

Grizzly Bear Denning Activities and Behavior obtained by using Wildlife Telemetry

Data on / (short lines)

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INTRODUCTION

Because the Yellowstone grizzly (*Ursus arctos horribilis* Ord) is largely nocturnal, inhabits a heavily timbered area of rugged terrain and enters its den for a winter sleep that lasts 5 to 6 months, it was necessary as one phase of a comprehensive ecological study (Craighead *et al.* 1960) to develop and employ a radiotracking and locating system (Craighead *et al.* 1963, Craighead & Craighead 1965). Such a system enabled us to gather data on den site selection, den construction, prehibernating behavior and denning activities of individuals in a population of between 175 and 200 grizzly bears ranging over an area of approximately 5000 square miles. In 1961 we began developing and testing radiotracking equipment and we continued this work through the fall of 1968. During this 8-year period, we made 48 instrumentations of 23 different grizzly bears. These animals were tracked or monitored for a total of over 1,200 tracking days; den location sometimes required monitoring for 3 months and intensive tracking for 4 consecutive days. Grizzly bear No. 40 was instrumented and monitored for portions of 8 consecutive years. Seven other bears were instrumented and monitored during 2 consecutive years each. The winter dens of six different grizzlies were located, but since more than one den was located for some bears over a period of years, we were able to obtain information on size and construction of 11 dens. Due to involvement of family groups, 22 animals were radiotracked and observed to have utilized the 11 dens.

In November, 1963, we successfully tracked a 5½-year old female grizzly, No. 164, to her winter den (Craighead & Craighead 1965). As far as we know, this is the first instance in which a radio transmitter was used to track and locate a grizzly bear as it entered its winter den.

Prior to this study, little was known concerning the denning activities and prehibernation behavior of wild grizzlies. Dens reported to us as those utilized by grizzlies turned out to be the dens of black bears. It was generally thought that the Yellowstone grizzlies, like black bears and the European brown bears (*Ursus arctos arctos* L.), utilized natural shelters—caves, hollow trees, wind-fall and dense vegetation—as sites for their 'hibernation' dens (Couturier 1954).

These were supposedly enlarged by digging, or improved to varying degrees as shelters for the long winter sleep (Lyman & Dawe 1960, Kayser 1961).

A short discussion of hibernation or winter sleep seems appropriate, since differences in hibernators and in how they hibernate have caused researchers to formulate varying definitions of this phenomenon.

Authors suggesting that the bear is not a hibernator point out that though the bears go into a deep sleep and are inactive for considerable periods of time, they do not become torpid and helpless as do most hibernators (Kayser 1961: 21-50). Bears can be readily aroused after which they can react quickly and energetically to disturbance; and their body temperature does not approach the ambient air temperature.

Hibernation is generally considered to be a torpid state in which the hibernator, partially or wholly, loses its sensibility or power of motion. This is a state from which the animal can be aroused only with difficulty. Thus, bears during their winter sleep are dormant rather than torpid because they can be rather easily aroused and they can move rapidly when disturbed—features enhancing survival of a group of mammals that have been hunted by man since prehistoric times. Low ambient air temperatures, deep snow and the unavailability of food appear to make hibernation or winter sleep essential to the survival of grizzlies in the Yellowstone area.

The study area in Yellowstone Park and the surrounding National Forests lies largely between 7,000 and 8,000 feet altitude. Temperatures of -40°F. and below have been recorded, at some time, from all areas of the Park where temperature records have been kept. The lowest recorded temperature is -66°F. (Anon. 1959).

METHODS

To obtain information on denning behavior and activities of grizzlies fitted with radio transmitters, the position and movements of instrumented bears were plotted from the inter-section of bearings (fixes) which were made from a distance. Then, guided by the fixes and using portable directional receivers, we moved on foot to observe the animals at close range.

The radiotracking system was designed to provide maximum use in various types of field work. A diagram of the location system is shown in Fig. 1. The transmitter collar radiates a pulsed signal which can be received by a variety of stations, depending on the receiving antenna employed. A small, 2-lb. battery-operated receiver with a directional loop antenna was used for tracking on foot when the distance between the receiver and the instrumented animal was not greater than 2 to 3 miles. (Varney, 1971).

The collar which was placed on the animal to be tracked consisted of the transmitter unit and a battery pack attached to a circular metal strap which acted both as a loop antenna and a collar (Fig. 2). The battery pack was waterproofed with paraffin and silicone rubber and the assembly was covered with fiberglass-reinforced acrylic resin to protect the electronics and batteries (Fig. 3). It also prevented flexing and bending which would otherwise have caused antenna detuning or eventual breakage.

The inside of the collar was padded with rubber hosing or foam rubber or a combination of both to make it fit the animal snugly and comfortably (Fig. 4). The collar was designed so the metal strap could be adjusted to the desired

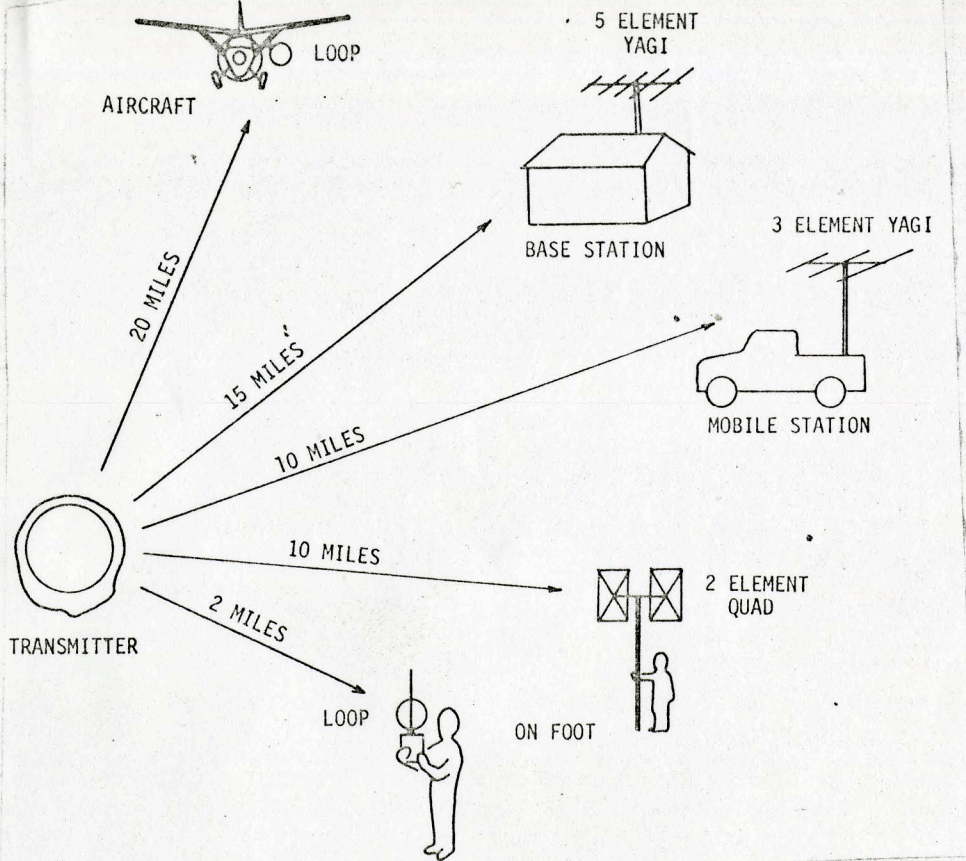


Fig. 1 Radio location system



Fig. 2 Male yearling grizzly No. 158, equipped with radio collar. He was tracked to a den shared with sow No. 39 and two littermates. Individual color-markers are visible in ears.

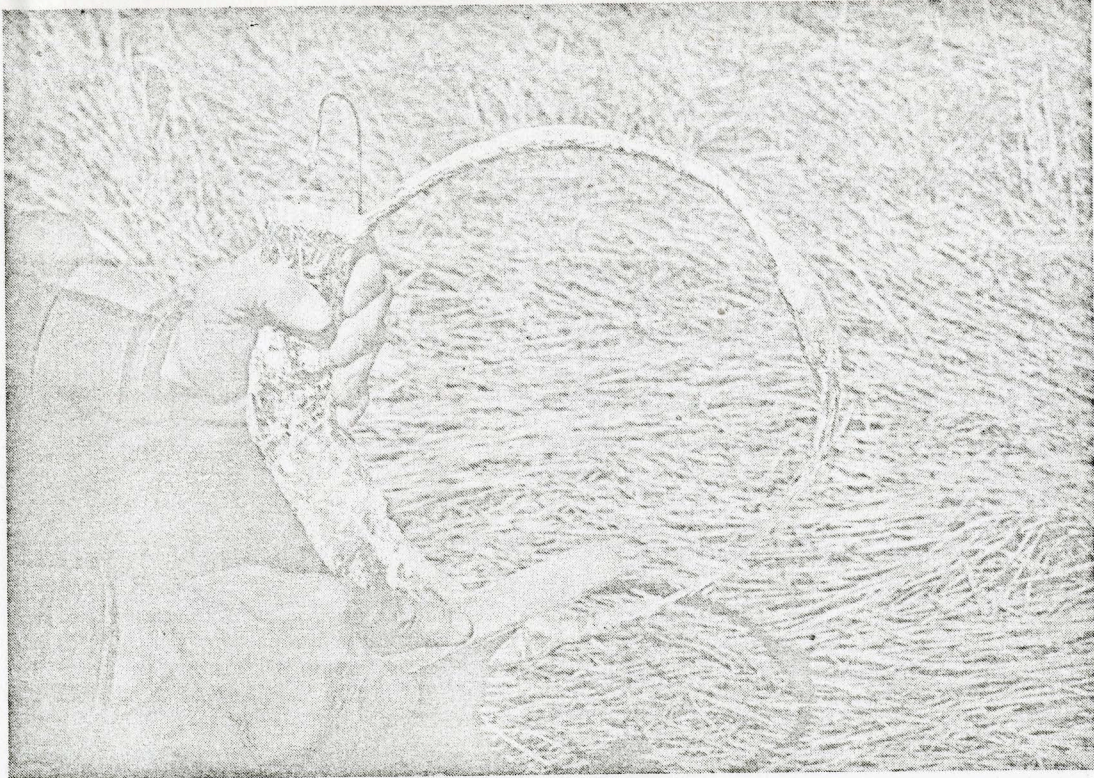


Fig. 3 Putting fiberglass on transmitter-collar assembly to make it waterproof, shockproof and bear-proof

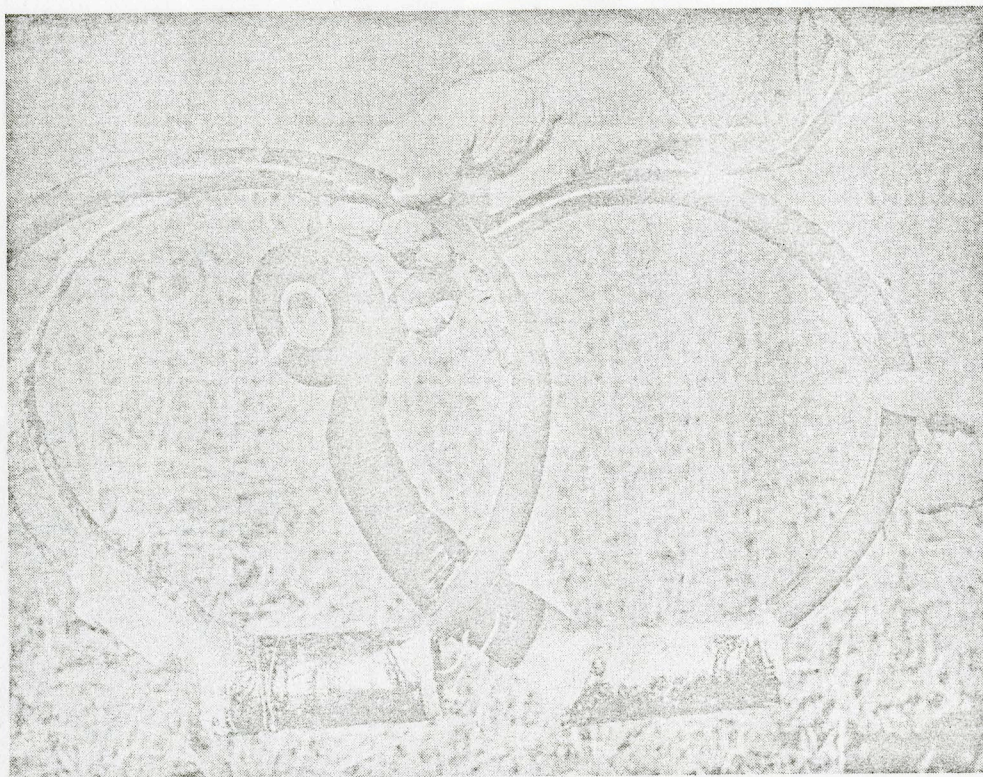


Fig. 4 Plastic hose and rubber padding, wrapped with tape of varying colors, make a comfortable and snug fit.

neck diameter by inserting two screws in a series of holes in the overlapping ends of the strap (Craighead & Craighead 1970).

We used two types of transmitters in tracking operations. One type was designed to operate continuously, emitting a 50 ms pulse at approximately 1 second intervals. The battery life with this type of transmitter (called the standard model) was 3 months. For longer life an additional timer circuit was used to turn the transmitter on and off at 30 second intervals. Battery life of this extended-life model was 9 months (Craighead & Craighead 1965). All transmitters of both types operated on the same frequency, but each had a different pulse rate which permitted identification of each grizzly.

Transistorized receivers were used for tracking on foot and obtaining bearings from base and mobile stations. Various kinds of antennas could be connected to a receiver, depending on tracking requirements. The receivers were battery-operated Citizen's band units modified to operate at 32 MHz. Early in the study some tracking at base and mobile stations was done with general-coverage communications receivers; however, these were later discarded in favor of the portable units (Craighead & Craighead 1970).

Summaries of the transmitter, receiver, and system characteristics are given in Tables 1, 2, and 3.

Normal tracking procedure was to record a signal from an instrumented grizzly at the base station using the 5-element yagi antenna. The direction of the signal source was plotted on a topographic map. A second and frequently a third bearing was made with the mobile unit. The intersection of the bearings generally fixed the animal's position to within a $\frac{1}{4}$ to $\frac{1}{3}$ mile area on the map (Fig. 5). We then hiked to within 2 to 4 miles of the fix and activated the portable receiver which was used to move in on the bear until he was sighted or jumped.

TABLE 1.—TRANSMITTER CHARACTERISTICS

Frequency	32 MHz
Output power	100 mW pulse
Pulse width	50 ms
Pulse repetition rate	1 per second (nominal)
Antenna type	resonant loop, 11 inch diameter
Antenna impedance	50 ohms
DC input power	280 mW peak, 18 mW average
Battery type	mercury, low temperature 9.3 volts, 4.5 Ah
Weight:	
electronics	0.1 lb
battery	0.9 lb
complete collar	2.0 lbs
Operating lifetime	3 months standard, 9 months with additional timer

TABLE 2.—RECEIVER CHARACTERISTICS

Frequency	32 MHz
Type	dual conversion, crystal controlled
Bandwidth (3 dB)	3 kHz
Sensitivity	—123 dBm nominal for 10 dB S/N
Battery type	Nickle-cadmium, 225 mAh
Size	3 × 7 × 8 inches
Weight	2 lbs
Battery life	10 hours between charges

TABLE 3.—SYSTEM RANGE WITH VARIOUS RECEIVING ANTENNAS

Antenna Type	Antenna Gain	Use	System Range*
Loop (11" dia.)	—10 dB (est.)	on foot from aircraft	2 miles 20
Dipole (reference)	0	—	
Quad	5	field station	10
3 element yagi	7	field station	10
5 element yagi	9	base station	15

*Typical value—varies widely with terrain

As the instrumented animal was approached, the signal strength increased so that, at about $\frac{1}{4}$ mile, a null became difficult to obtain. The receiver sensitivity setting was then reduced to get a null; the remaining distance to the instrumented grizzly was covered by following the null. Signal volume and receiver sensitivity provided a good indication of distance between the bear and the observer. We frequently approached grizzlies to within 100 feet before disturbing them. The average distance at which we 'jumped' them from daybeds in dense timber and windfall was 125 feet.

Grizzly bears that we planned to track to dens were generally instrumented in late summer or early fall. These animals were radiotracked almost daily either from the base station or in the field. Instrumented animals were followed on prehibernation treks to denning areas whenever possible; however, at such times the bears were not closely pursued.

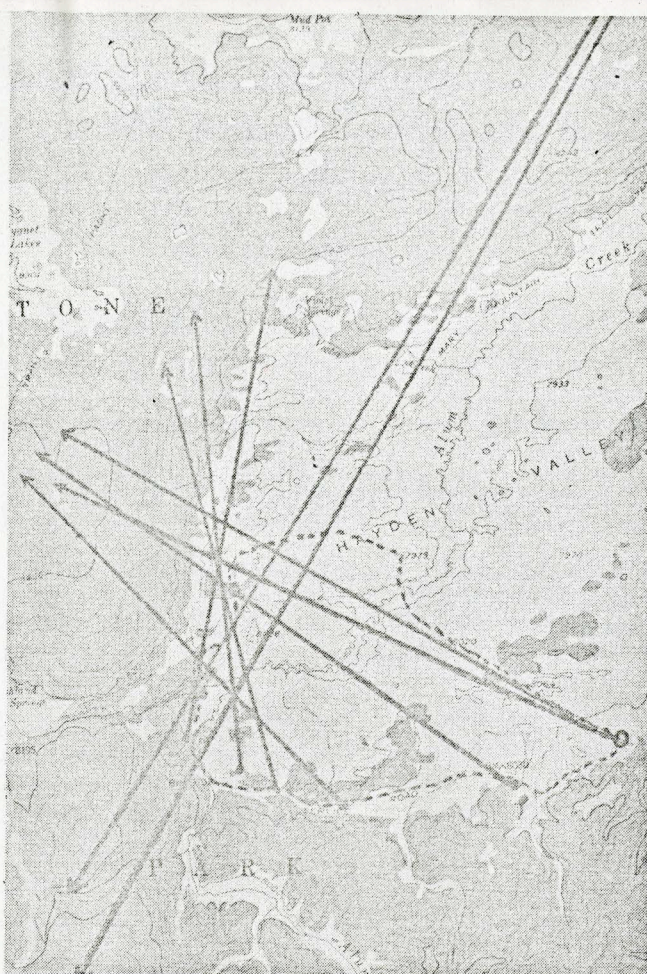


Fig. 5 Bearings of transmitter signal plotted over two consecutive days in order to locate instrumented grizzly. They were taken from a field station (circle) and the base station (upper right, just off map 8 miles to north). Dark spot is position of bear and dotted line is route of trackers using portable directional receivers.

RESULTS

Den Site Selection

The dens of six different grizzlies were located, some for consecutive seasons. Thus, 11 active ones were found and information was obtained on site preference, den size and construction. All dens used by grizzlies were located while they were being constructed, or when bears entered them for their winter sleep.

Information on den site selection (Table 4) was obtained from monitoring and observing instrumented grizzlies in the fall of the year. In 1961 and 1962 we were unable to track the radio-tagged bears to their dens. However, the dates of hibernation (29 and 21-22 October, respectively) were obtained by observing movements of grizzlies during snowstorms and the lack of tracks thereafter. Later, with improved equipment, tracking grizzlies became routine, and we obtained specific dates when they entered dens to remain for the winter.

Over a 9-year period, these dates when grizzlies entered their dens to remain varied by as much as a month. They were:

<i>Year</i>	<i>Month</i>	<i>Year</i>	<i>Month</i>
1960	Oct. 29	1965	November 11
1961	October 21-22	1966	November 19-21
1962	November 15 (approx.)	1967	November 19
1963	November 4-5	1968	November 3-4
1964	November 10		

Bears of both sexes and several age classes were tracked to dens. These included 1 young adult female (barren), 1 young adult female with her first cub, 2 adult pregnant females, 2 adult females with cubs, and 2 adult females with yearlings. Two young males were tracked to their dens, one as a weaned yearling and again as a 2-year-old—the other as a yearling with his mother and two littermates. Very large boars were instrumented and tracked to denning areas but none were successfully tracked to dens. Four dens of one female were located—three of these in consecutive seasons; the dens of two other bears for two successive seasons. An orphaned grizzly, cub No. 78, was observed until and soon after emerging from hibernation, evidence that cubs can survive the winter without parental care or guidance.

Grizzlies whose dens were located hibernated at altitudes ranging from 7,800 to 9,200 feet (Tables 4 and 5). All dens were located in timbered areas and all but one on northern slopes with the den entrance facing north. Couturier (1954) found that brown bears preferred a den that faced south. A north-facing den entrance appears to be advantageous to the hibernating grizzly in Yellowstone because prevailing southwest winds accumulate snow on northern exposures.

The deep snow that accumulates in such locations insulates the den chamber from the extreme ambient air temperatures that drop as low as -40°F . or even to -60°F . Also, there is less chance that snow on north slopes will melt during a warm period or winter 'chinook'. Water trickling into a den would appear to be disturbing and undesirable. Though early spring and later fall sightings revealed that grizzlies den throughout Yellowstone and beyond, all occupied dens were found in the central portion of the Park.

Dens were located relatively far from developed areas or human activity. Grizzlies seem to need and to seek isolation for the 6 months of their winter sleep. In the course of evolution, finding isolated den sites for hibernating would appear to be a factor favoring survival of the species. Primitive man and the American Indian undoubtedly found that grizzlies, lethargic until disturbed, were vulnerable in winter and the odds far more favorable for killing them during winter sleep than during their active period.

Den Construction

Most grizzlies prepared winter dens well in advance of the time they went into hibernation. The earliest recorded den diggings were on 3 and 8 September. The latest occurred 11 and 15 November; the bears completed these dens just in time to enter them for the winter. In one case, den construction had been delayed because the bear had abandoned her first den. The amount of disturbance needed to cause abandonment of a completed den or one under construction varied considerably with individual grizzlies.

TABLE 4.—CHARACTERISTICS OF ACTIVE GRIZZLY BEAR DENS

Designation of Grizzly No.	Sex	Year Den Used	Den Location	Vegetation Type	Soil Structure	Den Elevation (Feet)
164	F	1963*	Upper Alum Creek	Lodgepole	Soft earth	8, 200
158	M	1964	Upper Trout Creek	Lodgepole Pine	Packed soil Gravel layer	8, 400
40	F	1964	Upper Alum Creek	Lodgepole Pine Spruce-Fir	Packed soil	8, 200
40	F(3)	1965	Upper Alum Creek Beach Lake	Lodgepole Pine	Packed soil	8, 200
40	F	1966	Lower Trout Creek	Lodgepole Pine Spruce-Fir	Loose soil	8, 000
202	M	1965	Yellow- stone Canyon	Spruce-Fir	Rocky (talus)	7, 800
202	M	1966	Yellow- stone Canyon	Spruce-Fir	Rocky (talus)	7, 800
101	F	1966	Lower Trout Creek	Lodgepole Pine	Sandy soil	8, 000
101	F	1967	Hedges Peak	Spruce-Fir Whitebark Pine	Packed soil Rocks	9, 200
187	F	1967	Ice Lake	Lodgepole Pine	Packed soil	8, 100
40	F	1968	Upper Trout Creek	Spruce-Fir	Packed soil	8, 200

(1) Attempted earlier to dig den at base of tree.

(2) Den abandoned before lining.

(3) Female pregnant.

* Signs of use the previous year.

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which is part of the same Table)

Species of Den Tree	Den Measurements (inches)							Den Lining	Fate of Den First Spring
	Chamber L W Ht			Entrance L W Ht			Total Length		
Lodgepole	59	53	48	60	17	40	119	Conifer boughs	Remained intact
Spruce	64	60	60	32	30	42	96	Conifer boughs	Remained intact
Spruce	48	42	48	36	30	30	84	Conifer boughs	Collapsed
None	54	54	36	66	33	21	120	Grass Moss Rootlets	Remained intact
Dead stump	60	85	28	30	17	20	90	Conifer boughs	Collapsed
Log(1)	47	43	26	—	—	—	66	Conifer boughs	Remained intact
Log	43	37	28	—	—	—	63	Conifer boughs	Collapsed
Whitebark Pine	54	48	30	12	14	36	66	None (2)	Remained intact
Dead spruce	63	56	40	45	15	54	108	Fir boughs	Collapsed
Whitebark Pine	—	—	—	36	21	27	—	None (2)	Collapsed
Spruce	68	54	30	38	24	—	106	Conifer boughs	Remained intact

TABLE 5.—CHARACTERISTICS OF INACTIVE GRIZZLY BEAR DENS

Den Location	Vegetation Type	Soil Structure	Den Elevation (Feet)
Upper Trout Creek	Lodgepole pine	Hard, compacted	8,200
Absaroka Range Mist Creek	Whitebark pine	Rocky	9,000
Lower Trout Creek	Lodgepole pine Spruce-fir	Loose soil	8,000
Yellowstone Canyon (North side)	Douglas-fir	Fine-rock soil	7,600
Ice Lake Area	Lodgepole pine	Packed soil	8,100
Upper Trout Creek	Spruce-fir	Packed soil	8,200

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The duration of den-digging varied, but usually the major excavation was accomplished within 3-7 days; minor digging activity occurred over a period of weeks. Interrupted radio signals enabled us to determine when bears were digging dens, and we then located and observed them (Craighead 1968). For example, in 1966, No. 202 returned twice to his den and attenuated signals indicated he was digging; digging was visually confirmed on both occasions.

Natural shelters were not utilized as dens by grizzlies, though matted wind-falls and rock caves were available. All the dens we located were dug by grizzlies (Table 4). The Yellowstone grizzly frequently digs a den entrance at the base of a tree, and tunnels in through the large downward and outward sloping roots (Figs. 6 and 7). The roots limit the size of the den opening and may form a ceiling. Although grizzlies do not always select the base of a tree for den sites, such sites are preferred. Exceptions were sow No. 187 and male No. 202, who dug their dens under horizontal logs (Fig. 8).

We believe it is instinctive for the grizzly to dig a den rather than appropriate or modify a natural cavity; some behavior supports this. For example, in the fall when grizzlies dig dens and gather boughs for beds, they also dig to cover carrion or kills more frequently than at other seasons of the year (Fig. 9). In addition, when they move to their dens prior to hibernation, they perform a stereotyped 'housecleaning' by digging inside and outside the den (Fig. 7). This seasonal increase in digging may reflect a biological drive.

The grizzly bear dens were usually constructed with an entrance way leading into the bed chamber. The average size of this chamber (determined from 10 dens) was: 56 × 53 × 37 inches. A den which sheltered No. 39 and her 3 yearlings was almost as wide as it was long. In 1966 when No. 40 hibernated with 2 cubs, her den was wider than it was long, and the 3 bears slept curled up side by side (Table 4). Females with cubs or yearlings dig wider dens than bears that hibernate alone. Den entrances went directly into the chamber, or had entrance tunnels as long as 66 inches. Width of den openings varied from 14

Species of Den Tree	Den Measurements (Inches)						Total Length	Den Lining
	Chamber			Entrance				
	L	W	HT	L	W	HT		
Spruce	43	63	43	64	26	26	107	Conifer boughs
Whitebark pine	54	60	36	—	—	—	54	Conifer boughs
None	70	52	30	20	27	19.	90	Conifer boughs
Matted vegetation	—	48	—	—	—	—	96	Den collapsed
Mat of <i>Vaccinium scoparium</i>	—	30	24	—	—	—	84	Den collapsed
Spruce	64	38	26	44	45	—	108	Partially collapsed



Fig. 6 Den of grizzly No. 101. This was abandoned and a new one dug.

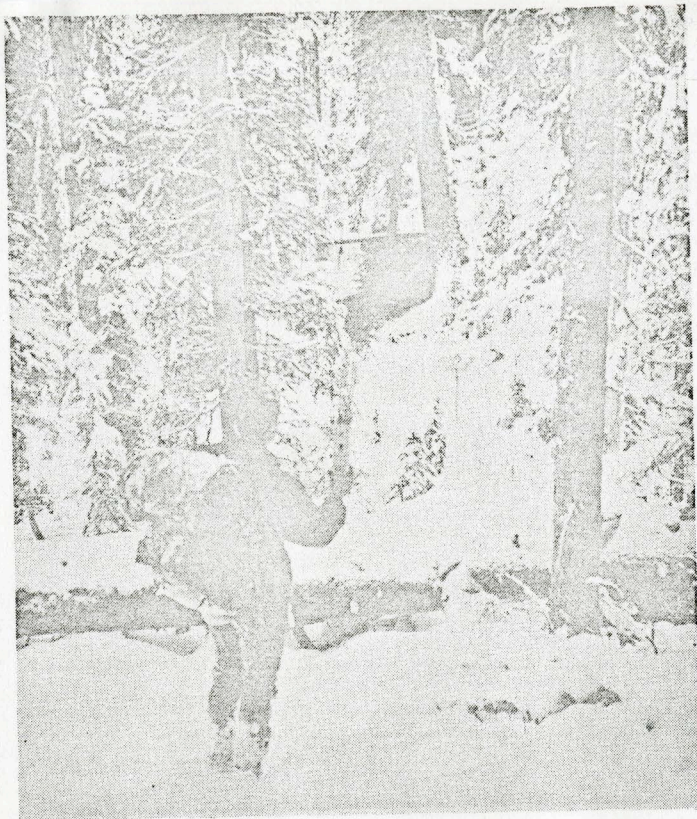


Fig. 7 Location of den of No. 40 by following transmitter signal with directional receiver. The den has been excavated at the base of a tree.



Fig. 8 Den of grizzly sow No. 187, which was abandoned prior to being lined with boughs. This was one of the few dens not dug at the base of a large tree but, instead, sited below a horizontal fallen log.



Fig. 9 Grizzly family sleeping on the remains of an elk carcass. The carcass was covered with grass and dirt when the bears were not feeding

to 33 inches and averaged 22; heights ranged from 20 to 54 inches and averaged 34.

After we located active dens by radiotracking grizzlies, a general pattern of den site preference emerged which enabled us to seek for and find dens used in previous years. The size and characteristics of ~~seven~~ such dens are shown in Table 5.

/six

Den Environment

Den beds were usually composed of spruce or fir boughs, 3-14 inches deep (Fig. 10). Normally boughs were chewed from spruce or fir trees growing within a radius of 50 feet of the den. During three winters when female No. 40 was not pregnant, she used conifer boughs, but when pregnant, she prepared a bed of moss and grass. Pregnant females may routinely use fine, soft material for beds. Dens are usually lined with bough beds soon after they are dug. In one case a grizzly accumulated a large pile of boughs outside the den entrance prior to starting bed construction.

The den of the grizzly bear is a very localized environment with temperatures warmer and more constant than those existing outside. In addition, when a deep insulating layer of boughs is used, many 'dead air' pockets form a microclimate next to the bear within the porous bedding material. Here the temperature is considerably warmer than the general ambient temperature of the chamber. Thus, a very narrow 'envelope' of bedding and air lies between a bear and its den.

The temperature of such a microclimate in a black bear den was recorded by placing a thermistor probe from a body temperature transmitter between the bear and his bed of dry pine needles and finely shredded twigs and rootlets

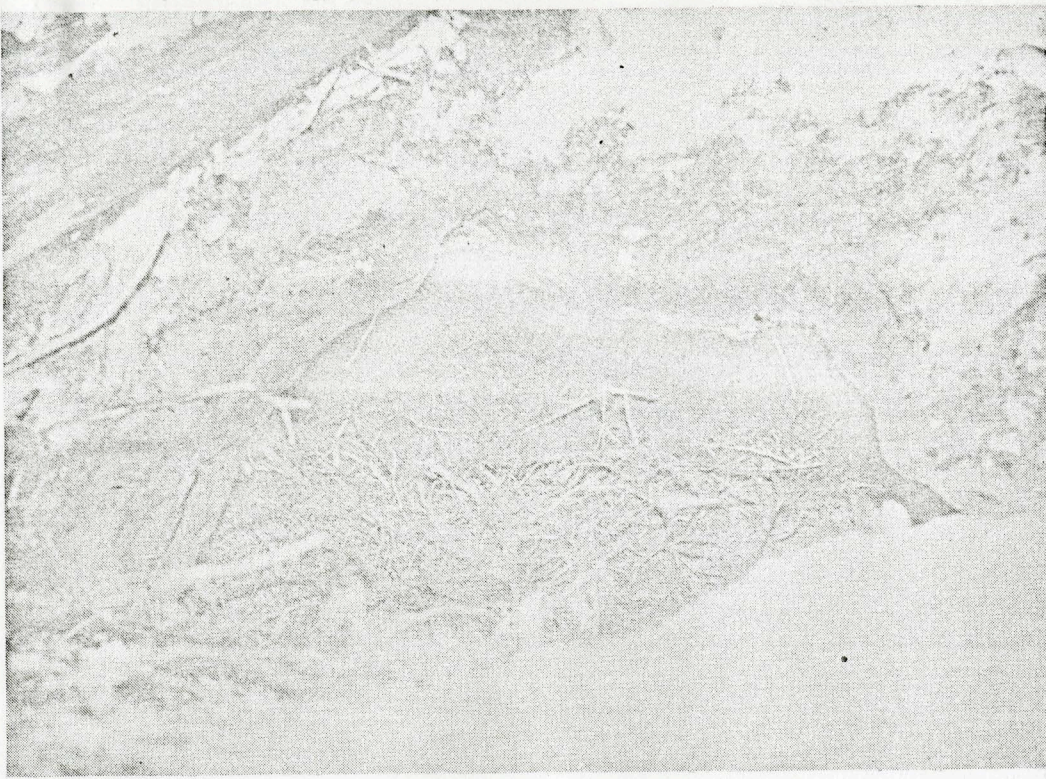


Fig. 10 Den of sow No. 40 (1966), showing the bough bed on which she and her two cubs slept side by side.

(Craighead & Craighead 1966). The maximum recorded temperature of $97^{\circ}\text{F.} \pm 2^{\circ}\text{F.}$ for the microclimate closely approached the body temperature of 101°F. recorded for an active bear in summer, and exceeded the average rectal temperature (96°F.) of a hibernating black bear which was monitored for 4 days (Craighead *et al.* in press). However, over a 55 minute period the temperature fluctuated between 97°F. and 83°F.

Distinctions Between Daybeds and Dens

In the Yellowstone region, most grizzlies are active both day and night during the early spring months when food is relatively scarce. They are again similarly active during the fall of the year when they forage prior to entering dens for the winter. In summer, they rest during daylight hours and forage at night. They seek windfalls and dense thickets of spruce, fir and lodgepole pine in which to rest. Here they excavate daytime beds or lairs most of which vary in depth from 1 to 18 inches. Forest duff is often scraped to mineral soil. Occasionally daybeds, like winter beds, are lined with grass, pine needles or other vegetation (Fig. 11). Most beds are shallow excavations, but at times denlike burrows are dug 3 or 4 feet into slopes or under fallen logs (Fig. 12); these burrows are cooler than surface beds.

Burrow-type daybeds can be mistaken for winter dens, and occasionally a den such as that of No. 202 can resemble a daybed. However, daybeds are usually located relatively close to feeding areas, may be visited and used by different bears and are not necessarily constructed into north-facing slopes nor at the base of large trees. They may function as retreats during the breeding season. In 1964, a large boar and a female in oestrus were located in daybeds 25 feet apart. The female had dug a burrow several feet into a hillside (Fig. 12). With her body in the burrow and her head and muzzle resting on the tailings from



Fig. 11 A grizzly's daybed which has been lined. Most daybeds are unlined shallow excavations.



Fig. 12 Burrow-type daybed prepared by young female No. 6.

the cave, she could discourage unsolicited attentions from the male. Daybeds, used during the pre- and post-hibernating periods, are normally clustered around a den, but even the most elaborate of these are easily distinguished from the den itself.

Re-use of Dens

Old bedding material found in a debris pile at the den where No. 164 wintered during 1963, suggested that this den might have been used the previous year. Grizzlies No. 40 (1966) and No. 101 (1967) raked the bedding out of their dens before leaving them in spring. This suggested that they would re-use them; however, these dens and others to which we radiotracked grizzlies were never re-used. Five dens collapsed when the soil became saturated with water in late spring, and thus were not suitable for re-use; however, six remained intact (Table 4) and could have been reoccupied, but were not.

In consecutive years, grizzly No. 202 dug two dens only 300 feet apart. His first den was poorly excavated and probably inadequate for re-use the following year. The second-year den was a decided improvement; the grizzly removed an estimated ton of rock in preparing it. Although we believe that the biological drive to dig a den is instinctive, a learning process is involved and den construction improves with experience.

No feces or traces of urine have been found in recently abandoned grizzly bear dens, or even observed close to them. Harrington (1968) found that polar bears usually keep their dens clean; only traces of urine and minute fecal fragments were found in six of nine dens he examined. We have found neither feces nor urine in six active black bear dens visited while the bears were in winter sleep. Three dens were examined after immobilizing and removing the bears; all six dens were inspected in the spring after the animals left. We observed black watery excrement, passed by grizzlies prior to entering winter dens; this suggests a scouring and cleaning of the alimentary tract. The Yellowstone grizzlies normally fast from the time they enter their dens until they leave them in the spring.

Prehibernation Movement and Behavior

In the early years of the study (1960-61), we observed that grizzlies moved to their dens during a snowstorm and that tracks were not visible anywhere in the area after the storm. This suggested that certain environmental stimuli may have triggered all or most of the grizzlies to move to and enter their dens simultaneously.

Grizzlies living under the same environmental conditions entered their dens at the same time during a storm regardless of whether they were waiting close to their dens (the case of No. 40 in 1965) or were foraging at some distance. At the time of entering dens, minimum ambient air temperatures as well as maximum temperatures in shaded den sites were below the freezing level. From 1963 through 1968 we never found tracks throughout extensive areas where grizzlies had been roaming and foraging prior to the storms that put them in their dens. The nearly simultaneous entering of dens during falling snow conceals tracks that could reveal the den locations and this behavior may have survival value for the species.

Prehibernation Lethargy

In the late fall of 1965, we noticed a distinct lethargy in all grizzlies closely observed prior to hibernation.

About two weeks later on 3 November, lethargy was even more pronounced. No. 202's radio signal led us to the edge of the Yellowstone Canyon. A 3-bearing fix placed the grizzly directly below us. While we scanned the terrain with binoculars, the crash of a dislodged rock brought a roar from the grizzly lying just below. For a half hour he remained nearly motionless in a sitting-fetal posture. He appeared to be in advanced lethargy and apparently never detected us.

On 25 October 1965, we approached to within 30 feet of No. 40 in her den. She was sufficiently lethargic for our presence not to disturb her.

The lethargic condition of these bears during the fall of 1965 was comparable to the condition of lethargy that they normally attained after entering their dens in winter.

Quite possibly weather conditions in the fall of 1965 initiated lethargy early in the season and affected grizzly prehibernation behavior and movement to den sites. An early fall period of snow and unusual cold occurred from 15 through 28 September. The minimum temperature for the 18-20 September cold spell was 7°F.

The combination of early snow and low temperatures did not stimulate grizzlies to hibernate, but it did disperse some from summer to fall foraging areas, and appears to have been a factor triggering hibernation processes so that the bears became lethargic and physiologically ready to hibernate by late October, before the usual environmental stimulus of a 'final' snowstorm caused them to enter their dens for the winter on 11 November.

Defense of Dens

Information obtained with and without the use of radios indicates that the Yellowstone grizzlies are not territorial (Craighead & Craighead 1971). On a number of occasions we have observed more than 20 grizzlies at one carcass feeding together with surprisingly little friction. We have never observed the defense of a home range or compensatory movements (Craighead & Craighead 1956) or mutual avoidance (Hornocker 1970). We thought that if grizzlies defended specific areas, these areas most likely would be in the vicinity of their winter dens. Here they might also attack a man. However, we observed no overt defense of a den or den areas against either man or other grizzlies.

On 3 November 1964, after a two day trek through the snow, our radio signal of 82 pulses per minute led us to the den of grizzly No. 40. With receiver sensitivity reduced the signal indicated that we were close to the den. A growl from the cub revealed that we had found it. A patch of earth tailings darkened the snow at the den entrance which led under the base of a huge fir tree. Neither the sow nor the cub were within. We glimpsed a flash of black as the cub tardily followed his mother. Both remained hidden in the dense timber within three to four hundred yards of their den, but exhibited no aggressive behavior and never attempted to come closer while we were in the vicinity.

The following day we picked up a signal at 52 pulses per minute, coming from the radio collar on the yearling grizzly No. 158. This we knew would lead us to the den of sow No. 39. We hoped to determine whether this yearling as well as his two large littermates would den with their mother (Craighead & Craighead 1969). The signal lured us deeper into the Yellowstone wilderness. Sometimes it was only a weak pulse; other times it came to us intermittently and finally strongly as we approached the den. Occasionally it halted our trek when it died out completely for long periods while the instrumented grizzly

remained in the den. In late afternoon still following the signal we entered a thicket of 'doghair' lodgepole pine. Visibility was only a few feet. A sudden increase in signal strength informed us that the instrumented grizzly and probably the entire family were moving toward us. Immediately after we climbed trees, our signal revealed that the bears were running away. Sow No. 39, a grizzly that had a record as a belligerent bear, had not attempted to defend her den.

While tracking this same sow a few weeks earlier, we had inadvertently approached to within 75 feet of her daybed. This signal from her yearling indicated that she was nearby but we were first aware of her very close proximity when her ears rose to the alert position from behind a fallen log. We retreated even more slowly and cautiously than we had approached. After climbing trees, we shouted to further alert the grizzlies and were startled by a loud roar. Within seconds our radio receiver indicated that the bears were moving away at a rapid rate. As revealed by her tracks, this ill-tempered sow had charged 20 feet through the snow in huge bounds heading directly for us. She then abruptly turned and fled in the opposite direction, an example of the bluff-like charge that is not uncommon with grizzlies.

In the fall of 1967, we approached to within 200 feet of the den of grizzly No. 101. The radio signal showed she was inside. We moved on without disturbing her. Several hours later we returned and saw fresh bear tracks leaving the den and got a faint signal on our radio receiver. We followed the tracks for a half mile through knee-deep snow. Signs showed us that after leaving the den, No. 101 crossed our trail. When she did so, she started running and urinating and the urine trail persisted for about 200 yards. We interpreted this as a physiological manifestation of fright. The female abandoned the den. Later in the season when her newly dug second den was approached, she growled threateningly, came out of the den, and retreated a short distance. We observed similar behavior at the dens of grizzlies No. 40, 164, 202 and 187.

These and other incidents, including our observation of sows Nos. 40 and 101 together at their respective den sites, suggest that grizzlies do not actively defend dens either from other bears or from humans if alternate courses of action are available to them. Grizzlies are dangerous animals but our experience over the years studying them at close range, tracking them by radio and handling them has indicated that most grizzlies respect man and although they do not fear him, they prefer to avoid him.

The most dangerous grizzlies are those that have been wounded, sows protecting cubs, and those that at one time or another have associated food directly with humans (Craighead & Craighead 1971). After such conditioning with food, they will approach so close that an overt act triggers the bear to charge, perhaps in self defense, rather than to flee.

Emergence from Hibernation

Bough and bark beds laid on the snow near the den of grizzly No. 40 and her yearlings in 1965 (Fig. 13) indicated that they had emerged from the den in late March but did not leave the den area until about 20 April. The beds were on different snow strata or levels, indicating time intervals between construction.

Other grizzlies emerged from dens 3 to 4 weeks before they left their den sites. When grizzlies first emerge, the snow is frequently too soft and deep for them to travel, and they remain at the dens until warm sunny days followed by chilly nights crust the snow so it will support their weight.

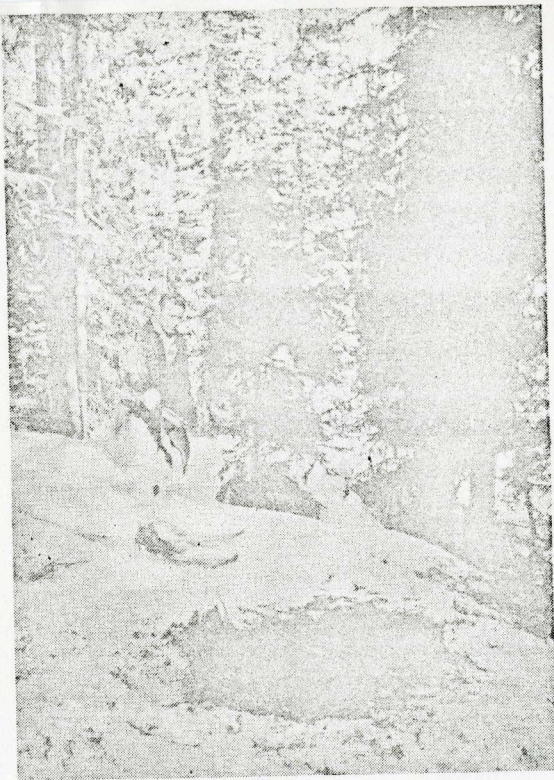


Fig. 13 Bough bed constructed in deep snow near entrance to winter den. It was made in late March.

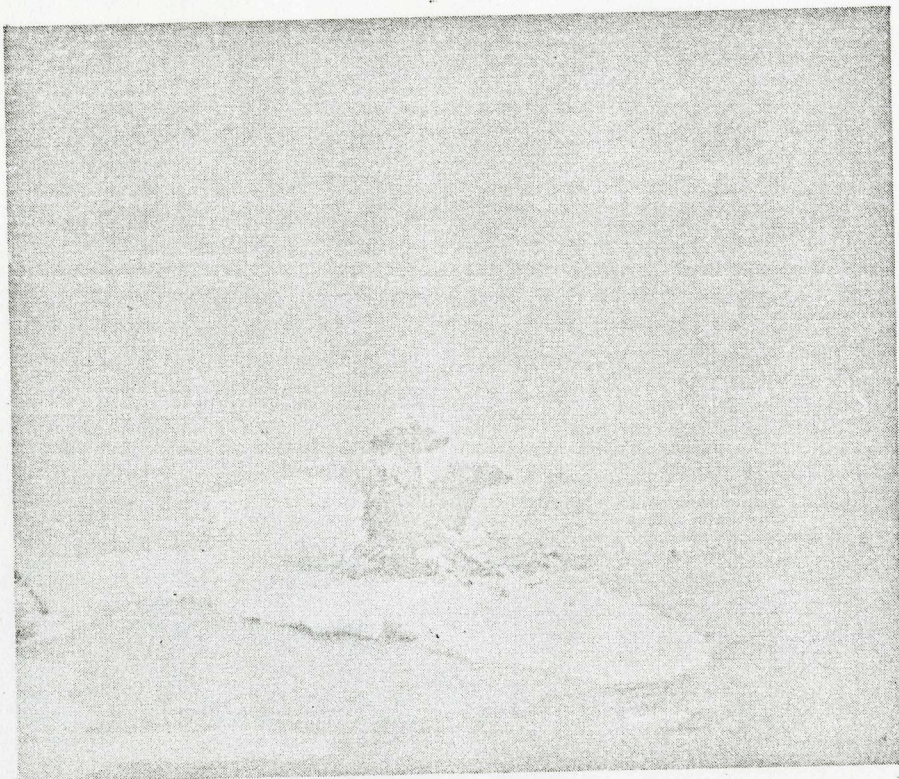


Fig. 14 Grizzly No. 40 (instrumented) with her yearling feeding on the carcass of a drowned bison soon after they had emerged from 'hibernation'.

Our observations reveal that mature male and female grizzlies tend to leave den areas earlier than females with yearlings. Females with cubs of the year are the last to leave den sites and some may remain in the vicinity of the den until the snow has disappeared.

The carcasses of winter-killed animals (Fig. 14) form a considerable portion of the diet of grizzly bears in early spring. In addition, grizzlies kill those weakened by a severe winter. Our records include observations and authentic reports of grizzlies killing full-grown moose, bison and elk. In most cases the animals were attacked in deep snow, while crossing rivers, or when otherwise handicapped or incapacitated. Some were so close to death from malnutrition that they made no attempts to evade attack. We have a number of sight records (our own and others) of two or more grizzlies pursuing and killing elk in well-coordinated attacks. The majority of elk and bison carcasses that were utilized by grizzlies were in advanced stages of malnutrition as evidenced by bone marrow tests. The same was true of most of those that fell prey to bears (Craighead & Craighead unpub.).

A late spring with deep snow on the ground, such as occurred in 1970, can produce a higher than normal number of starving ungulates which fall prey to hungry grizzlies. Such predation is atypical except where ungulate populations exceed winter range carrying capacities. The fundamental cause of death is malnutrition, not predation.

Our observations indicate that the grizzly's role as a carnivore, prior to and immediately after hibernation, in Yellowstone is first a scavenger, second a predator on small prey species (especially when these are at high densities (Craighead & Craighead 1968) and, only last, a killer of large prey animals.

GRIZZLY BEAR MANAGEMENT

Grizzly bears constructed their winter dens in timbered areas isolated from human habitation and activities. It would appear that extensive areas of wilderness and of undeveloped Park or Forest lands are suitable for denning and in fact may be essential to the welfare of the grizzly.

The Yellowstone grizzly prefers a combination of open land habitat and dense timber (Craighead & Craighead 1963). In Yellowstone Park and surrounding National Forests, prior to winter sleep, the grizzly bears obtain the greater portion of their food in open areas dominated by sagebrush and grasses. Where such areas are isolated and denning requirements met, the grizzly is likely to 'hibernate'. To encourage a maintenance of present grizzly bear population levels, consideration should be given to managing such areas as though they were wilderness. Roding, recreation development, and heavy late fall recreation use should certainly be discouraged.

In regard to the meat portion of his diet, the grizzly is principally a scavenger and can detect and will move to 'ripe' carcasses from long distances. Some marked animals have moved airline distances of 18.5 miles to such sources of food. As many as twenty grizzlies have been observed at one time around a single carcass. Radio-instrumented grizzlies have located dead animals three miles away in three days—about the minimum time needed for a carcass to decompose to the stage where it can be readily detected by scent. In the fall of the year prior to 'hibernation' and in spring soon after emergence from 'hibernation', grizzlies can be readily attracted to carcasses. Where grizzly bear populations are low or declining the use of 'baits' to attract and shoot

grizzlies during hunting seasons should be prohibited or permitted only with reservations and with options to prevent the use of 'baits' during some seasons.

ACKNOWLEDGEMENTS

This phase of a long-range ecological study of the grizzly bear could not have been conducted without the help of numerous individuals and support from many organizations. We extend special thanks and credit to Joel Varney, who designed and constructed the radiotracking equipment; to Bart O'Gara for helpful suggestions; to Maurice Hornocker, Robert Ruff, Henry McCutchen, Charles Ridenour, Harry Reynolds, III, Harry Reynolds, Jr., Jay Sumner, and Jack Seidensticker—all of whom, at one time or another, aided us in testing equipment, collaring animals, or tracking grizzly bears to dens or den sites.

Special thanks are also due to Mr. Lemuel Garrison, former Superintendent, and other personnel of Yellowstone National Park; Dr. Melvin Payne, President, National Geographic Society; Dr. Vincent J. Schaefer, Director, Atmospheric Sciences Research Center, State University of New York at Albany; and Mr. Frank H. Goodyear, Treasurer, Environmental Research Institute. All, in different ways, encouraged us in our research efforts.

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A TRACKING AND TELEMETRY SYSTEM FOR WILDLIFE RESEARCH

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LOCATION SYSTEM

The following requirements were established for the location system:

Range:	2 miles minimum 20 miles desirable
Transmitter life:	2 months minimum 1 year desirable
Transmitter weight:	under 5 lbs

The system had to be simple to operate since it would be used by field personnel without previous experience in electronics, and mechanically rugged.

A system using a low power CW transmitter and a narrowband phase lock receiver was considered and rejected on the basis of equipment complexity. After some field experimentation with various types of transmitters and receivers, the approach shown in figure 1 was selected. It consists of a 32 MHz transmitter emitting short 100 mW pulses attached to the animal with a resonant loop antenna collar, and tracked by an AM receiver connected to one of a variety of directional antennas.

ABSTRACT

This paper describes radiolocation and telemetry equipment developed for use in studies of elk and grizzly bear during the past nine years. It is representative of equipment presently being used by many engaged in wildlife research. Most of it is relatively simple and straightforward in terms of the present state of the art in aerospace telemetry, but illustrates some of the special requirements and approaches used for equipment of this type. Areas in which more sophisticated techniques might prove useful are pointed out, and the probable direction of future development is discussed.

INTRODUCTION

The radiolocation system was initially developed for use in a study of grizzly bear ecology in Yellowstone National Park conducted by Dr. F.C. Craighead Jr. and Dr. J.J. Craighead. It was necessary to have some means of finding particular animals at will, day or night, whether the bear was in the open or hidden in timber, so that observations of behavior and movements could be made. Attaching a small beacon transmitter to the bear proved to be a practical method of doing this. Once the basic location system had been designed and was in field operation, it became apparent that it could easily be upgraded to permit telemetry of environmental and physiological information from the animal. The equipment has also been used in studies of other animals, including black bear and elk.

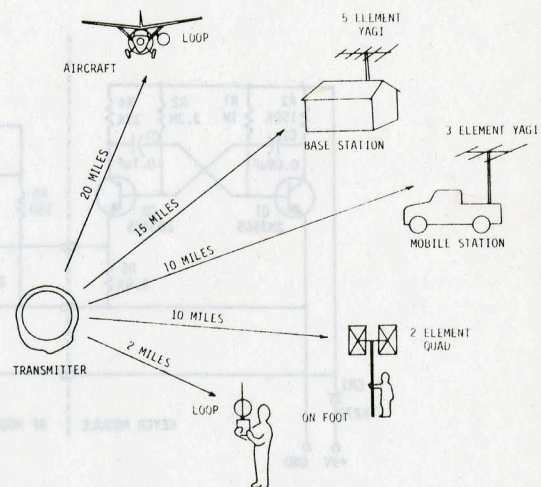


Figure 1: Radiolocation system

In order to maximize transmitter range and life while keeping battery weight to a minimum, a pulsed signal was used. Battery drain was minimized by using a low duty cycle and turning the transmitter off between pulses. The peak power of the pulse was adjusted to give the desired range.

The operating frequency of the system was chosen on the basis of ground propagation characteristics, antenna size constraints, and available frequency allocations. A low frequency was desirable to reduce shielding effects in the mountainous terrain in which the system would be used, while a high frequency would result in smaller and more manageable directional receiving antennas. The 20 to 50 MHz region was chosen as a good compromise, and permission was obtained from the Department of the Interior to use 32 MHz.

Transmitter Design

A circuit diagram of the basic beacon transmitter is shown in figure 2. The oscillator stage Q3 is turned on for 50 ms at 1 second intervals by the astable multivibrator formed by Q1 and Q2. The power amplifier Q4 is a class C stage and draws no current when the oscillator is off, so power consumption is very low between pulses. The transmitter duty cycle is 5%, resulting in an increase of nearly 20 compared to CW operation.

The transmitter will operate for 3 months with a 0.9 lb mercury battery pack. In situations where a longer life is desirable, an additional multivibrator circuit is used to apply DC power to Q1 and Q2 for 10 seconds at 30 second intervals. The result is a series of 10 pulses 1 second apart each 30 seconds, and extends the transmitter life to 9 months.

The construction of the transmitter is shown in figure 3. A cordwood approach with urethane foam encapsulation was used. The multivibrator was fabricated separately to simplify testing and permit installation of a keyer with a desired pulse rate in each transmitter, since the pulse rate is used to identify individual animals.

The transmitter collar assembly is shown in figure 4. The transmitter circuitry is sealed in a 1 x 1 x 2 inch metal can and attached to a brass strap which acts both as a collar and a loop antenna. The loop is resonated at the operating frequency by a tuning capacitor diametrically opposite the transmitter. Impedance matching between transmitter and antenna is provided by an inductive tap 3 inches away from the transmitter case.

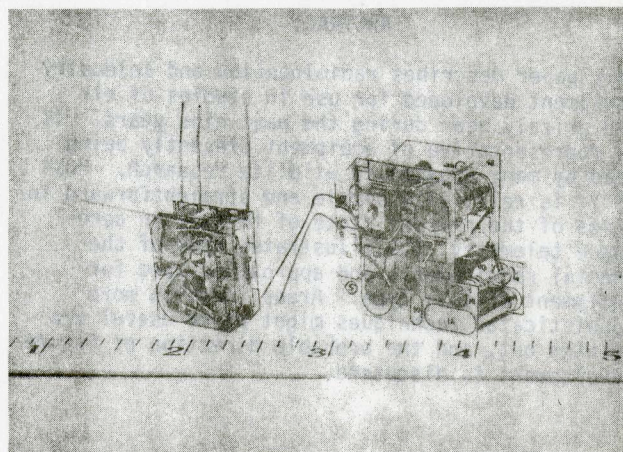


Figure 3: Transmitter construction

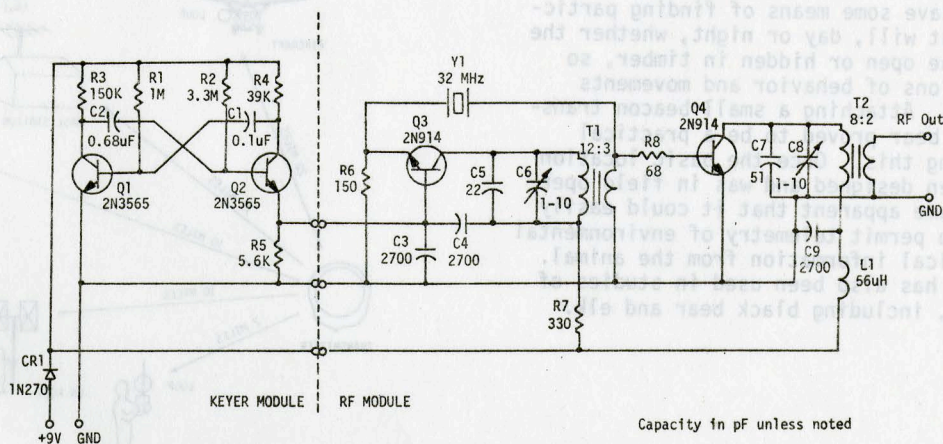


Figure 2: Transmitter circuit

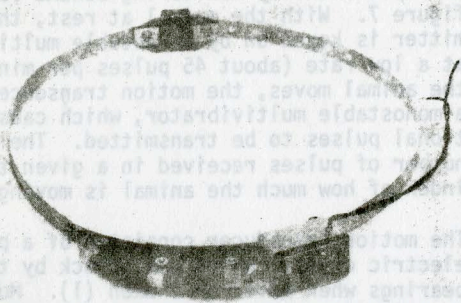


Figure 4: Transmitter collar assembly

The loop antenna was chosen because it is much less dependent on ground proximity and conductivity than a whip type and more efficient than various small ferrite-loaded loops tested. Some efficiency is lost when it is on an animal because of induced eddy currents in the neck. However, the deep nulls characteristic of small loops are no longer present when the collar is in place. It is also mechanically superior to a whip and not subject to snagging or breaking.

A waterproofed battery pack is attached to the collar adjacent to the transmitter case and the entire assembly is covered with a fiberglass-epoxy coat. This makes the collar rigid and prevents flexing and bending which would cause eventual breakage or antenna detuning. Padding is placed on the inside of the collar for size adjustment for various animals, and wrapped with colored plastic tape for better visibility at a distance. A completed collar on a bear is shown in figure 5.

A summary of the transmitter characteristics is given in table 1.



Figure 5: Immobilized grizzly fitted with transmitter collar. A field strength meter used to tune the antenna is next to the collar.

Table 1: Transmitter Characteristics

Frequency	32 MHz
Output power	100 mW pulse
Pulse width	50 ms
Pulse repetition rate	1 per second (nominal)
Antenna type	resonant loop 11 inch diameter
Antenna impedance	50 ohms
DC input power	280 mW peak 18 mW average
Battery type	mercury, low temperature 9.3 volts, 4.5 Ah
Weight	
electronics	0.1 lb
battery	0.9 lb
complete collar	2.0 lbs
Operating lifetime	3 months standard 9 months with additional timer

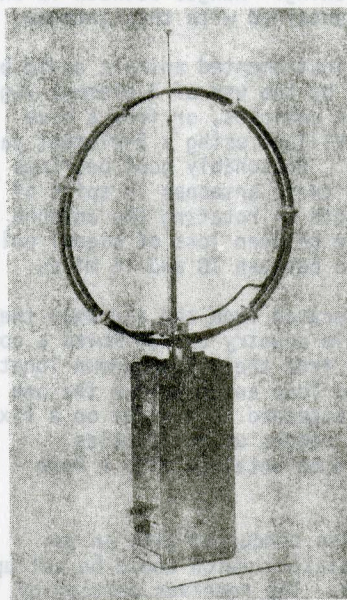


Figure 6: Portable receiver with loop antenna

Receivers and Receiving Antennas

The receivers used for location are conventional battery-operated AM dual-conversion super-heterodyne types. A BFO was incorporated to permit reception of the unmodulated CW pulse from the transmitters. This approach gave maximum system range since it takes advantage of the ability of the human ear to detect the presence of received signals at signal-to-noise ratios considerably below unity.

The receivers were used with a variety of antenna types, depending on the tracking range and degree of mobility desired. Figure 6 shows a receiver equipped with a loop antenna which was used for tracking on foot at distances up to 2 or 3 miles. A sense antenna suppressed one lobe of the loop pattern to allow the direction of arrival of the signal to be determined.

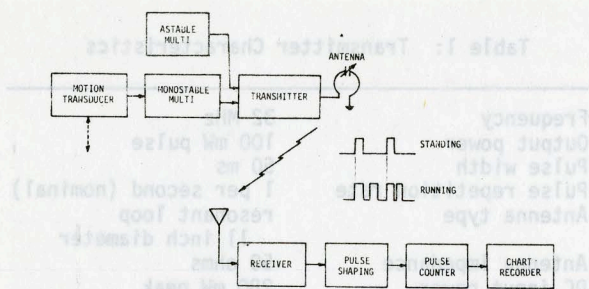


Figure 7: Activity telemetry system

If more range was desired when tracking on foot, the receiver was connected to a quad antenna (a two element array using one-wavelength wire loops rather than dipoles) which could be dismantled for backpacking. Ranges between 10 and 15 miles could be obtained with this antenna.

In many cases the instrumented animals could be located from roads by the use of 3-element yagi antennas mounted on vehicles, or from a base station at Canyon Village using a 5-element yagi on a 30 foot tower. Reasonably good bearings were obtained with these antennas in spite of their broad beamwidth by rotating the antenna and bisecting the angle between loss of signal points. Maximum ranges were between 10 and 15 miles.

Animals could be located from the air when they were in inaccessible country or had moved a considerable distance from their last known location. An 11 inch diameter loop antenna like the one shown in figure 6 attached to a strut on a fixed-wing aircraft gave ranges up to 20 miles. Greater range would be obtained with a more efficient antenna.

Experiments were also conducted with an unattended repeater station which could be set up in remote locations. The receiver portion of the repeater, connected to an omnidirectional antenna, was adjustable in sensitivity so that signals exceeding a predetermined level would trigger a transmitter on the same channel after a short time delay. The transmitter was connected to a directional antenna oriented toward the base station. Animals coming within the preset coverage radius of the station would trigger the repeater and cause the signal to be relayed to the base station.

TELEMETRY SYSTEMS

Slight modification of the location system described above made it possible to telemeter data about the animal's environment, condition, and behavior. Amplitude modulation was selected for compatibility with the receivers used for location. Pulse frequency or pulse duration modulation was used in most cases to minimize transmitter power requirements so that battery life would be as long as possible.

Activity

A simple activity monitoring scheme is shown in figure 7. With the animal at rest, the transmitter is keyed on by an astable multivibrator at a low rate (about 45 pulses per minute). When the animal moves, the motion transducer triggers a monostable multivibrator, which causes additional pulses to be transmitted. The total number of pulses received in a given time is an index of how much the animal is moving about.

The motion transducer consisted of a piezoelectric crystal which was struck by two ball bearings when moved or shaken (1). More quantitative information could be obtained if this simple transducer were replaced with an accelerometer.

In some cases sounds or calls made by animals or birds were of interest. A small AM transmitter was designed which broadcast sounds picked up by a built-in microphone. The power requirements were higher for the resulting continuous signal than for a pulsed signal, so a small solar panel was used to provide the power for the transmitter.

Heart Rate

A prototype system for monitoring the animal's heartbeat rate is shown in figure 8. The transmitter is keyed on by an astable multivibrator whose frequency is controlled by the amplified EKG voltage. The EKG waveform is sensed by two electrodes attached to the animal.

The astable multivibrator operates at 200 pulses per second so that frequency components up to at least 50 Hz in the EKG waveform will be transmitted with good fidelity.

The received PFM signal is demodulated by integrating the output of a monostable multivibrator triggered by the 200 pps subcarrier. The resulting EKG waveform is displayed on a portable oscilloscope or chart recorder.

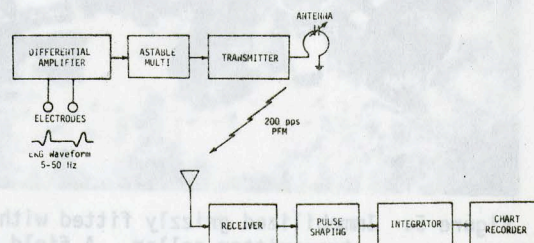


Figure 8: EKG telemetry system

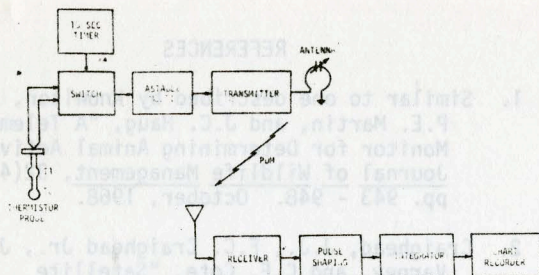


Figure 9: Two-channel body temperature telemetry system



Figure 10: Preparing to place temperature transmitter on an immobilized elk

Body Temperature

A body temperature measurement system is shown in figure 9. Temperature is sensed by a thermistor probe which is placed under the skin of the animal in the neck or shoulder region. As in the other systems, the transmitter is keyed on by an astable multivibrator. In this case, the pulse width is controlled by the resistance of the thermistor used as the temperature sensing element. A 15 second timing circuit alternately switches between each of two thermistors so that temperature at two different depths beneath the skin can be measured.

Figures 10, 11, and 12 show the system being tested on an elk in Yellowstone Park.

Another body temperature measurement system that has been used on a hibernating black bear is shown in figure 13. A small temperature-sensitive transmitter is surgically implanted or rectally inserted in the bear. The signal from the transmitter is picked up by a loop antenna placed on the floor of the den and recorded by equipment a short distance outside.

This approach eliminates troublesome wires and external attachments to the animal but is limited to very short ranges. Future experiments will use an implanted transmitter with an external repeater collar to obtain longer range.

Satellite Monitoring

In the future, satellites will probably play an important role in data collection for ecological and wildlife research programs. Two feasibility experiments recently carried out using the IRLS system were the first steps in this direction. The first, tracking of a migrating elk, is discussed in later papers in this session. In the second experiment, environmental data were telemetered from the den of a hibernating black bear (2).



Figure 11: Attaching temperature probe



Figure 12: Recording body temperature data

Figure 14 is a diagram of the den monitoring equipment. Temperature sensors were placed inside and outside the den to measure the influence of outside ambient temperature changes and of the bear's body heat on the temperature inside the den. Light sensors helped determine local weather conditions and whether the den entrance was covered with snow.

Collection of data by satellite is ideally suited for experiments conducted in inaccessible locations. In this case it considerably simplified our field problems in comparison with work in previous years at other dens with on-site monitoring and recording equipment. Further, when the bear left the den we were able to determine this from the data and visit the area within a day to make observations.

CONCLUSION

The tracking equipment described above has been used for several years in studies of both bear and elk. It has proved to be extremely useful to the field biologists, enabling them to make observations and gather data on animal movements and behavior that would be difficult or impossible to obtain using older methods. Other investigators are using systems of the same general type and complexity in studies of a wide variety of animals.

Many of the telemetry techniques that have been developed and are in use in aerospace and other fields have not yet been applied to wildlife research. For example, time-delay ranging using a transponder attached to the animal would have advantages over the triangulation methods generally used. There is room for much improvement and innovation in the antennas for animal-carried transmitters. Recently introduced low cost linear integrated circuits make narrow-band phase lock receivers for tracking appear much more practical than before. Large scale integration of semiconductor memories and logic is greatly reducing the cost and complexity of data sampling and storage devices that would be useful in many field projects. These and other new techniques and equipment could greatly expand the capabilities and applications of wildlife telemetry in the next decade.

ACKNOWLEDGEMENTS

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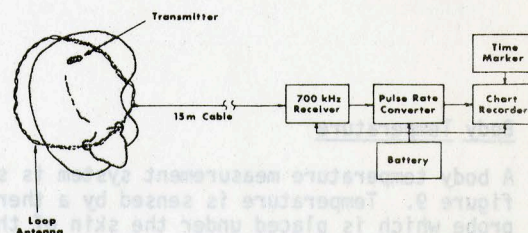


Figure 13: Temperature measurement system for a hibernating bear

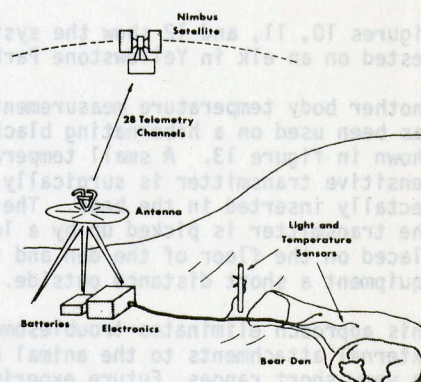


Figure 14: Monitoring a bear den with the IRLS system

Nov. 1971

DATA ON
GRIZZLY BEAR DENNING ACTIVITIES AND BEHAVIOR
OBTAINED USING WILDLIFE TELEMETRY

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INTRODUCTION

Because the Yellowstone grizzly (Ursus arctos horribilis Ord) is largely nocturnal, inhabits a heavily timbered area of rugged terrain and enters its den for a winter sleep that lasts 5 to 6 months, it was necessary as one phase of a comprehensive ecological study (Craighead et al, 1964) to develop and employ a radiotracking and locating system (Craighead et al. 1963, Craighead and Craighead 1965). Such a system enabled us to gather data on den site selection, den construction, prehibernating behavior and denning activities of individuals in a population of between 175 and 200 grizzly bears ranging over an area of approximately 5000 square miles (Craighead and Craighead 1967).

In 1961 we began developing and testing radiotracking equipment and we continued this work through the fall of 1968. During this 8-year period, we made 48 instrumentations of 23 different grizzly bears. These animals were tracked or monitored for a total of over 1,200 tracking days; den location sometimes required monitoring for 3 months and intensive tracking for 4 consecutive days. Grizzly bear No. 40 was instrumented and monitored for portions of 8 consecutive years. Seven other bears were instrumented and monitored during 2 consecutive years each. The winter dens of six different grizzlies were located, but since

more than one den was located for some bears over a period of years, we were able to obtain information on size and construction of 11 dens. Due to involvement of family groups, 22 animals were radiotracked and observed to have utilized the 11 dens.

In November , 1963, we successfully tracked a 5-1/2-year old female grizzly, No. 164, to her winter den (Craighead and Craighead 1965). As far as we know, this is the first instance in which a radio transmitter was used to track and locate a grizzly bear as it entered its winter den.

Prior to this study, little was known concerning the denning activities and prehibernation behavior of wild grizzlies. Dens reported to us as those utilized by grizzlies turned out to be the dens of black bears. It was generally thought that the Yellowstone grizzlies, like black bears and the European brown bears (Ursus arctos arctos L.), utilized natural shelters--caves, hollow trees, windfall and dense vegetation--as sites for their "hibernation" dens (Couturier 1954). These were supposedly enlarged by digging, or improved to varying degrees as shelters for the long winter sleep (Lyman and Dawe 1960, Kayser 1961).

A short discussion of hibernation, or winter sleep, seems appropriate since differences in hibernators, and variances in how they hibernate, have caused researchers to formulate varying definitions of this phenomenon.

Authors suggesting that the bear is not a hibernator

point out that though the bears go into a deep sleep and are inactive for considerable periods of time, they do not become torpid and helpless, as do most hibernators (Kayser 1961:21-50). Bears can be readily aroused after which they can react quickly and energetically to disturbance, and their body temperature does not approach the ambient air temperature.

Hibernation is generally considered to be a torpid state in which the hibernator, partially or wholly, loses its sensibility or power of motion. This is a state from which the animal can be aroused only with difficulty. Thus, bears during their winter sleep are dormant rather than torpid because they can be rather easily aroused and they can move rapidly when disturbed--features enhancing survival of a group of mammals that have been hunted by man since prehistoric times. Low ambient air temperatures, deep snow, and the unavailability of food appear to make hibernation or winter sleep essential to the survival of grizzlies in the Yellowstone area.

The study area in Yellowstone Park and the surrounding National Forests lies largely between 7,000 and 8,000 feet altitude.

Temperatures of -40°F. and below have been recorded, at some time, from all areas of the Park where temperature records have been kept. The lowest recorded temperature is -66°F. (Anon. 1959).

METHODS

To obtain information on ^{denning} behavior and activities of grizzlies fitted with radio transmitters, the position and movements of instrumented bears were plotted from the intersection of bearings (fixes) which were made from a distance. Then, guided by the fixes and using portable directional receivers, we moved on foot to observe the animals at close range.

The radiotracking system was designed to provide maximum use in various types of field work. A block diagram of the location system is shown in Fig. 2. The transmitter collar radiates a pulsed signal which can be received by a variety of stations, depending on the receiving antenna employed.

A small, 2-lb. battery-operated receiver with a directional loop antenna was used for tracking on foot when the distance between the receiver and the instrumented animal was not greater than 3 to 4 miles (Fig. 3).

The collar which was placed on the animal to be tracked consisted of the transmitter unit and a battery pack attached to a circular metal strip which acted both as a loop antenna and a collar^(Fig. 1). The battery pack was waterproofed with parafin and silicone rubber and the assembly was covered with fiberglass-reinforced acrylic resin to protect the electronics and batteries (Fig. 4). It also prevented flexing and bending which would otherwise have caused antenna detuning or eventual breakage.

The inside of the collar was padded with rubber hosing or foam rubber or a combination of both to make it fit the animal snugly and comfortably (Fig. 5.) The collar was designed so the metal strap could be adjusted to the desired neck diameter by inserting two screws in a series of holes in the overlapping ends of the strap. (Craighead and Craighead 1970)

We used two types of transmitters in tracking operations. One type was designed to operate continuously, emitting a 50 ms pulse at approximately 1 second intervals. The battery life with this type of transmitter (called the standard model) was 3 months. For longer life an additional timer circuit was used to turn the transmitter on and off at 30 second intervals. Battery life of this extended-life model was 9 months. (Craighead and Craighead 1965). All transmitters of both types operated on the same frequency, but each had a different pulse rate which permitted identification of each grizzly.

Transistorized receivers were used for tracking on foot and ^{for obtaining bearings} from base and mobile stations. Various kinds of antennas could be connected to a receiver, depending on tracking requirements. The receivers were battery-operated Citizen's band units modified to operate at 32 MHz. Early in the study some tracking at base and mobile stations was done with general-coverage communications receivers; however, these were later discarded in favor of the portable units. (Craighead & Craighead 1970)

Summaries of the transmitter, receiver, and system characteristics are given in Tables 1, 2, and 3.

Normal tracking procedure was to record a signal from an instrumented grizzly at the base station using the 5 element yagi antenna. The direction of the signal source was plotted on a topographic map. A second and frequently a third bearing was made with the mobile unit. The intersection of the bearings generally fixed the animal's position to within a $1/4$ to $1/3$ mile area of the map (Fig. 6). We then hiked to within 2 to 4 miles of the fix and activated the portable receiver which was used to move in on the bear until he was sighted or jumped.

As the instrumented animal was approached, the signal strength increased so that, at about $1/4$ mile, a null became difficult to obtain. The receiver sensitivity setting was then reduced to get a null; the remaining distance to the instrumented grizzly was covered by following the null. Signal volume and receiver sensitivity provided a good indication of distance between the bear and the observer. We frequently approached grizzlies to within 100 feet before disturbing them. The average distance at which we "jumped" them from daybeds in dense timber and windfall was 125 feet.

Grizzly bears that we planned to track to dens were generally instrumented in late summer or early fall. These animals were radiotracked almost daily either from the base station or in the field. Instrumented animals were followed on prehibernation treks to denning areas whenever possible; however, at such times the bears were not closely pursued.

RESULTS

Den Site Selection

The dens of six different grizzlies were located, some for consecutive seasons. Thus, 11 active ones were found and information was obtained on site preference, den size, and construction. All dens used by grizzlies were located while they were being constructed, or when bears entered them for their winter sleep.

Information on den site selection (Table 4) was obtained from monitoring and observing instrumented grizzlies in the fall of the year. In 1961 and 1962 we were unable to track the radio-tagged bears to their dens. However, the dates of hibernation (Oct. 29 and Oct. 21-22, respectively) were obtained by observing movements of grizzlies during snowstorms and the lack of tracks thereafter. Later, with improved equipment, tracking grizzlies became routine, and we obtained specific dates when they entered dens to remain for the winter.

Over a 9-year period, these dates when grizzlies entered their dens to remain varied by as much as a month. They were:

<u>Year</u>	<u>Month</u>
1960	Oct. 29
1961	October 21-22
1962	November 15 (approx.)
1963	November 4-5

<u>Year</u>	<u>Month</u>
1964	November 10
1965	November 11
1966	November 19-21
1967	November 19
1968	November 3-4

Bears of both sexes and several age classes were tracked to dens. These included 1 young adult female (barren), 1 young adult female with her first cub, 2 adult pregnant females, 2 adult females with cubs, and 2 adult females with yearlings. Two young males were tracked to their dens, 1 as a weaned yearling and again as a 2-year-old -- the other as a yearling with his mother and 1 littermates. Very large boars were instrumented and tracked to denning areas but none were successfully tracked to dens. Four dens of one female were located -- three of these in consecutive seasons; the dens of 2 other bears for 2 successive seasons.

An orphaned grizzly, cub No. 78, was observed up to and soon after emerging from hibernation, evidence that cubs can survive the winter without parental care or guidance.

Grizzlies whose dens were located hibernated at altitudes ranging from 7,800 to 9,200 feet (Tables 4 and ⁵8). All dens were located in timbered areas and all but one on northern slopes with the den entrance facing north. Couturier (1954) found that brown bears preferred a den that faced south. A north-facing den entrance appears to be advantageous to the hibernating grizzly in Yellowstone because prevailing

southwest winds accumulate snow on northern exposures. The deep snow that accumulates in such locations insulates the den chamber from the extreme ambient ^{air} temperatures that drop as low as -40°F. or even to -60°F. Also, there is less chance that snow on north slopes will melt during a warm period or winter "chinook". Water trickling into a den would appear to be disturbing and undesirable. Though early spring and later fall sightings revealed that grizzlies den throughout Yellowstone and beyond, all occupied dens were found in the central portion of the Park (Fig. 7).

Dens were located relatively far from developed areas or human activity.

Grizzlies seem to need and to seek isolation for the 6 months of their winter sleep. In the course of evolution, finding isolated den sites for hibernating would appear to be a factor favoring survival of the species. Primitive man and the American Indian undoubtedly found that grizzlies, lethargic until disturbed, were vulnerable in winter and the odds far more favorable for killing them during winter sleep than during their active period.

Den Construction

Most grizzlies prepared winter dens well in advance of the time they went into hibernation. The earliest recorded den diggings were on 3 and 8 September. The latest occurred 11 and 15 November; the bears completed these dens just in time to enter them for the winter. In one case, den construction had been delayed because the bear had abandoned her first den. The amount of disturbance

needed to cause abandonment of a completed den or one under construction varied considerably with individual grizzlies.

The duration of den-digging varied, but usually the major excavation was accomplished with ⁱⁿ 3-7 days; minor digging activity occurred over a period of weeks. Interrupted radio signals enabled us to ^{determine} ~~observe~~ when bears were digging dens, and we then located and observed them (Craighead 1968). For example, in 1966, No. 202 returned twice to his den and, on each occasion, attenuated signals indicated he was digging; digging was visually confirmed on both occasions.

Natural shelters were not utilized as dens by grizzlies, though matted winfal~~ls~~ and rock caves were available. All the dens we located were dug by grizzlies (Table 4). The Yellowstone grizzly frequently digs a den entrance at the base of a tree, and tunnels in through the large downward and outward ~~sloping~~ sloping roots (Figs 8 and 9). The roots limit the size of the den opening and may form a ceiling. Although grizzlies do not always select the base of a tree for den sites, such sites are preferred. Exceptions were sow No. 187 and male No. 202. They dug their dens under horizontal logs. (Fig. 10).

We believe it is instinctive for the grizzly to dig a den rather than appropriate or modify a natural cavity; some behavior supports this. For example, in the fall when grizzlies dig dens and gather boughs for beds, they

also dig to cover carrion or kills more frequently than at other seasons of the year (Fig. 11). In addition, when they move to their dens prior to hibernation, they perform a stereotyped "housecleaning" by digging inside and outside the den (Fig. 9). This seasonal increase in digging may reflect a biological drive.

The grizzly bear dens were usually constructed with an entrance way leading into the bed chamber (~~Fig. 8~~). The average size of this chamber (determined from 10 dens) was: 56 x 53 x 37 inches. A den which sheltered No. 39 and her 3 yearlings was almost as wide as it was long. In 1966 when No. 40 hibernated with 2 cubs, her den was wider than it was long, and the 3 bears slept curled up side by side (Table 4). Females with cubs or yearlings dig wider dens than bears that hibernate alone. Den entrances went directly into the chamber, or had entrance tunnels as long as 66 inches. Width of den openings varied from 14 to 33 inches and averaged 22; heights ranged from 20 to 54 inches and averaged 34.

After we located active dens by radiotracking grizzlies, a general pattern of den site preference emerged which enabled us to seek for and find dens used in previous years. The size and characteristics of six such dens are shown in Table 6.

Den Environment

Den beds were usually composed of spruce or fir boughs, 3-14 inches deep (Fig. 12). Normally boughs were chewed

from spruce or fir trees growing within a radius of 50 feet ^{of} ~~from~~ the den. During three winters when female No. 40 was not pregnant, she used conifer boughs, but when pregnant, she prepared a bed of moss and grass. Pregnant females may routinely use fine, soft material for beds.

Dens are usually lined ^{with bough beds} soon after they are dug, ~~but~~ ^I in one case a grizzly accumulated a large pile of boughs ^{outside the den entrance} prior ^{starting} to ¹ bed construction, ~~and left them outside the den entrance.~~

The den of the grizzly bear is a very localized environment with temperatures warmer and more constant than those existing outside. In addition, when a deep insulating layer of boughs ~~is~~ used, many "dead air" pockets form a microclimate next to the bear within the porous bedding material. Here the temperature is considerably warmer than the general ambient temperature of the ~~bed~~ ^{den} chamber. Thus, a very narrow "envelope" of bedding and air lies between a bear and its den.

The temperature of such a microclimate in a black bear den was recorded ~~by~~ placing a thermistor probe from a body temperature transmitter between the bear and his bed of dry pine needles and finely shredded twigs and rootlets. (Craighead and Craighead 1966). The maximum recorded temperature for the microclimate of 97°F. ⁺ ~~2~~ 2°F. closely approached the body temperature of 101°F recorded for an active bear in summer, and exceeded the average rectal temperature (96°F.) of a hibernating black bear which was monitored for 4 days (Craighead et al. in press). However

over a 55 minute period the temperature fluctuated between 97°F. and 83°F.

Distinctions Between Daybeds and Dens

In the Yellowstone region, most grizzlies are active both day and night during the early spring months when food is relatively scarce. They are again similarly active during the fall of the year when they forage prior to entering dens for the winter. In summer, they rest during daylight hours and forage at night. They seek windfalls and dense thickets of spruce, fir, and lodgepole pine in which to rest. Here they excavate daytime beds or lairs most of which vary in depth from 1 to 18 inches. Forest duff is often scraped to mineral soil. Occasionally daybeds, like winter beds, are lined with grass, pine needles or other vegetation (Fig. 13). Most beds are shallow excavations, but at times denlike burrows are dug 3 or 4 feet into slopes or under fallen logs; these burrows are cooler than surface beds (Fig. 14).

Burrow-type daybeds can be mistaken for winter dens, and occasionally a den such as that of No.202 can resemble a daybed. However, daybeds are usually located relatively close to feeding areas, may be visited and used by different bears, and they are not necessarily constructed into north-facing slopes nor at the base of large trees. They may function as retreats during the breeding season. In 1964, a large boar and a female in estrus were located

in daybeds 25 feet apart. The female had dug a burrow several feet into a hillside (Fig. 14). With her body in the burrow and her head and muzzle resting on the tailings from the cave, she could discourage unsolicited attentions from the male. Daybeds, used during the pre- and post-hibernating periods are normally clustered around a den, but even the most elaborate of these are easily distinguished from the den itself.

Re-use of Dens

Old bedding material found in a debris pile at the den where No. 164 wintered during 1963 suggested that this den might have been used the previous year. Grizzlies No. 40 (1966) and No. 101 (1967) raked the bedding out of their dens before leaving them in spring. This suggested that they would re-use them; however, these dens and others to which we radiotracked grizzlies were never re-used. Five dens collapsed when the soil became saturated with water in late spring, and thus were not suitable for re-use; however, six remained intact (Table 4) and could have been reoccupied, but were not.

In 2 consecutive years, grizzly No. 202 dug two dens only 300 feet apart. His first den was poorly excavated and probably inadequate for re-use the following year. The second-year den was a decided improvement; the grizzly removed an estimated ton of rock in preparing it. Although we believe that the biological drive to dig a den is instinctive, a learning process is involved, and den construction improves with experience.

No feces or traces of urine have been found in recently abandoned grizzly bear dens, or even observed close to them. Harrington (1968) found that polar bears usually keep their dens clean; only traces of urine and minute fecal fragments were found in six of nine dens he examined. We have found neither feces nor urine in six active, black bear dens visited while the bears were in winter sleep. Three dens were examined after immobilizing and removing the bears; all six dens were inspected in the spring after the animals left. We observed black watery excrement, passed by grizzlies prior to entering winter dens; this suggests a scouring and cleaning of the alimentary tract. The Yellowstone grizzlies normally fast from the time they enter their dens until they leave them in the spring.

Prehibernation Movement and Behavior

In the early years of the study (1960-61), we observed that grizzlies moved to their dens during a snowstorm and that tracks were not visible anywhere in the area after the storm. This suggested that certain environmental stimuli may have triggered all or most of the grizzlies to move to and enter their dens simultaneously.

Grizzlies living under the same environmental conditions entered their dens at the same time during a storm regardless of whether they were waiting close to their dens (the case of No. 40 in 1965) or were foraging at some distance. At the time of entering dens, minimum ambient

air temperatures as well as maximum temperatures in shaded den sites were below the freezing level. From 1963 through 1968 we never found tracks throughout extensive areas where grizzlies had been ~~roaming~~ and foraging prior to the storms that put them in their dens. The nearly simultaneous entering of dens during falling snow conceals tracks that could reveal the den locations. *This behavior may have survival value for the species.*

Prehibernation Lethargy

In the late fall of 1965, we noticed a distinct lethargy in all grizzlies closely observed prior to hibernation.

About ~~two~~ weeks later on 3 November, lethargy was even more pronounced. No. 202's radio signal led us to the edge of the Yellowstone Canyon. A 3-bearing fix placed the grizzly directly below us. While we scanned the terrain with binoculars, the crash of a dislodged rock brought a roar from the grizzly lying just below. For a half hour he remained nearly motionless in a sitting-fetal ~~position~~ ^{posture}. He appeared to be in advanced lethargy and apparently never detected us.

On October 25, 1965, we approached to within 30 feet of No. 40 in her den. She was sufficiently lethargic that our presence did not disturb her.

The lethargic condition of these bears during the fall of 1965 was comparable to the condition of lethargy that they normally attained after entering their dens in winter.

Quite possibly weather conditions in the fall of 1965 initiated lethargy early in the season and affected grizzly prehibernation behavior and movement to den sites. An early fall period of snow and unusual cold occurred from 15 through 28 September. The minimum temperature for the 18-20 September cold spell was 7°F.

The combination of early snow and low temperatures did not stimulate grizzlies to hibernate, but it did disperse some from summer to fall foraging areas, and appears to have been a factor triggering hibernation processes so that the bears became lethargic and physiologically ready to hibernate by late October, before the usual environmental stimulus of a ~~final~~ snowstorm caused them to enter their dens for the winter on 11 November.

Defense of Dens

Information obtained with and without the use of radios indicates that the Yellowstone grizzlies are not territorial. On a number of occasions we have observed more than 20 grizzlies at one carcass feeding together with surprisingly little friction. We have never observed the defense of a home range or compensatory movements (Craighead and Craighead 1956) or mutual avoidance (Hornocker 1970). We thought that if grizzlies defended specific areas, these areas most likely would be in the vicinity of their winter dens. Here they might also attack a man. However, we observed no overt defense of a den or den areas against either man or other grizzlies.

(Craighead
and
Craighead 1971)

3
On November 1, 1964, after a two day trek through the snow, our radio signal of 82 pulses per minute led us to the den of grizzly No. 40. With receiver sensitivity reduced the signal indicated that we were close to the den. A growl from the cub revealed that we had found it. A patch of earth tailings darkened the snow at the den entrance which led under the base of a huge fir tree. Neither the sow nor the cub were within. We glimpsed a flash of black as the cub tardily followed his mother. Both remained hidden in the dense timber withⁱⁿ three to four *hundred* yards of their den, but exhibited no aggressive behavior and never attempted to come closer while we were in the vicinity.

The following day we picked up a signal at 52 pulses per minute, coming from the radio collar on the yearling grizzly No. 158. This we knew would lead us to the den of sow No. 39. We hoped to determine whether this yearling as well as his mother two large littermates would den with their mother. *(Craighead & Craighead 1969)* The signal lured us deeper into the Yellowstone wilderness. Sometimes it was only a weak pulse; other times it came to us intermittently and finally strongly as we approached the den. Occasionally it halted our trek when it died out completely for long periods while the instrumented grizzly remained in the den. In late afternoon still following the signal we entered a thicket of "doghair" lodgepole ^{pine} ~~growing beneath towering pines.~~ Visibility was only a few feet. A sudden increase in signal

strength informed us that the instrumented grizzly and probably the entire family were moving toward us.

Immediately after we climbed trees, our signal revealed that the bears were running away. Sow No. 39, a grizzly that had a record as a belligerent bear, had not attempted to defend her den.

While tracking this same sow a few weeks earlier, we had inadvertently approached to within 75 feet of her daybed. This signal from her yearling indicated that she was nearby but we were first aware of her very close proximity when her ears rose to the alert position from behind a fallen log. We retreated even more slowly and cautiously than we had approached. After climbing trees, we shouted to further alert the grizzlies and were startled by a loud roar. Within seconds, our radio receiver indicated that the bears were moving away at a rapid ~~pace~~^{rate}. As revealed by her tracks, this ill-tempered sow had charged 20 feet through the snow in huge bounds heading directly for us. She then abruptly turned and fled in the opposite direction, an example of a bluff-like charge, one that is not uncommon with grizzlies.

In the fall of 1967, we approached to within 200 feet of the den of grizzly No. 101. The radio signal showed she was inside. We moved on without disturbing her. Several hours later we returned and saw fresh bear tracks leaving the den and got a faint signal on our radio receiver. We followed the tracks for a half mile through knee-deep snow. Signs showed us that after leaving the den, No. 101

crossed our trail. When she did so, she started running and urinating and the urine trail persisted for about 200 yards. We interpreted this as a physiological manifestation of fright. The female abandoned the den. Later in the season when her newly dug second den was approached, she growled threateningly, came out of the den, and retreated a short distance. We observed similar behavior at the dens of grizzlies No. 40, 164, 202, and 187.

These and other incidents, including our observation of sows Nos. 40 and 101 together at their respective den sites, suggest that grizzlies do not actively defend dens either from other bears or from humans if alternate courses of action are available to them. Grizzlies are dangerous animals but our experience over the years studying them at close range, tracking them by radio and handling them has indicated that most grizzlies respect man and although they do not fear him, they prefer to avoid him.

The most dangerous grizzlies are those that have been wounded, sows protecting cubs, and those that at one time or another have associated food directly with humans. ^(Craighead & Craighead 1971) After such conditioning with food, they will approach close enough that an overt act triggers the bear, ^{perhaps in self defense,} ~~instinct~~ to charge, rather than to flee.

Emergence from Hibernation

Bough and bark beds laid on the snow near the den of grizzly No. 40 and her yearlings in 1965 (Fig. 15)

indicated that they had emerged from the den in late March but did not leave the den area until about 20 April. The beds were on different snow strata or levels, indicating time intervals between construction.

Other grizzlies emerged from dens 3 to 4 weeks before they left their den sites. When grizzlies first emerge, the snow is frequently too soft and deep for them to travel, and they remain at the dens until warm sunny days, followed by chilly nights, crust the snow so it will support their weight.

Our observations reveal that mature male and female grizzlies tend to leave den areas earlier than females with yearlings. Females with cubs of the year are the last to leave den sites and some may remain in the vicinity of the den until the snow has disappeared.

The carcasses of winter-killed animals (Fig.) form a considerable portion of the diet of grizzly bears in early spring. In addition, grizzlies kill those weakened by a severe winter. Our records include observations and authentic reports of grizzlies killing full-grown moose, bison, and elk. In most cases the animals were attacked in deep snow, while crossing rivers, or when otherwise handicapped or incapacitated. Some were so close to death from malnutrition that they made no attempts to evade attack. We have a number of sight records (our own and others) of two or more grizzlies pursuing and killing elk in well-coordinated attacks. The majority of elk and bison carcasses that were utilized by grizzlies were in

advanced stages of malnutrition as evidenced by bone marrow tests. The same was true of most of those that fell prey to bears (Craighead and Craighead, unpub.).

A late spring with deep snow on the ground, such as occurred in 1970, can produce a higher than normal number of starving ungulates which fall prey to hungry grizzlies. Such predation is atypical except where ungulate populations exceed winter range carrying capacities. The fundamental cause of death is malnutrition, not predation.

Our observations indicate that the grizzly's role as a carnivore, prior to and immediately after hibernation, in Yellowstone is first a scavenger, second a predator on small prey species (especially when these are at high densities [Craighead and Craighead 1968]), and last, a killer of large prey animals.

GRIZZLY BEAR MANAGEMENT

Grizzly bears constructed their winter dens in timbered areas isolated from human habitation and activities. It would appear that extensive wilderness areas and expansive undeveloped Park or Forest lands are suitable for denning and in fact may be essential to the welfare of the grizzly.

The Yellowstone grizzly prefers a combination of open land habitat and dense timber (Craighead and Craighead 1963). In Yellowstone Park and surrounding National Forests, prior to winter sleep, the grizzly bears obtain the greater portion of their food in open areas dominated by sagebrush

and grasses. Where such areas are isolated and denning requirements met, the grizzly is likely to "hibernate". To encourage a maintenance of present grizzly bear population levels, consideration should be given to managing such areas as though they were wilderness. Roading, recreation development, and heavy late fall recreation use should certainly be discouraged.

In regard to the meat portion of his diet, the grizzly is principally a scavenger and can detect and will move to "ripe" carcasses from long distances. Some marked animals have moved airline distances of 18.5 miles to such sources of food. As many as twenty grizzlies have been observed at one time around a single carcass. Radio instrumented grizzlies have located dead animals three miles away in three days--about the minimum time needed for a carcass to decompose to the stage where it can be readily detected by scent. In the fall of the year prior to "hibernation" and in spring soon after emergence from "hibernation", grizzlies can be readily attracted to carcasses. Where grizzly bear populations are low or declining the use of "baits" to attract and shoot grizzlies during hunting seasons should be prohibited or permitted only with reservations and with options to prevent the use of "baits" during some seasons.

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Foraging Habits

Artificial food sources and natural food (ex. Hayden Valley) a single population as revealed by observed movement, censuses, and radiotracking - not 2 populations: 1) one wild, 2) the other "habitual users of artificial food sources in campgrounds and other developed areas".

Grizzlies - scavengers

Raven, grizzly, coyote - grizzly the principle scavenger in Yellowstone. Instrumented sow #150 and cubs took 60 hours to locate a fresh carcass.....1 3/4 miles away from bedding sits. First grizzlies to arrive --wind unfavorable. *#172 (max) 18.5 mi. 3 days*

Grizzlies usually find carcass and dispose of it within a week.
(20) grizzlies on one carcass.

Pine nut crop - fall 1962 - bears high on ridges.

Microtus population high - also pocket gophers - 1963 - Bears in open and tubers of Melica spectabilis and Perideridia gardneri heavily utilized.

Baits used to move grizzlies away from campgrounds. *-37 carcasses
av. distance traveled*

Baits used to lure grizzlies to lurking hunter. *to carcass 4.5 mi.
max on carcass at one time - 24*

Plant foods

*Duration of carcasses = 4 days
av. length of time carcass held by bear
3.1 days*

Habitat preference - combination of open country and timber open - sagebrush - grass subclimax type.

Man-Bear Relationships

Tendency of grizzlies is to avoid areas where visitors concentrate. Grizzlies detect man by scent and take off on run. Reluctant to leave daytime beds. Grizzlies jumped from beds - 40 feet in timber to 600 feet in open country. 15 measured distances where grizzlies detected trackers - jumping distance averaged 176 feet.

Attacks - apparent or real

Grizzly Number 150 and cubs - early morning fog, 200 feet away, sow got scent and apparently unable to determine direction of scent bolted toward us - started up tree, she discovered us and changed course.

Grizzly Number 39 approached too close, roar, false charge.

Grizzly family approached to within 100 yards of me in sagebrush - no trees. Made presence known, bears rose on hind legs then took off at run.

Incident of boar returning to elk kill - Washborn.

Prevent conditioning of bear to man and food - ex. Glacier. Let bear know of man's presence - scent, sound, sight. Bear often cannot identify man beyond 100 yards. Keep beyond attack distance - perhaps 100-150 feet. Curiosity - bear moves toward unidentified object, ~~XXXX~~ rises on hind legs to get scent. Mistaken as an attack. Give wounded animal a wide berth. Try to prevent injuring or wounding grizzlies. Don't turn and run if no tree is close - ex. John at dump..charge checked.

Submissive attitude if actually attacked - remain still and lying down. Climb tree if possible. ~~XXX~~ Zone areas where grizzlies feed and rest. Twelve years of close association with grizzlies - no one ever injured.



Sir Hugh Elliott
173 Woodstock Road
Oxford
England

FRANK C. CRAIGHEAD JR.

P.O. BOX 156 MOOSE, WYOMING 83012

Dear Sir Elliott

garbled

I am sorry that the cablegram has caused confusion and ~~some~~ extra work for you. You are correct in assuming the name is Varney. The addition of his name and date in brackets at the end of the paragraph page 85 ending in 2-3 miles is all that is required here.

Reference number twelve should read ^{Dec} ~~Sept.~~ 1971 instead of "In press". The seventeenth and ~~last~~ additional ^{item in the} ~~reference~~ ^{reference} should read ^{reference} Varney, J.R., 1971 gives the relevant details list of references refers to.

and should read: Varney, J.R. A Tracking and Telemetry System for Wildlife Research, National Telemetry Conference Record, p 247-252.

Reference number twelve should read Dec. 1971 instead of "In press".

I hope this clarifies the suggested changes

Sincerely,
Frank C.

Sir Hugh Elliott
173 Woodstock Road
Oxford, England

733-2833



Proof fine. Page 85 line 38 add Varney 1971.

Reference number 12 ^{Dec.} ~~Sept.~~ 1971 BioScience.

Add Varney 1971 National Telemetry Conference
Record.

over

Elk - Circadian rhythms $\frac{1}{2}$ hr B.T. 97.8°F to 99.5°F (1.7°F) with 3°rise
in ambient temperature

photodiode

Temp scales - -40 to $+10^{\circ}\text{C}$ + 0 to 50°C

M99 - etorprin - 7mg.

M2F5 - chlorzephine - antagonist

Elk travels ~~28~~ 10.4 mi. Spend back to Gros Ventre, To Signal Mt, 17 mi.
Circuits route - 3 times as far as direct route

20 satellite locations

latitude mean over 3 mi, longitude 4 mi (Bearden 26 locations)
av. location over 2.34 mi)

on refuge elk av. about 1.6 mi/day

April 25 backtracked 9.1 mi,

dropping barometer, infasonic (6-19 cycles)

Tracked for 1 month by ~~st~~ satellite April

7 in samples for sensor 1.5 min. intervals

10 channels 5 ext, 5 int.

1.61 $\overline{) 28.00}$
16 6
12 80
11 27

~~scribble~~

5

LIST OF ILLUSTRATIONS (FIGS.)

1. Yearling grizzly No. 158 fitted with radio collar. This yearling, his littermates, and sow No. 39 were tracked to a winter den which was occupied by the entire family.
2. Radio location system.
3. Transmitter collars and a portable, directional receiver.
4. Putting fiberglass on transmitter-collar assembly to make it waterproof, shockproof, and bearproof.
5. Plastic hose and rubber padding wrapped with varied colored tapes make a comfortable and snug fit.
6. Intersecting bearings from base station (upper right) and field station (circle) reveal position of bear on two consecutive days. Dotted line is course taken to "jump" bear (dot) from daybed.
7. Location and distribution of grizzly bear dens. Clumping of dens suggests that these sites ~~possessed~~ *met* denning requirements to a greater degree than did other locations.
8. Den of grizzly No. 101--den was abandoned and a new one dug.
9. Locating den of No. 40 by following transmitter signal with directional receiver. Den excavation is at base of tree.
10. Den of grizzly sow No. 187. The den was abandoned prior to being lined with boughs. This was one of the few dens not dug at the base of a large tree.
11. Grizzly bear family sleeping on remains of an elk carcass. The carcass was covered with grass and dirt when the bears were not feeding.
12. Den of sow No. 40 (1966) and bough bed on which she and her two cubs slept side by side.
13. Grizzly bear lined daybed. Most daybeds are unlined shallow excavations.
14. Burrow-type daybed prepared by young female No. 6.
15. Bough bed constructed on deep snow near entrance to winter den. Bed was made in late March.
16. Grizzly No. 40 (instrumented) and her yearling feeding on the carcass of a drowned bison soon after ~~they~~ *they* emerged from "hibernation".