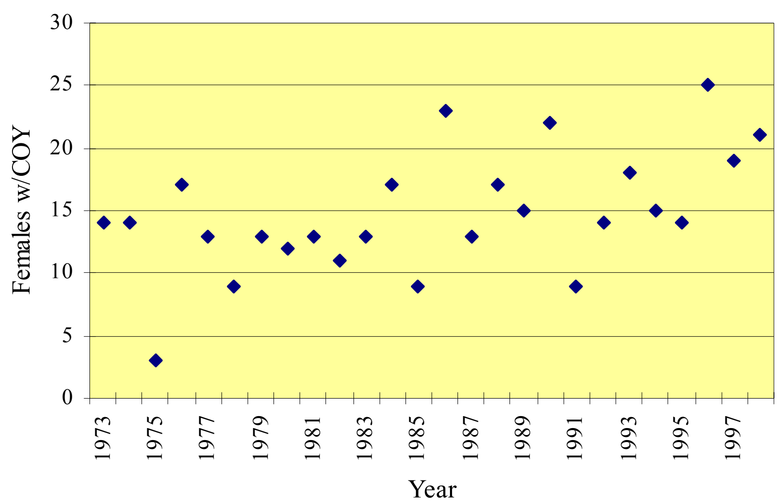


Figure 11. Number of initial sightings of unduplicated females with cubs-of-the-year (COY), excluding sightings collected at or near known moth sites (within about 2 km of a moth site center), 1973-98.

Whitebark Pine Cone Production *(Mark Haroldson, Interagency Grizzly Bear Study Team)*

Whitebark pine is one of the most important fall foods for grizzly bears in the Greater Yellowstone Area (Craighead et al. 1982, Mattson et al. 1991*a*). The IGBST monitors whitebark pine cone production on a series of transects throughout the ecosystem. Whitebark pine cone production averaged 8.4 cones per tree during 1998 (Table 20). Cone production was extremely variable both within and among transects (Table 21), with no cones production on transect G (Figure 12) on the Pitchstone Plateau. Overall, our cone counts are considerably higher than the 1997 average of 4.5 cones per tree when 6 transects exhibited no cone production (Figure 13).

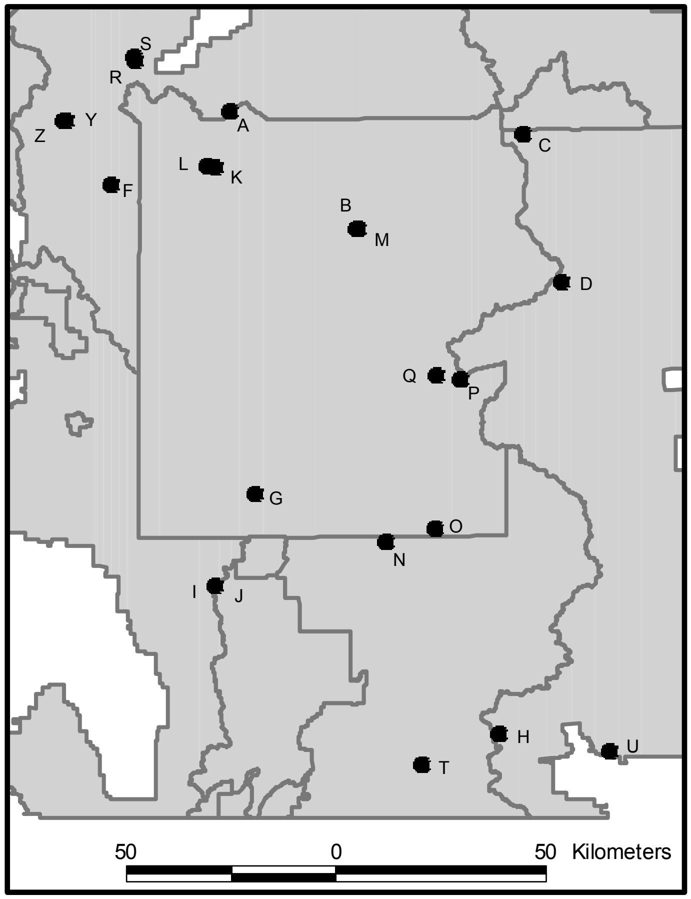
Table 20. Summary statistics for whitebark pine cone production transects in the Greater Yellowstone Area, 1998.

Total			Trees				Transects			
Cones	Trees	Transects	Mean cones	SD	Min.	Max.	Mean cones	SD	Min.	Max
1,566	187	19	8.4	12.5	0	91	82.4	52.8	0	216

Near exclusive use of whitebark pine seeds by feeding grizzlies occurs during years in which mean cone production on transects exceeds 20 cones/tree (Blanchard 1990, Mattson et al. 1992). During years of low whitebark pine seed availability, grizzly bears range wider and seek alternate foods which often brings them in close proximity to humans. This often results in an increase in the number of management captures and transports (Figure 14) and human-caused mortalities. However, during August through October of 1997 and 1998 only 3 and 5 management captures resulting in transport or removal of grizzly bears occurred, respectively. When virtually no whitebark pine seeds were available in 1995, 38 grizzly bear captures resulting in 17 transports and 6 removals occurred during the same time period. Factors contributing to the low number of management actions during the fall of 1997 and 1998 were possibly the extensive use of army cutworm moths by bears in the southeastern portion of the ecosystem, an increase in use of ungulate meat in other areas, and the use of whitebark pine seeds. Mattson (1997*b*) suggests that reliance on meat from ungulates by grizzly bears increases during years with poor whitebark pine cone production.

Table 21. Whitebark pine cone production transect results for the Greater Yellowstone Area, 1998.

Transect	Cones	Trees	Mean	SD
A	94	9	10.4	6.4
B	70	10	7.0	8.4
C	49	9	5.4	4.2
D	88	9	9.8	15.4
F	63	10	6.3	13.1
G	0	10	0	0
H	156	10	15.6	14.6
J	31	10	3.1	6.3
K	30	10	3.0	2.8
L	69	10	6.9	6.2
M	152	10	15.2	27.1
N	32	10	3.2	5.1
O	126	10	12.6	21.8
P	65	10	6.5	6.7
Q	216	10	21.6	19.1
R	104	10	10.4	9.7
S	21	10	2.1	1.6
T	77	10	7.7	4.4
U	123	10	12.3	10.4



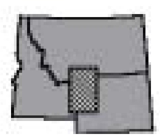


Figure 12. Location of whitebark pine cones production transects in the Greater Yellowstone Area.

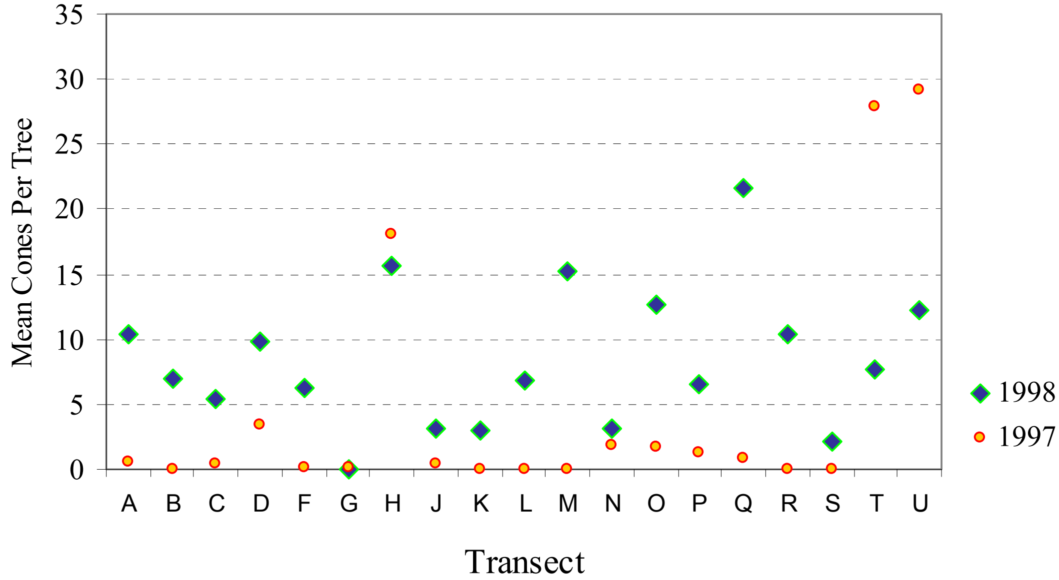


Figure 13. Mean cones per tree for 19 whitebark pine cone production transects in the Greater Yellowstone Area, 1997 and 1998.

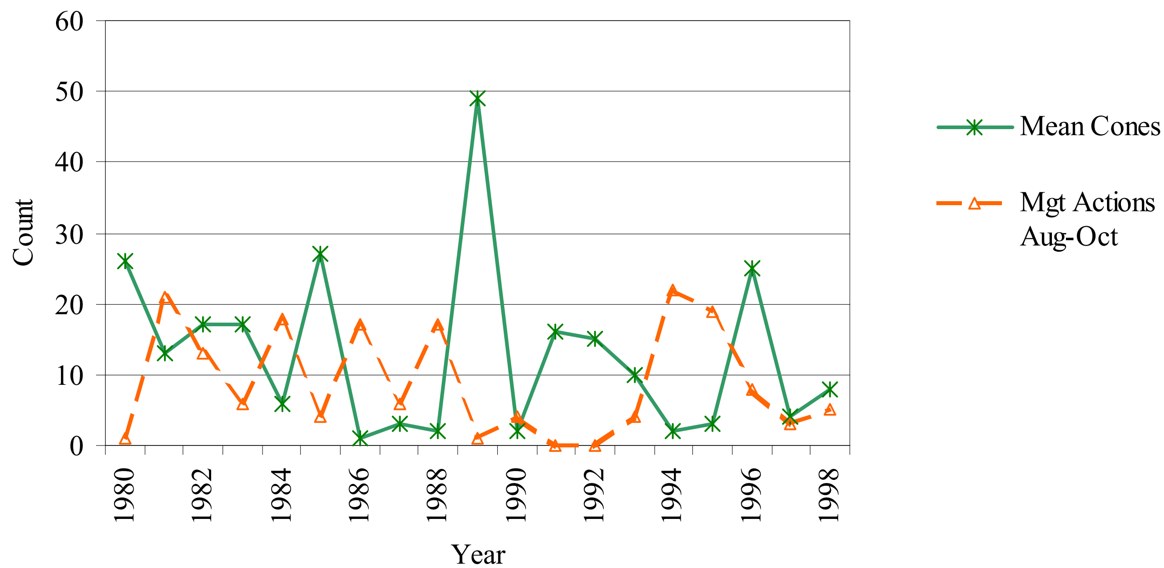


Figure 14. Relationship between mean whitebark pine cone production and the number of August through October management actions of grizzly bears older than yearlings in the Greater Yellowstone Area, 1980-1998.

1998 Grizzly Bear Telemetry Site Investigations *(Shannon Podruzny, Interagency Grizzly Bear Study Team)*

We investigated 71 aerial locations of radio-collared grizzly bears from April-October 1998. We found evidence of feeding activity at 34% of the sites. We also found evidence of activity other than feeding (e.g., denning, bedding, rub trees, tracks, and scat) at an additional 7 sites, and no sign of bear activity was evident at the remaining 41 sites. We also discovered grizzly bear activity at an additional 35 sites not associated with an aerial location of an instrumented bear (30 with feeding activity and 22 with other sign recorded). Activities for those 54 sites with evidence of feeding activity are summarized (Table 22).

Table 22. Percent of 7 feeding activities, by season, found at 54 sites during 1998. Multiple feeding activities were observed at 4 sites, so total activities summed to 58.

	Spring[a] (n = 20)	Summer[b] (n = 31)	Fall[c] (n = 7)	Total (n = 58)
Ungulates	25.0	0.0	0.0	8.6
Rodents/ caches	15.0	3.2	0.0	6.9
Roots	30.0	41.9	14.3	34.5
Grazed foods	15.0	12.9	0.0	12.1
Berries	0.0	19.4	0.0	10.3
Insects	15.0	16.1	14.3	15.5
Whitebark pine	0.0	6.5	71.4	12.1

[a]Spring = April-June
[b]Summer = July-August
[c]Fall = September-October

Use of ungulate meat and digging for roots were the most common feeding activities in the spring. Roots, particularly of biscuit root (*Lomatium cous*) and pondweed (*Potamogeton* spp.), were also the most frequently recorded feeding activity during summer. Bears also made use of globe huckleberry (*Vaccinium globulare*) and other berry-producing shrubs during late summer, and berry production appeared to be particularly good in the Crandall/Sunlight BMU (BMU 6). Excavating red squirrel (*Tamiasciurus hudsonicus*) middens for whitebark pine cones was the most frequently recorded fall feeding activity.

Other IGBST activities around the ecosystem documented feeding activities not encountered during habitat investigations. These included: use of spawning cutthroat trout on the tributaries of Yellowstone Lake, use of false truffles (*Rhizopogon* spp.) on the Central Plateau, and use of the fall run of kokanee salmon (*Oncorhynchus nerka*) from Henrys Lake.

***Scat Analysis** (Mark Haroldson, Interagency Grizzly Bear Study Team, and Kevin Frey, Montana Department of Fish, Wildlife and Parks)*

Here, we present a brief summary of fecal analysis for scats collected by the IGBST during 1998. Graminoids, cutthroat trout, forbs, and meat from elk were the most frequent food items found in spring scats (Table 23). Spawning cutthroat trout were abundant during 1998, and field crews worked on the spawning streams from May through August. Both factors contributed to the large sample of scats containing cutthroat trout obtained during the spring season. Graminoids and forbs dominated summer scats, but use of meat from elk was also common. We only collected 7 fall scats because field crews were no longer active.

Food habits represented by fecal analysis often do not accurately reflect relative proportions of ingested items because different diet items are digested at varying rates and to different degrees. More easily digested items such as meat and berries are under-represented in fecal analysis while vegetal items are over-represented. Additionally, results also reflect the food habits in geographic areas in which the collections were made and do not necessarily reflect an ecosystem wide pattern.

Table 23. Contents of 215 scats collected during 1998 in the Greater Yellowstone Area. Analyses include both known grizzly bear scats and scats for which species in unknown. Known black bear scats are excluded.

	Spring[a] (*n* = 110)		Summer[b] (*n* = 98)		Fall[c] (*n* = 7)		Total (*n* = 215)	
	% freq.	% vol.	% freq.	% vol.	% freq.	% vol.	% freq.	% vol.
Whitebark Pine Seeds			3	1	57	56	3	2
Berries								
Vaccinium			2	2			1	1
Sporophytes	3	1	7	5	14	1	5	3
Equisetum	3	1	3	2			3	2
Mushrooms			4	3	14	1	2	1
Foliage								
Graminoids	75	53	68	45	43	19	71	48
Melica (roots)			1	1			T[d]	T
Forbs	21	16	57	37			37	25
Cirsium	1	T	5	5			3	2
Epilobium	1	1	1	T			1	1
Fragaria			1	1			T	T
Taraxacum	10	8	17	12			13	9
Trifolium	2	1	24	10			12	5
Osmorhiza	1	1	3	3			2	2
Lomatium (roots)	4	4	5	4			4	4
Mammals	17	9	12	4			14	6
Elk	15	9	9	3			12	6
Cattle (domestic)			1	1			T	T
Rodent	2	T	1	T			1	T
Meat (unknown)	1	T	1	T			1	T
Fish	41	12	5	1	29	11	24	7
Cutthroat trout	41	12	5	1			23	6
Kokanee					29	11	1	T
Insects								
Ants	1	T	7	1			4	T
Debris	32	8	19	5	14	13	26	7

[a] Spring = March, April, May, and June.
[b] Summer = July and August.
[c] Fall = September and October.
[d] Trace (less than 0.5).

HABITAT MONITORING

Monitoring Effects of Human Activities on Grizzly Bear Habitat *(Kim Barber, Shoshone National Forest, and Doug Ouren, Interagency Grizzly Bear Study Team)*

Grizzly bear use of habitats and available foods is influenced by the presence of humans in the Greater Yellowstone Area (Mattson et al. 1987, Mattson 1990). Several tools have been developed over the last decade to assist in evaluating the cumulative effects of human activities on grizzly bear habitat effectiveness; including the Yellowstone Grizzly Bear Cumulative Effects Model (CEM) (Weaver et al. 1986, USDA 1990; Bevins 1997) and the Grizzly Bear Motorized Access Management process (IGBC 1998). Coefficients used to evaluate habitat value and habitat effectiveness in the CEM are in the process of being updated and tested using the most recent information on human activities and bear use of habitats. However, the databases developed for use with CEM have been instrumental in providing the basis for completing an evaluation of the motorized access and secure area situation in the Grizzly Bear Recovery Area.

A taskforce of the Interagency Grizzly Bear Committee was created in 1994 to assess existing state and federal techniques for evaluating the effects of motorized access on grizzly bears in the lower 48 states. The final product of that taskforce was the Interagency Grizzly Bear Committee Taskforce Report on Grizzly Bear/Motorized Access Management (IGBC 1994). In 1998, that report was reviewed and updated to assess the clarity and applicability of the recommendations and definitions in the 1994 report. The access analysis process discussed on the following pages is consistent with the updated report (IGBC 1998).

Motorized access is one of the most influential human use factors affecting grizzly bear use of habitats. Open road density has been utilized historically as a measure of human impacts to grizzly bear habitat. Recent research indicates that motorized roads, restricted roads and motorized trails, and high use hiking trails are also important factors influencing grizzly bear use of habitats in the Northern Continental Divide Ecosystem (Mace et al. 1996, Mace and Waller 1996). There is also a recognition among managers and researchers that secure areas free of motorized access and high use trails during the non-denning period are important to grizzly bears (IGBC 1998).

The evaluation of motorized access and secure areas was completed for those areas within the Grizzly Bear Recovery Zone, an area of approximately 23,940 km^2 (9,242 square miles). Outputs were summarized for each of the 40 subunits within the Recovery Zone (Figure 15). Subunits are subdivisions of BMUs that provide greater landscape and seasonal habitat use resolution. A subunit typically encompasses a major drainage and portions of intervening ridges. The subunit provides the basic scale of analysis for the evaluation of motorized access route density, secure areas, and also for CEM (USDA 1990). GIS databases, for the most part, are not available for areas outside the Recovery Zone.

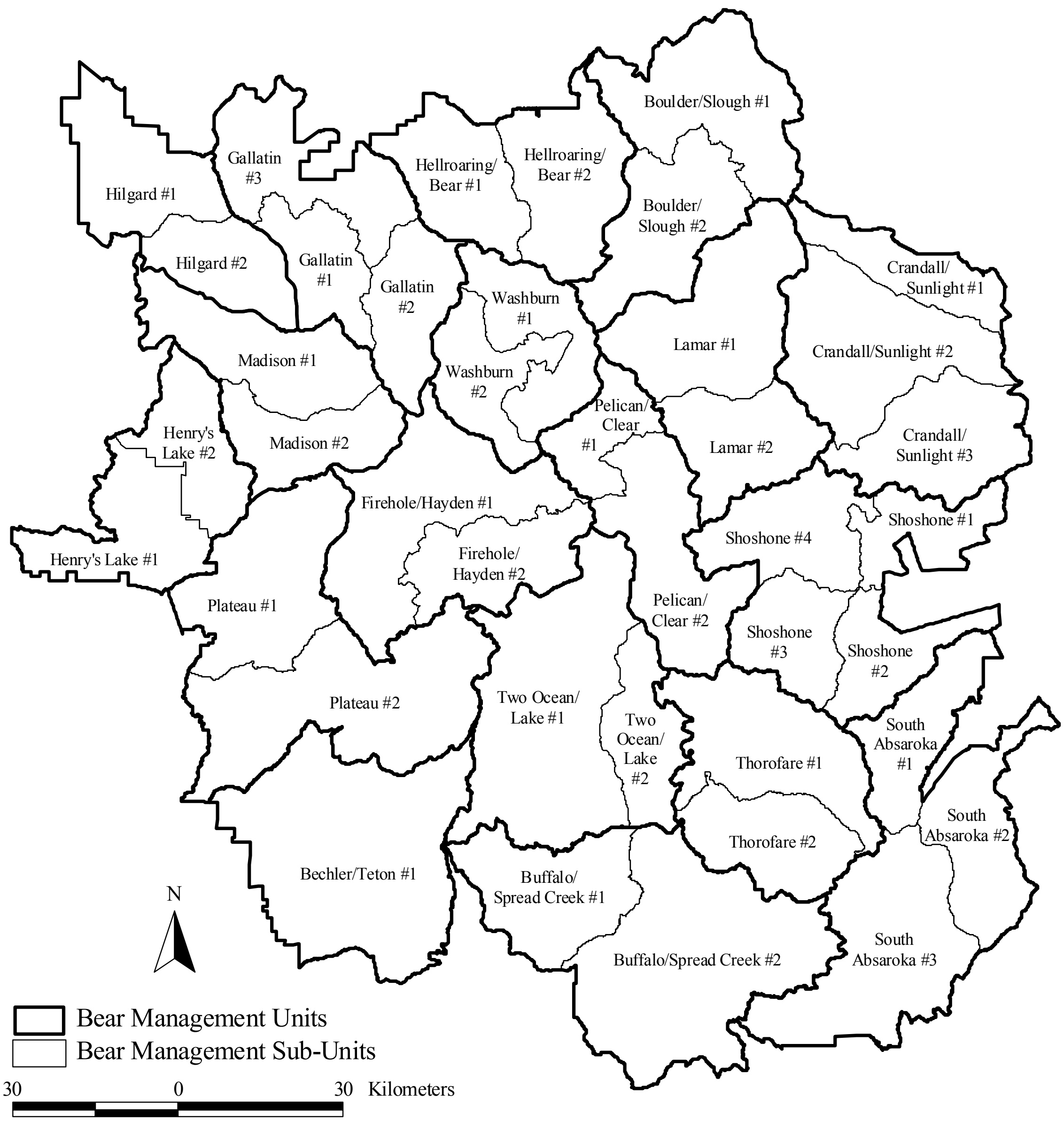


Figure 15. Grizzly bear management units and subunits in the Greater Yellowstone Grizzly Bear Recovery Zone.

Road and Trail Database

Human activities databases were created by the respective land management agencies over the last decade for evaluation of cumulative effects using the CEM. Map manuscripts were created at 1:24,000 scale (1:62,000 scale for Yellowstone National Park), digitized, and entered into the Arc/Info GIS. Human activities were mapped as point, linear, or polygon features, and stratified according to type (motorized point, non-motorized linear, etc.), intensity (low or high), and duration (year-round, 1 June through 30 September, etc.) (USDA 1990; Weaver et al. 1986). Only the linear database was needed for the motorized access and secure area analysis. Data was updated by the land management agencies to reflect the 1998 situation and additional attributes added as discussed below. Linear features were mapped to within 1.6 km (1 mile) outside the Recovery Zone to facilitate both the CEM and the motorized access route density analysis. An additional linear database was developed that reflected the full implementation of the Revised Targhee Forest Plan (USDA 1997). Two seasons were identified for analysis of motorized access route density and secure areas within subunits. These seasons were delineated based on bear habitat use within the ecosystem during the non-denning period (Mattson 1998). Season 1 was defined as 1 March - 15 July and Season 2 as 16 July - 30 November. The road and trail database was attributed as to status of the linear feature for each season. Each feature was first attributed as a motorized route or non-motorized route. Motorized routes were identified as open, restricted, or obliterated (IGBC 1998). A road that was open for 1 day in the season was considered open for the entire season. Non-motorized routes were identified as high or low use. A trail that received high use for over half the season according to CEM definitions (USDA 1990) was considered high for that season in analysis. A gated road that received high levels of use according to CEM definitions (USDA 1990, IGBC 1998) was evaluated as an open motorized access route. Motorized routes were also coded as to whether or not they received high levels of non-motorized use.

While the described linear feature database represents a focused, consistent, and cooperative mapping effort involving a great deal of edge matching across administrative boundaries, it has limitation. Any mapping and classification effort, especially one envisioned for a contiguous 6 million acre area, is constrained by artificiality induced error through definition, categorization, and delineation. Interpretation of mapping standards and item definitions, variability associated with quad map templates conforming to National Map Accuracy Standards, unique field situations, skill of field personnel, and many other factors all contribute to inherent yet presumably inconsequential levels of error. However, given these limitations, the database appears adequate to effectively evaluate the impact of human access at the subunit level. The agencies are continuing with efforts designed to increase the mapping and coding accuracy.

Open Motorized Access Route Density (OMARD).--OMARD was calculated using a GIS moving window routine (Turner and Gardner 1990) and followed the definitions and criteria outlined in the Grizzly Bear/Motorized Access Management report (IGBC 1998). The analysis process was completed using the Arc/Info GIS software and used the subunit and linear feature coverages for the ecosystem. The first step was to use the reselect command to select only the motorized routes classified as open for each of the 2 seasons from the combined linear coverage for the recovery area. The linear features were turned into a grid with a 30-meter cell size using the linegrid command. Arc/Info tends to over represent the area of a linear feature when creating a grid.

Thus the thin command was used to create a grid that is a better representation of a vector road. The grid was thinned with the no filter and sharp arguments with a maximum thickness of 3 cells. The focul sum command was used to perform the moving window analysis with a window size of 54 by 54 30-meter cells or approximately 1 square mile. Outputs for each subunit were classified into 1 of 4 categories (0.0 mi/mi^2, 0.1-1.0 mi/mi^2, 1.1-2.0 mi/mi^2, and > 2.0 mi/mi^2) using the reclass command and then using the gridpoly command turned into an Arc/Info vector coverage. The frequency command was used to clip out the area from the density coverage for each subunit and calculate the percentage of each of the 4 density categories within each subunit for each season. Several large lakes (Hebgen, Quake, Shoshone, Lewis, Heart, and Henrys) on multiple-use lands were removed from the secure area calculations. The process creates artificial density in these lakes due to adjacent roads and skews the percentage calculations. Similar density created in lakes in the National Parks was determined to be inconsequential.

Because land managers can only manage motorized access routes under their jurisdiction, an evaluation of the contribution of federally-managed roads to the overall OMARD for each subunit was completed. The process outlined above was first completed for just state, county, and private motorized access routes. This output was intended to depict the OMARD that could be considered as a baseline. A second evaluation included all features regardless of management responsibility. The difference between the two outputs was the contribution of federally-managed roads.

For the subunits that encompass parts of the Targhee National Forests, outputs were created depicting the motorized access density both before and after full implementation of the access standards in the Revised Forest Plan (USDA 1997).

Total Motorized Access Route Density (TMARD).--TMARD was calculated using the same process as outlined above for OMARD with two exceptions. Linear features selected from the master coverage included all open and restricted motorized access routes. Outputs were summarized for the entire year rather than by season as seasonal density values are equal.

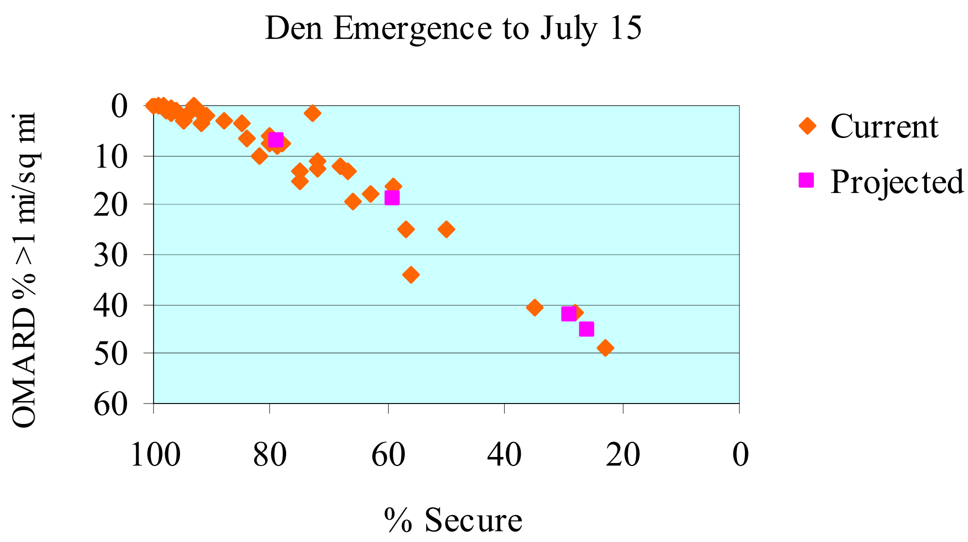
Secure Areas.--The Arc/Info GIS software was also used to calculate the percent secure area as defined in the Grizzly Bear/Motorized Access Management report (IGBC 1998). The process used the subunit and linear feature coverages and the output coverage from the OMARD analysis. All open and gated motorized access routes and high use trails were selected from the ecosystem linear database using the reselect command. All of these linear features were buffered at 500 m with the buffer command. The identity command was used to create the coverage depicting the secure area for each subunit. The OMARD coverage was unioned with the buffered coverage to determine areas of overlap between secure areas and OMARD. Inconsistencies between the secure area and OMARD analysis were resolved by reclassifying any secure areas that overlapped with OMARD greater than 0 mi/mi^2 as non-secure areas. All secure area polygons less than 10 acres (4.05 hectares) were reclassified as non-secure to reduce complexity. Unnecessary polygon divisions present after these reclassifications were eliminated using the dissolve command. The percent secure area in each subunit for each season was calculated with the frequency command. To maintain consistent area representation, the same lakes (Hebgen, Quake, Henry's, Shoshone, Lewis, and Heart) removed from the OMARD and TMARD calculations were eliminated from the secure area summaries.

Habitat use by grizzly bears has been documented to be significantly less than expected in areas where OMARD is greater than 1 mi/mi^2 and/or TMARD is greater than 2 mi/mi^2 (Mace and Manley 1993, Mace et al. 1996). Table 24 displays the percentage of OMARD and TMARD in these categories and the percent secure area for each of the subunits in the Yellowstone Grizzly Bear Recovery Zone by season. All but 6 subunits have both secure area greater than 65% and OMARD > 1 mi/mi^2 less than 30% for each season (Figure 16). The values for these parameters by management responsibility of the access route are presented in Appendix 1.

Table 24. The 1998 values for open motorized access route density (OMARD) > 1mi/mi^2, total motorized access route density (TMARD) > 2 mi/mi^2, and secure areas. Values have an estimated error of + or - 5%. Season 1 is from 1 March to 15 July. Season 2 is from 16 July to 30 November.

		OMARD % > 1 mi/mi^2			% Secure		
BMU Name and Subunit #	BMU#	Season 1	Season 2	TMARD % > 2 mi/mi^2	Season 1	Season 2	(mi^2)
Hilgard #1	1	25	25	11	57	56	202
Hilgard #2	1	16	18	6	59	44	141
Gallatin #1	2	2	2	0	92	88	128
Gallatin #2	2	8	8	4	80	73	155
Gallatin #3	2	41	41	17	35	33	218
Hellroaring/Bear #1	3	19	20	12	66	61	185
Hellroaring/Bear #2	3	0	0	0	98	88	229
Boulder/Slough #1	4	2	2	0	91	81	282
Boulder/Slough #2	4	1	1	0	96	81	232
Lamar #1	5	5	7	3	84	74	300
Lamar #2	5	0	0	0	100	95	181
Crandall/Sunlight #1	6	11	16	3	72	47	130
Crandall/Sunlight #2	6	15	16	9	75	73	316
Crandall/Sunlight #3	6	13	16	7	72	68	222
Shoshone #1	7	1	1	1	97	97	122
Shoshone #2	7	1	1	0	98	98	132
Shoshone #3	7	3	3	1	95	95	141
Shoshone #4	7	4	4	1	92	91	189
Pelican/Clear #1	8	1	1	0	94	84	108
Pelican/Clear #2	8	3	3	0	88	84	257
Washburn #1	9	12	12	3	68	62	178
Washburn #2	9	4	4	1	85	81	144
Firehole/Hayden #1	10	6	6	1	80	73	339
Firehole/Hayden #2	10	7	8	1	78	77	177
Madison #1	11	18	25	10	63	52	227
Madison #2	11	34	34	22	56	54	157
Henrys Lake #1 [a]	12	42 (42)	42 (42)	24	28 (29)	28 (29)	201
Henrys Lake #2 [a]	12	49 (45)	49 (45)	25	23 (26)	23 (26)	153
Plateau #1 [a]	13	25 (19)	25 (19)	10	50 (59)	50 (59)	286
Plateau #2 [a]	13	8 (7)	8 (7)	2	72 (79)	66 (73)	431
Two Ocean/Lake #1	14	2	2	0	73	69	485
Two Ocean/Lake #2	14	0	0	0	93	93	143
Thorofare #1	15	0	0	0	100	94	274
Thorofare #2	15	0	0	0	100	93	180
South Absaroka #1	16	0	0	0	97	97	163
South Absaroka #2	16	0	0	0	99	99	191
South Absaroka #3	16	3	3	2	95	94	348
Buffalo/Spread Creek #1	17	10	10	4	82	76	222
Buffalo/Spread Creek #2	17	13	14	10	75	70	508
Bechler/Teton #1	18	13	13	4	67	65	534

[a] Numbers in parenthesis indicate projected 1999 values based on full implementation of the access management standards in the Revised Targhee Forest Plan (USDA 1997).



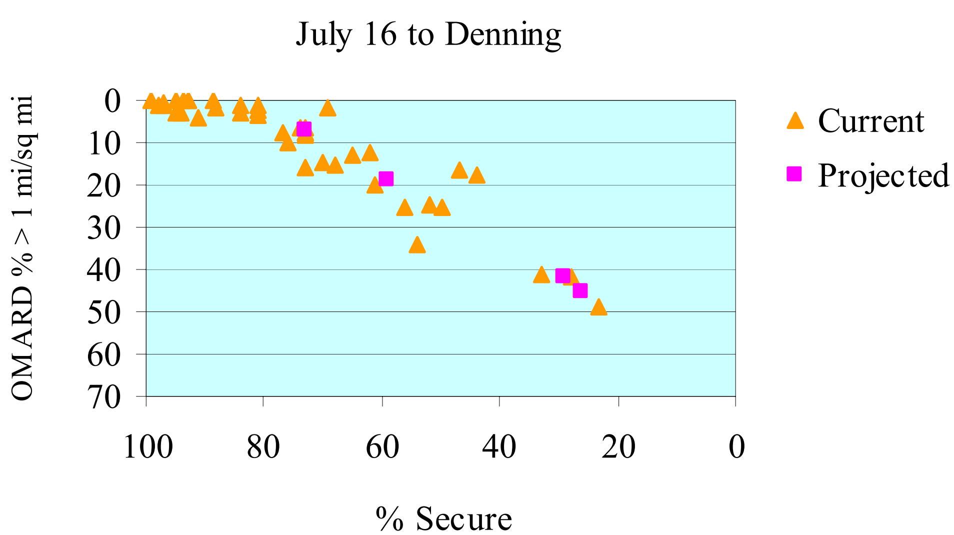


Figure 16. Percent open motorized access route density (OMARD), > 1 mi/mi^2, plotted against percent secure area for the 40 BMU subunits in the Greater Yellowstone Grizzly Bear Recovery Zone for each of the 2 seasons, 1998. Projected values reflect change that will occur when of the access management standards in the Revised Targhee Forest Plan (USDA 1997) is fully implemented.

***Yellowstone National Park Recreational** Use (Kerry Gunther, Yellowstone National Park)*

In 1998, 3,120,830 people visited Yellowstone National Park. These visitors spent 708,039 use nights camping in developed area roadside campgrounds and 45,612 use nights camping in backcountry campsites. Average annual park visitation has increased each decade from an average of 333,835 visitors per year in the 1930s to an average of 3,011,975 visitors per year thus far in the 1990s (Table 25). Average annual backcountry use nights have been less variable between decades than total park visitation, ranging from 39,280 to 47,395 use nights per year (Table 25). The number and capacity of designated backcountry campsites limits the number of backcountry use nights in the park.

Table 25. Average annual visitation and average annual backcountry use nights in Yellowstone National Park by decade from 1931 through 1998.

Decade	Average annual Park-wide visitation	Average annual Backcountry use nights
1931-39	333,835	Data not available
1940s	552,227	Data not available
1950s	1,355,559	Data not available
1960s	1,958,924	Data not available
1970s	2,243,737	47,395[a]
1980s	2,381,258	39,280
1990-98	3,011,975	43,720

[a] Backcountry use data available for the years 1973-1979.

***Grand Teton National Park Recreational Use** (Steve Cain, Grand Teton National Park)*

In 1998, total visitation in Grand Teton National Park was 4,118,106 people, including recreational, commercial (e.g. Jackson Hole Airport), and incidental (e.g. traveling through the Park on U.S. Highway 191 but not recreating) use. Recreational visits alone totaled 2,757,060. Backcountry user nights totaled 31,286. Long-term trends of total visitation and backcountry user nights by decade are shown in Table 26.

Table 26. Average annual visitation and average annual backcountry use nights in Grand Teton National Park by decade from 1951 through 1998.

Decade	Average annual Park-wide visitation [a]	Average annual backcountry use nights
1950s	1,104,357	Data not available
1960s	2,326,584	Data not available
1970s	3,357,718	25,267
1980s	2,659,852	23,420
1990-98	3,642,341	27,952

[a] In 1983, a change in the method of calculation for park-wide visitation resulted in decreased numbers. Another change in 1992 increased numbers. Thus, park-wide visitation data for the 1980s and 1990s are not strictly comparable.

Trends in elk hunter numbers within the Grizzly Bear Recovery Zone plus the 10-mile perimeter area *(Dave Moody, Wyoming Game and Fish Department; Jeff Copeland, Idaho Department of Fish and Game; and Kurt Alt, Montana Department of Fish, Wildlife and Parks)*

The State wildlife agencies in Idaho, Montana, and Wyoming annually estimate the number of people hunting most major game species. We used state estimates for the number of elk hunters by hunt area as an index of hunter numbers for the Grizzly Bear Recovery Zone plus the10-mile perimeter area. Because some hunt area boundaries did not conform exactly to the Recovery Zone and 10-mile perimeter area, field personnel familiar with each area were queried to estimate hunter numbers within the Recovery Zone plus the 10-mile perimeter area. The numbers produced represent a reasonably accurate index of total hunter numbers within areas occupied by grizzly bears in the Greater Yellowstone Area.

We generated a complete data set from all states from 1988 to 1996 (Table 27). Elk hunter numbers increased from a low of 32,746 in 1988 to just over 40,000 in 1991. These numbers fluctuated less than 7% from 1992 to 1996, averaging about 38,600. This trend primarily reflects increasingly liberal elk seasons in this region in the late 1980s in an attempt to stabilize or decrease elk herds in Wyoming and Montana. In 1988, Idaho implemented more restrictive hunting seasons in an effort to increase bull:cow ratios for there herds. Hunter numbers in Idaho have actually decrease since 1988. The majority of the increase in hunters during the early 1990s occurred within Montana, after 1990. Hunter numbers have been fairly constant in Wyoming since 1988.

Table 27. Estimated numbers of elk hunters within the Grizzly Bear Recovery Zone plus a 10-mile perimeter in Idaho, Montana, and Wyoming for the years 1988-1998.

	Year										
State	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Idaho	3,923	2,924	3,172	2,292	2,573	2,962	2,682	2,366	3,102	2,869	2,785
Montana	14,334	14,376	13,988	21,502	19,321	18,238	20,042	18,783	18,044	[a]	[a]
Wyoming	14,489	17,842	16,190	16,233	17,154	17,105	17,053	17,464	16,283	17,458	15,439
Total	32,746	35,142	33,350	40,027	39,048	38,305	39,777	38,713	37,429		

[a] Hunter number estimates not currently available.

There are several lines of speculation as to why bear losses have increased. They range from too many hunters in occupied grizzly habitat, to an increasing bear population with increased odds of bear-hunter encounters. However, it is commonly accepted that most bear losses could be avoided if people followed the recommended standards for human behavior in bear country. To that end, State wildlife and federal land agencies have attempted to reduce the loss of bears to hunters by expanding information and education programs. "Living in Bear Country" workshops are conducted annually in most of the gateway communities in Wyoming, and licensed outfitters and guides have instituted increased training for their members and clientele. The success of these programs will be directly reflected in grizzly bear moralities associated with hunters. We will continue to monitor hunter numbers and grizzly bear hunter conflicts in an attempt to provide information that will help managers make ungulate hunting more compatible with grizzly bear conservation.

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Appendix 1. The 1998 values for open motorized access route density (OMARD), and total motorized access route density (TMARD), and secure habitat in each subunit by management responsibility. The values for National Park Service, USFS Multiple Use, and Private/Other represents the contribution to the total values from access routes managed by the respective entities. Access routes managed by one entity may influence access route density or secure area parameters on an area managed or owned by another due to the manner in which the moving window and secure area analysis is performed (see Methods section). In addition, the Private/Other category includes State and County Highways that may cross federally managed or private lands.

Name	BMU No.	OMARD % > 1 mi/sq mi S1	OMARD % > 1 mi/sq mi S2	TMARD % > 2 mi/sq mi	Percent secure habitat S1	Percent secure habitat S2	Size (sq. mi.)
Hilgard #1	1	25	25	11	57	56	202
National Park Service		0	0	0			
USFS Multiple Use		15	15	6			
Private/Other		9	9	6			
Hilgard #2	1	16	18	6	59	44	141
National Park Service		0	0	0			
USFS Multiple Use		13	14	4			
Private/Other		3	3	2			
Gallatin #1	2	2	2	0	92	88	128
National Park Service		2	2	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Gallatin #2	2	8	8	4	80	73	155
National Park Service		8	8	4			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Gallatin #3	2	41	41	17	35	33	218
National Park Service		0	0	0			
USFS Multiple Use		26	26	8			
Private/Other		15	15	8			
Hellroaring/Bear #1	3	19	20	12	66	61	185
National Park Service		0	0	0			
USFS Multiple Use		14	15	8			
Private/Other		4	4	4			
Hellroaring/Bear #2	3	0	0	0	98	88	229
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Boulder/Slough #1	4	2	2	0	91	81	282
National Park Service		0	0	0			
USFS Multiple Use		2	2	0			
Private/Other		0	0	0			

Appendix 1. continued.

Name	BMU No.	OMARD % > 1 mi/sq mi S1	OMARD % > 1 mi/sq mi S2	TMARD % > 2 mi/sq mi	Percent secure habitat S1	Percent secure habitat S2	Size (sq mi)
Boulder/Slough #2	4	1	1	0	96	81	232
National Park Service		1	1	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Lamar #1	5	6	7	3	84	74	300
National Park Service		2	2	0			
USFS Multiple Use		3	3	2			
Private/Other		1	1	1			
Lamar #2	5	0	0	0	100	95	181
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Crandall/Sunlight #1	6	11	16	3	72	47	130
National Park Service		0	0	0			
USFS Multiple Use		11	16	3			
Private/Other		1	1	0			
Crandall/Sunlight #2	6	15	16	9	75	73	316
National Park Service		0	0	0			
USFS Multiple Use		13	14	8			
Private/Other		2	2	1			
Crandall/Sunlight #3	6	13	16	7	72	68	222
National Park Service		0	0	0			
USFS Multiple Use		10	13	5			
Private/Other		3	3	2			
Shoshone #1	7	1	1	1	97	97	122
National Park Service		0	0	0			
USFS Multiple Use		1	1	1			
Private/Other		0	0	0			
Shoshone #2	7	1	1	0	98	98	132
National Park Service		0	0	0			
USFS Multiple Use		1	1	0			
Private/Other		0	0	0			
Shoshone #3	7	3	3	1	95	95	141
National Park Service		0	0	0			
USFS Multiple Use		3	3	1			
Private/Other		0	0	0			
Shoshone #4	7	4	4	1	92	91	189
National Park Service		0	0	0			
USFS Multiple Use		4	4	1			
Private/Other		0	0	0			

Appendix 1. continued

Name	BMU No.	OMARD % > 1mi/sq mi S1	OMARD % > 1mi/sq mi S2	TMARD % > 2 mi/sq mi	Percent secure habitat S1	Percent secure habitat S2	Size (sq mi)
Pelican/Clear #1	8	1	1	0	94	84	108
National Park Service		1	1	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Pelican/Clear #2	8	3	3	0	88	84	257
National Park Service		3	3	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Washburn #1	9	12	12	3	68	62	178
National Park Service		12	12	3			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Washburn #2	9	4	4	1	85	81	144
National Park Service		4	4	1			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Firehole/Hayden #1	10	6	6	1	80	73	339
National Park Service		6	6	1			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Firehole/Hayden #2	10	7	8	1	78	77	177
National Park Service		7	8	1			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Madison #1	11	18	25	10	63	52	227
National Park Service		1	1	0			
USFS Multiple Use		14	21	8			
Private/Other		3	3	2			
Madison #2	11	34	34	22	56	54	157
National Park Service		4	4	1			
USFS Multiple Use		28	28	19			
Private/Other		3	3	2			
Henrys Lake #1	12	42 (42)	42 (42)	24	28 (29)	28 (29)	201
National Park Service		0	0	0			
USFS Multiple Use		39	39	22			
Private/Other		3	3	2			
Henrys Lake #2	12	49 (45)	49 (45)	25	23 (26)	23 (26)	153
National Park Service		0	0	0			
USFS Multiple Use		39	39	20			
Private/Other		6	6	5			

Appendix 1. continued.

Name	BMU #	OMARD % > 1mi/sq mi S1	OMARD % > 1mi/sq mi S2	TMARD % > 2 mi/sq mi	Percent secure habitat S1	Percent secure habitat S2	Size (sq mi)
Plateau #1	13	25 (19)	25 (19)	10	50 (59)	50 (59)	286
National Park Service		0	0	0			
USFS Multiple Use		18	18	10			
Private/Other		1	1	0			
Plateau #2	13	8 (7)	8 (7)	2	72 (79)	66 (73)	431
National Park Service		0	0	0			
USFS Multiple Use		6	6	2			
Private/Other		0	0	0			
Two Ocean/Lake #1	14	2	2	0	73	69	485
National Park Service		2	2	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Two Ocean/Lake #2	14	0	0	0	93	93	143
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Thorofare #1	15	0	0	0	100	94	274
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
Thorofare #2	15	0	0	0	100	93	180
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
South Absaroka #1	16	0	0	0	97	97	163
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
South Absaroka #2	16	0	0	0	99	99	191
National Park Service		0	0	0			
USFS Multiple Use		0	0	0			
Private/Other		0	0	0			
South Absaroka #3	16	3	3	2	95	94	348
National Park Service		0	0	0			
USFS Multiple Use		3	3	2			
Private/Other		0	0	0			
Buffalo/Spread Crk #1	17	10	10	4	82	76	222
National Park Service		8	8	3			
USFS Multiple Use		1	1	0			
Private/Other		1	1	0			

Appendix 1. continued.

Name	BMU No.	OMARD % > 1 mi/sq mi S1	S2	TMARD % > 2 mi/sq mi	Percent secure habitat S1	S2	Size (sq mi)
Buffalo/Spread Crk #2	17	13	14	10	75	70	508
National Park Service		0	0	0			
USFS Multiple Use		13	14	10			
Private/Other		1	1	0			
Bechler/Teton	18	18 (13)	18 (13)	4	61 (67)	58 (65)	534
National Park Service		1	1	0			
USFS Multiple Use		11	11	4			
Private/Other		0	0	0			