File

GRIZZLY BEAR PREHIBERNATION AND DENNING ACTIVITIES

AS DETERMINED BY RADIOTRACKING

Frank C. Craighead, Jr.
State University of New York, Albany, N.Y.
Atmospheric Science Research Center
Environmental Research Institute, Moose, Wyo.

John J. Craighead
Bureau of Sport Fisheries and Wildlife
University of Montana, Missoula, Montana

1968
Contribution from the Environmental Research Institute, State University of New York, and Montana Cooperative Wildlife Research Unit, University of Montana.

INTRODUCTION

The grizzly bear (Ursus arctos horribilis) is largely nocturnal and the Yellowstone grizzly enters his den for a winter sleep that lasts approximately five to six months. This remnant population of between 175 and 200 grizzlies inhabit an area of about 5,000 square miles, 75 to 80 per cent timbered. Studying and observing the species under these conditions is difficult. Gathering data on den site selection, den construction, prehibernation behavior, and denning activities was one facet of a comprehensive ecological study of the grizzly bear (Craighead, et al., 1960). To obtain the desired results, it was necessary to develop and employ a radio locating and tracking system (Craighead, Craighead and Davies, 1963; Craighead, F., and J. Craighead, 1965). This enabled us to gather much of the information on grizzly bear ecology presented here.

Relatively little is known of the denning activities and prehibernation behavior of wild grizzlies, nor is there much enlightenment to be found in the literature. It was rather generally thought that the Yellowstone grizzly, like the black bear (Ursus americanus) and the European brown bear (Ursus arctos arctos) (Couturier, 1954) utilized natural shelters and caves, hollow trees, windfall and dense vegetation as a site for their "hibernation" dens. These were then supposedly improved, enlarged by digging or to varying degrees prepared as a shelter for the long winter sleep. Invariably den sites and dens reported to us as those utilized by grizzlies turned out to be the dens of black bears, not grizzlies.

In November, 1963, we successfully tracked a barren female grizzly, No. 164, to her winter den (Craighead, F. and J. Craighead, 1965). As far as we know, this is the first instance where radio transmitters were used to actually track and locate a grizzly bear as it entered its winter

den. The radiotracking of grizzly bears to obtain information on denning and prehibernation behavior, as well as on other activities, began in 1961 and continued through the fall of 1967. During this seven year period we made 40 instrumentations of grizzly bears, 31 different grizzlies being involved. These animals were tracked or monitored for a total of over 1000 tracking days. Some were followed in deep snow for four consecutive days until the dens were located. One grizzly bear, No. 40, (Fig. 1) was instrumented and monitored for seven consecutive years. Seven other bears were instrumented and monitored for two consecutive years each. Eighteen grizzlies, including family members, were tracked to dens. The winter dens of seven different grizzlies have been located and eleven active dens have been found and information obtained on the size, character and construction of these dens. The winter den of one grizzly has been located for three consecutive years and two others for two consecutive years. Tables 1, 2 and 3 show information gathered on grizzly dens and prehibernation behavior as related to environmental conditions and to the annual cyclic behavior of bear hibernation.

The term hibernation is a controversial one. Literally, it means passing the winter. However, both quantitative and qualitative differences in hibernators have produced varying opinions as to the preferred definition and to the limits of the condition of hibernation. For this reason a short discussion of the subject seems imperative. A comprehensive compilation on the subject has been presented by Lyman and Dawe (1960) and Ch. Kayser (1961). Hibernating species differ in the duration of hibernation, the degree of drop in body temperature, the relation of body temperature to ambient temperature, the accumulation of fat reserves,

the depression of metabolic activities, and the variations in specialization of individual organs and tissues for functioning in the hibernating state. The general condition of hibernation reveals a depressed metabolism, as indicated by a low body temperature and reduced heart and respiratory rates, as well as suspension of all general activities. In a sense, hibernation might be considered a condition varying in degree: the bear, for example, showing less change in body functions and being less of a "true" hibernator than the ground squirrel.

If we define hibernation following Hock (1960) as "a periodic phenomenon in which body temperature falls to a low level, approximating ambient, and heart rate, metabolic rate, and other physiologic functions fall to correspondingly minimum levels," then by this definition the grizzly bear is not a hibernator. Instead of hibernation, Hock has proposed the term carnivorean lethargy. Hock has also pointed out, as have others, that due to the shortened season into which hibernators must compress their annual cycle of activities, nearly all facets of their life history and consequently their physiologic functions reflect the fact that they are constantly preparing for hibernation, hibernating, or recovering from that condition. Thus, the whole year is involved in a cyclic phenomenon that is hibernation. To a considerable degree, this is true of the bear. Those suggesting that the bear is not a hibernator point out that though 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. They can generally react quickly and energetically to disturbance and their body temperature does not approach the ambient temperature. However, depression of the body temperature below the normal range (31°+ C.) has been reported (Kalabukhov, 1956). Following anesthetizing and instrumenting

of a hibernating black bear, the body temperature of the bear dropped to 28.5° C. and gradually rose to 36.0° C. twenty-one and a half hours later (Craighead, F. and J. Craighead, 1967). Morrison (1960) points out that because of its low critical temperature, the bear should have difficulty in cooling and that this would be so even with a considerable increase in conductance. He goes further to state that it may also be calculated that because of its low thermal conductance the bear cannot maintain a body temperature near the ambient temperature, and he concludes "in any event, it is clear that bears lie in the interfacial zone between animals which might last through the winter at or near their basal metabolic rates and those which cannot."

An animal's potential energy reserve is proportional to body weight in animals of all sizes, but the basal metabolic rate is weight dependent. Thus the fasting potential will vary directly with weight--the larger the animal, the lower the metabolic rate. The larger animal can thus fast longer than the smaller without modifying his metabolic level. The average bear going into winter sleep with the usual fat reserve can readily fast 200 days (7 months) without greatly reducing body temperature and basal metabolic rates as do "true" hibernators. However, low ambient temperatures, deep snow, and the unavailability of food make it appear that hibernation or winter sleep is essential to the survival of bears in the Yellowstone area. Morrison suggests that the limited observed depression of body temperature and metabolism in the bear may qualify the bear as an "ecological" hibernator, while the limited extent of these changes and the lack of adaptations for functioning at low temperatures may disqualify the bear as a "physiological" hibernator. This

distinction is a useful one--so, taking this viewpoint, we will consider the bear not as a nonhibernator but as an ecological hibernator.

Another view that helps to clarify terminology regarding the winter sleep condition of bears is that of Matson (1946) who compares hibernation to dormant state, as does Eisentraut (1933). For him, hibernation is a "torpid state"; "torpid" being defined as "having lost, partially or wholly, sensibility or the power of motion." This is considered a state from which the animal can be aroused only with difficulty. The condition of bears during their sleep might be described as dormant rather than torpid in the sense that they are rather easily aroused to action.

STUDY METHODS AND TECHNIQUES

Information on prehibernation behavior and denning activities of grizzlies was obtained by means of radiotracking. This was accomplished by plotting the position and movements of bears from the intersection of bearings (fixes) made from a distance. Then by moving in on foot with portable directional receivers, the grizzlies were observed at close range. Changes in signal strength and regularity also provided information (Craighead, F. and J. Craighead, 1965). For example, an interrupted signal often indicated that a grizzly was either digging a den or moving in or out of a den.

The radiotracking system was designed so as to be as flexible and as portable as possible, thus making it of maximum use in various types of field work. Basically, the system consists of transmitter-collar assemblies that are placed around the necks of the bears (Fig. 2). A padded tuned loop-antenna acts as a collar. The transmitters are variously pulsed so

that individual bears can be identified by the different pulse rates. The signal is picked up by portable, fully-transistorized receivers that are directional when used with various types of antennas. With the hand-held portable receiver, a loop antenna was employed in conjunction with a sense antenna (whip).

The equally sensitive lobes of the loop antenna resulted in a 180 degree ambiguity, making it difficult to determine signal source or direction unless the sense antenna was activated. This suppressed one lobe of the loop antenna pattern, thus providing a 13 db suppression of the reverse lobe and a 3 db enhancement of the forward lobe, giving a 16 db front-to-back ratio (Varney, 1963). In practice, this proved very effective in accurately determining signal direction.

At the base station, a five-element antenna was connected to the receiver; and for our mobile and other portable units, a three-element antenna and a portable quad antenna were utilized. The system thus consisted of a base station, a field station, several mobile tracking units and the portable hand-held tracking receivers. The frequency utilized was 32.02 mc. The output of the transmitters was approximately 100 milliwatt pulses when powered by seven Mallory mercury cells, type 1450 in series. The range varied from 15-20 miles with a five-element receiving antenna to 2-3 miles with the portable receivers and loop antenna under average conditions of terrain and shielding effect. The maximum life of the continuously pulsed transmitters was over three months and the life of the extended-life transmitters, with an ON-OFF period of 10 and 20 seconds, respectively, was approximately one year. The performance of the system is difficult to express in terms of degree of accuracy or

percentage of error of bearings. This is due largely to the varying conditions under which the work was carried out. However, some idea of system performance can be obtained through the citing of examples. For instance, a transmitter dropped by a grizzly was recovered using a bearing made from a distance of nine miles. When two miles away, we "homed in," using a portable receiver with loop antenna and sighted the radio-collar when within 15 feet of it in dense timber. The collar was lying within a small depression. The average distance at which we jumped instrumented grizzlies from daybeds in dense timber and windfall was 125 feet.

Figure 3 shows intersecting bearings made from our base and field stations when monitoring and tracking grizzly No. 150 on two consecutive days--October 10 and 11, 1964. The dotted line is the course taken in following the signal to jump or intersect the grizzly. Allowance was made for wind direction in making the final approach. The position of the grizzly was eight miles from our base station to the north and three from the field station. The bearing from base plotted on October 10 was about 2.5 degrees in error, assuming the grizzly had not wandered in the interval between the time the bearing was made and the moment when jumped. The elevation of the base station was 120 feet lower than the grizzly. Between the two locations was a timbered ridge rising several hundred feet above the instrumented grizzly. This shielding ridge was 300 to 400 feet above many of the locales where grizzly No. 150 was monitored from base.

In 1964, grizzly No. 40 and grizzly No. 158 were radiotracked to their dens in the course of a four-day trek. Fixes were plotted, using a set of bearings from base station located about 12 miles from the instrumented bears and another set obtained from the field station, 4.5

miles distant. One field station bearing, as verified later, went directly through the den site of No. 40 and the other slightly to the east of No. 158's den.

DEN SITE SELECTION AND CONSTRUCTION

The winter dens of seven different grizzlies have been located, some for consecutive seasons. Thus eleven active dens have been found and information obtained on their size and construction. All of the dens were located either while they were being constructed, or at or close to the time the bears entered them for their winter sleep. One den was found in late fall of 1963, two in 1964, two in 1965, and three in both 1966 and 1967.

A fairly representative cross-section of age classes was tracked to winter dens. These included one young adult female (barren), one young adult female with her first cub, two adult pregnant females, two adult females with cubs, and two adult females with yearlings. One of these was a rather old bear. Two young male bears were tracked to their dens. One was tracked as a weaned yearling and again as a two year old; another as a yearling with his mother and two littermates (Fig. 2). Very large boars were instrumented and tracked to denning areas but none successfully tracked to winter dens. The den of one female grizzly was located for three consecutive years; the dens of two other bears, for two successive years. Table 1 presents information relative to construction, site, size and character of the grizzly dens. All dens were completely dug and prepared by the grizzlies themselves. This is in contrast to the European brown bear where natural shelters are often used (Couturier, 1954). No

natural shelters were utilized by the grizzlies though natural shelters ranging from matted windfall to rock caves were available. All of the dens were located in timbered areas and all but one on northern slopes with the den entrance facing north. Couturier found the brown bear preferred a den that faced south. A north-facing den entrance appears to be advantageous to the hibernating Yellowstone grizzly as more snow accumulates on northern exposures and there is less chance of snow melting during a warm period or winter chinook. Water trickling into a den would certainly be disturbing and undesirable. The deep snow that accumulates in such locations insulates the den chamber from the extreme ambient temperatures that may drop as low as -40 to -60° F. Though grizzlies den throughout the Park and beyond, all of the active dens were located in the general area of Hayden Valley and ranged in elevation from 7800 to 9200 feet. All dens, except those that were abandoned prior to using them, were lined with conifer boughs or other bed material (Fig. 4). This served to insulate the sleeping bears from the cold ground. No dens contained any excrement or any traces of urine.

All of the dens were located relatively far from human habitation or human activity. Snow insulation above and boughs below created a den chamber with a microclimate less extreme and less variable than the outside environment. It appeared that isolation is a factor that the grizzlies need and seek when spending six months of their lives under rather vulnerable conditions. Primitive man and the American Indian undoubtedly found that the odds were more favorable for killing a grizzly when it was lethargic during winter sleep than when active in summer. Seeking isolation during hibernation would be a factor favoring survival of the species.

Six of the ten dens illustrated in Table 1 were dug at the base of trees (Fig. 5). Three others were dug at the base of stumps or with the entrance excavated beneath a horizontal log. Erickson (1964) found that most black bears favored dens dug beneath objects such as logs, stumps, or holes dug into hillsides. No mention is made of dens excavated beneath trees. The Yellowstone grizzly appears to prefer to dig a den entrance at the base of a tree, tunnelling in through the large downward and outward sloping roots as illustrated in Figure 5. These roots limit the size of the opening and others act as a ceiling or support for the earth roof. Although the Yellowstone grizzly does not always select the base of a tree for its den site, it may be instinctive for it to do so if a suitable location is available. The young grizzly, No. 202, dug his dens in a steep rocky talus slope of the Yellowstone Canyon (Table 2). Neither of these dens was dug at the base of a tree, but both were dug with the entrance under a horizontal log (Fig. 6). However, the grizzly initially made several unsuccessful attempts to dig a den at the base of large trees but was prevented from completing the dens due to his inability to remove large rocks and boulders from the narrow entranceways between the roots of the trees. A similar situation was noted when an interrupted signal indicated that No. 40 might be digging a den. We moved in to investigate and found the sow digging a den entrance at the base of a large fir tree. Number 40 never completed this den, perhaps because we disturbed her but more likely because the space between major roots was too narrow for a den opening. The fact that all grizzly bear dens located were completely dug by the bears with no use of natural shelters might indicate that it is instinctive for the grizzly to dig a winter den rather than appropriate or modify a natural cavity.

The grizzly dens were not extensive excavations, but were adequate to house the number of bears involved, whether a single individual or a family. Sows with cubs as well as sows with yearlings were found to spend the winter in the same den. The dens were usually constructed so that there was an entranceway leading into the bed chamber (Fig. 7). The average size of this chamber determined from nine dens was: 55 inches long, by 53 inches wide, and 38 inches high. The den entrance varied from no entrance at all, where the opening went directly into the chamber, to an entrance tunnel 60 inches long. The width and height of the entrance or the den opening varied from a narrow width of 14 inches to a maximum of 33 inches. Heights ranged from a minimum of 20 inches to a maximum of 54 inches. The den openings seem relatively small considering the size of the grizzlies. In some instances, it was difficult to visualize even a medium sized bear squeezing through the opening and into the chamber beyond.

The beds were usually composed of spruce or fir boughs sometimes laid as deep as 14 inches (Fig. 4). Occasionally a bed platform lay slightly above the entranceway, similar to the bed platform in a snow house, thus creating a heat trap that prevented warm air from escaping out the den opening (Fig. 8). Digging a den so as to create a heat trap is probably accidental, but there may be an instinctive tendency for the animals to prepare their dens in this manner when it is feasible to do so. Dens not so prepared but with the bed lower than the entranceway were usually situated so that the entrance would fill up with snow (Fig. 9). Thus in effect a similar result was obtained, the snow forming a sealed chamber with little transfer of air. The grizzly bear winter den is, as mentioned previously, a very localized environment with temperatures

warmer and more constant than those existing outside. In addition, when a deep insulating bed of boughs is used, a microclimate is created between the bear and his bed that is considerably warmer than the general ambient temperature of the den chamber. The bough bed prepared by grizzly No. 202 was circular and cuplike in shape. The diameter of the depression across the top was 31 inches. It was 12 inches deep.[1] The yearling bear curled himself up in this bed cavity with his head and shoulders protected by the partially dug den (Fig. 6). The rest of his body was covered and insulated by accumulating snow.

Some idea of the microclimates between a bear and his bed was obtained by placing a body-temperature transmitter between a black bear and his well-insulated bed. The winter bed was fashioned from a porous mixture of dried pine needles and finely shredded twigs. Here a microclimate was created between bear and bed with a temperature approaching that of the bear's body. The maximum temperature reading of this microclimate was 36° C. and probably occurred when the probe was in a position under a portion of the bear's body where his hair was thin and heat conduction was efficient. The bear had been awakened and was alert, and at this time probably had a body temperature close to the normal activity temperature of 37.8° C. The microclimate between the bear and his bed constituted an estimated area of approximately three quarters of the bear's body surface when curled in sleep. The insulated bed was 18 inches deep by 30 inches in diameter, cuplike in shape, with nearly perpendicular walls against

1. The depth was measured in spring following winter use. It was probably closer to 16 or 18 inches deep when first constructed.

which the bears body snugly fit (Fig. 10). Bed materials differed from those used by grizzlies, but in its dimensions and structure the bed was very similar to that prepared by grizzly yearling No. 202. When the black bear was curled in his sleeping position just slightly below the rim of the bed cavity, he was in a microclimate where temperature changes were minimized. Possibly the resulting microclimatic temperature achieved when the bear is sleeping determines within limits the degree of hypothermia or of lethargy needed and achieved by the bear in its winter den, whether it be a black bear or a grizzly. In other words, the dormancy temperature may be influenced by the environmental microclimatic temperature enveloping the bear, and this in turn may to a considerable extent vary with or even be regulated by the bear's thermoregulatory processes. Winter sleep conditions of wild bears thus may vary considerably with individuals and with the care and extent to which each prepares a den and bed. It probably also varies considerably from conditions observed in captivity.

UNKNOWN GRIZZLY DENS

Table 2 reveals information on six additional grizzly bear dens. These were constructed by unknown grizzlies and were not in current use. After a few active dens were located, a general pattern of den site location emerged which enabled us to seek for and locate dens other than those found through radiotracking. The inactive dens were on north facing slopes, in timber, in secluded areas, and quite often were dug at the base of large trees. The bed chamber measurements averaged 50 inches in length, 58 inches in width, and 36 inches in height. Three out of four

of these dens, where complete measurements were obtained, revealed that the den chamber was wider than it was long. We suspect these were used by sows with offspring as in the case of grizzly No. 39 where the den sheltered her instrumented yearling No. 158 as well as two littermates. This den was almost as wide as it was long. The 1966 den of No. 40, housing the sow and her two large cubs, was wider than it was long and the three bears slept within curled up side by side (Fig. 4). This might indicate a tendency for sows with cubs and sows with yearlings to dig wider dens than do those bears that are hibernating alone or with only a single cub.

DISTANCES TRAVELLED TO DEN SITES

Instrumented grizzlies travelling to their winter dens or sites from fall or summer foraging areas covered the following airline distances:

Grizzly Number	Distance Travelled
40	5 1/2 miles
40	5 1/2
40	6 3/4
101	2 1/2
101	11
202	8
202	8
187	11
39	5
14	16

Grizzly Number	Distance Travelled
164	14
7	14
34	16+
150	6
96	30+
76	21+

Observations of marked animals, made during the fall period of dispersal to den sites, revealed that some grizzlies travelled even greater distances than those measured by radio. Some definitely travelled beyond the boundaries of Yellowstone Park.

ISOLATION OF BEAR DENS

The hibernation dens of the young male grizzly No. 202 were dug in rocks on a forty-five degree talus slope in a steep, nearly inaccessible part of the Yellowstone Canyon. Snow avalanches run down these slopes each spring. Huge rocks periodically break off from the cliffs and start small rock avalanches on the slopes below. There are few trees not deeply scarred by the careening rocks. Islands of timber, some containing quite large trees, have established themselves between the avalanche runs. However, even these islands of timber do not appear to be a safe place for a bear to hibernate; yet No. 202 dug his dens in such a spot. The one thing that this and other known den locations seem to provide is isolation, and it may be that this need for isolation is such that grizzlies, particularly young insecure ones, even take the risk of selecting a denning site on or close to avalanche slopes in order to be

assured of privacy. This den was difficult to approach in summer and practically impossible to reach after the first snow.

Family units such as a sow with cubs or sow with yearlings hibernated together. Other than this, however, the grizzlies appeared to prefer to hibernate alone and to seek solitude and isolation during their winter sleep. There was one interesting exception. During the summer of 1966 instrumented grizzly No. 40 with her two cubs established a close relationship with grizzly sow No. 101 and her cub. Throughout the summer months they travelled together, slept together, foraged together, and were apparently inseparable--one always being seen when we saw the other or moved in on a signal bearing to observe them. This close relationship of these two sows and their three cubs continued right up to the time they entered their dens. Apparently the relationship affected the selection of a den site by both bears. Instead of returning to her former distant hibernating site in the upper reaches of Alum Creek, No. 40 dug her den about three and a half miles from this area. Number 101 also dug her den nearby, the distance between the bears' dens being only one and one half miles. A year later, in the fall of 1967, when the sows had separated, we located the den of No. 101 in the area of Dunraven Pass. This was apparently the general area where she normally hibernated. The usual denning areas of sows No. 40 and 101 were thus approximately sixteen airline miles apart. In 1966 when No. 101 ran with No. 40, she dug her den approximately thirteen miles from her normal hibernating site and, as previously mentioned, within one and one half miles of No. 40's relocated den. When the two sows denned close together they appeared loathe to separate and to hibernate. Even when snow was on the ground and the

conditions seemed favorable for the bears to enter their dens, they travelled back and forth from one den site to the other. Our approach to the den site of No. 101 caused her to abandon the den, so we were unable to determine how long this situation would have continued. This apparent anomaly of two female bears preparing their dens close together and moving back and forth from one den to the other right up to the time that they hibernated reveals a behavior pattern contrary to that exhibited by most of the grizzlies who sought solitude for themselves or families. There was a forceful attraction of these animals for one another and this was further supported by their actions the following spring. Number 40 weaned her yearlings and bred the same spring. Number 101 did not come into estrus but kept her cub and assumed the responsibility of taking care of the two yearlings weaned by sow No. 40. This behavior enabled No. 40 to follow a two-year breeding cycle, yet still have her yearlings receive maternal care. In practice such a behavior pattern would tend to increase the productivity of the species and would benefit the survival of an age class where mortality is relatively high.

REUSE OF DENS

Bedding material in the debris piles of some dens indicated that the dens had been used in previous years (Fig. 11). This was the case with the den of No. 164. It may also be significant that No. 40 cleaned out her 1966 den prior to leaving it in spring. However, the roof collapsed a few months later making the den unusable for another winter. None of the dens to which we radiotracked the grizzlies was ever reused. In many cases the dens caved in when the soil became saturated with water in late

spring, and thus were not suitable for reuse (Fig. 12). Grizzly No. 202 dug two separate dens in consecutive years, and their distance apart was only three hundred feet. His first den was not much more than an elaborate daybed and thus probably was not adequate for reuse the following year (Fig. 7). The second-year den, as indicated previously, was much better constructed than his first one. He removed an estimated ton of rock in preparing it. This might indicate learned behavior reinforcing an instinctive urge. At a number of the active den sites, we found evidence of former dens (Fig. 12). There were three dens, all of them having caved in, very close to the active den of grizzly No. 164, and there was also a caved-in den within a few hundred feet of the 1966 den of No. 40. Plant growth on the debris pile indicated this den was at least five to seven years old. It has not been unusual to find old abandoned dens close to newly dug ones.

Because of this it is interesting to speculate why the two dens at the 1966 den site of No. 40 should be separated in time but spacially close. Possibly the site characteristics are such that the area attracted different bears at different times to this same north facing slope. It is well isolated and within dense forests of lodgepole pine, spruce and fir. It is also conceivable that the old den was the nativity den of No. 40 and she eventually returned to the site to dig a den of her own making.

RELATION OF DEN SITE TO RANGE SIZE AND PATTERN

Two types of grizzly bear seasonal and home range patterns were plotted and delineated by means of radiotracking. One consisted of a

distinct continuous area over which the grizzlies wandered and foraged throughout the year or during spring, summer and fall. The home range unit contained winter den sites or a den. The other range pattern consisted of summer and fall foraging areas, often widely separated from an early-spring and late-fall area that contained the winter den. The latter pattern can be visualized as two distinct ranges, with the bear often travelling rather rapidly from one to the other. The home range of an animal provides all the essentials for life of the individual and thus by definition includes its den site. Den site selection, location and prehibernation behavior are to a certain extent influenced by the range size and pattern. They are also influenced by numerous other factors including age and sex of the bear, social status, topography, vegetation, general and seasonal availability of food and meteorological conditions.

Examples of interesting prehibernation behavior of monitored grizzlies as related to their ranges was recorded. On October 25, 1965, yearling grizzly No. 202 left his regular summer haunts (summer range), swam the Yellowstone River and headed northward directly for his hibernation site on the steep slopes of the Yellowstone Canyon. In 1965, No. 202 was carefully monitored. His first purposeful and independent move away from the summer range of his mother was when he crossed the Yellowstone River and headed for this den site. As far as we know, except during his spring trek from the den of his birth and his return travels the ensuing fall, this young bear spent all of his life in the immediate vicinity of Hayden Valley. This weaned yearling had not prepared his den in advance as mature bears had done, but dug it within a few days of selecting the site. The den constructed by the inexperienced grizzly in rocky talus was not much

more than a daybed but it is interesting that he hibernated within the home range of his mother as revealed by evidence gathered on marked sow No. 65.

In comparison to No. 202, weaned grizzly No. 188 also established a summer range within the home range of his mother, No. 40, but left this to hibernate. His summer range was smaller and largely distinct from hers. In view of the fact that this yearling had spent all of his life within a rather restricted area (20 square miles), the range of his mother, it seemed logical that he might hibernate within this familiar territory. However, in late October during a snowstorm, he took off into new and strange territory to seek a distant hibernation site thus establishing a range pattern quite different from that of his mothers' and one that he may continue to follow throughout his life. This fall dispersion of young bears is a common occurrence. The young independent bears, low in the bear social heirarchy and insecure, wander both in spring and fall more than do other segments of the population.

PREHIBERNATION MOVEMENT AND BEHAVIOR

In the early years of the study, 1960-61, we observed that the Yellowstone grizzlies moved to their dens during snowstorms, and that following these storms there were no tracks anywhere throughout the area where grizzlies had been seen and were previously active. A number of questions were posed including:

When did the Yellowstone grizzlies hibernate?

Did certain environmental stimuli trigger movement of grizzlies to their winter dens?

Did other stimuli retard hibernation?

To what degree did the grizzlies become lethargic and when did this occur?

In order to obtain information on this subject, we instrumented grizzlies in the fall of the year with radio transmitters (Fig. 1). The first two years (1961-62) that we instrumented grizzlies, we were unable to track the bears to their dens. Our first successful tracking occurred in 1963 with improvements in equipment performance (Varney, 1963). Tracking grizzlies to their dens became routine after this. Observations and sight-tracking of grizzlies in the fall of 1960, 1961 and 1962, supplemented in 1963 by radiotracking, provided us with information on the hibernation dates of the grizzlies; that is, the dates when the grizzlies entered their dens to remain for the winter. These were:

Year	Month
1960	October 29
1961	October 21-22
1962	November 15 (approximately)
1963	November 3-4
1964	November 10
1965	November 11
1966	November 19-21
1967	November 19

All of the grizzlies involved hibernated at altitudes ranging from 7800 to 9200 feet (Table 1). Those ranging and foraging at altitudes several thousand or more feet lower, as at Mammoth or Gardiner, did not hibernate

simultaneously with those generally distributed throughout the Yellowstone Plateau. The dates through 1962 were obtained by observing movement of grizzlies during snowstorms and lack of tracks thereafter. The later dates were obtained by radiotracking grizzlies to their dens (Table 3). The date at which the bears entered their dens to remain inside for most of the winter varied by as much as a month over an eight-year period. The earliest date was October 21-22, 1961 and the latest was November 19-21, 1966. The general pattern of prehibernation movement and activity that occurred was as follows:

Most grizzlies prepared winter dens well in advance of the time that they went into hibernation. The earliest recorded den diggings were September 3 and September 8 (Table 3). The latest occurred November 11 and 15, the bears completing the dens just in time to enter them for the winter. In these latter cases the den construction had been delayed by abandonment of previously prepared dens or had been influenced by one kind of disturbance or another which affected or altered the behavior of the animal. Usually dens were not approached closer than a hundred feet but even so some were abandoned. (Den of No. 101 in both 1966 and 1967, No. 187 in 1967.) Individuals varied considerably in the degree of disturbance needed to cause abandonment of a completed den. Dates of den digging activity shown in Table 3 are dates when excavating was first detected and do not show the duration of digging. Usually the dens were dug in a matter of a few days with subsequent minor digging activity.

After early preparation of a den, the bears would return to their established fall foraging areas and continue to feed and put on weight. Most early snowstorms did not elicit movement. The grizzlies continued

with their regular feeding activities. Sometimes one small storm followed another, causing no change in grizzly behavior. Eventually, however, either a late or a major snowstorm with falling barometer moved the grizzlies back to their den sites. On a number of occasions grizzlies were detected moving to den sites in clear, warm weather with a falling barometer. For instance on October 15, 1965, No. 40 started moving to her den in the morning of a warm sunny day. By late afternoon, a snowstorm was in progress and No. 40 was tracked to her den site. The grizzlies appeared able to detect variations in barometric pressure and such changes seemed to initiate movement to dens before storm signs were visually apparent.

When moving back to dens, the grizzlies would continue to "rake" dirt out of their dens and often add more bed materials. If warm, clement weather followed a storm, the grizzlies tended to return to their fall foraging areas until still another storm sent them denward. In some cases, the grizzlies moved back to their den sites during snowstorms remaining in close proximity to the den opening until a following snowfall and low temperatures put them in for the winter. On other occasions such as in 1961 and 1963, grizzlies moved directly from their foraging areas in falling snow and immediately entered their dens and remained within.

The general picture then of prehibernation behavior and movement of Yellowstone grizzlies is that as early as several months prior to hibernation, some grizzlies dig and prepare their dens for the winter. The time at which each individual does this varies considerably. The dens are not only dug, but are usually lined in advance with a bough bed. Movement back and forth between feeding areas and den sites generally only occurs in the advent of a snowstorm. If the storm is a sizable one and

winter conditions prevail thereafter, the grizzlies enter their dens and remain. All or most of the grizzlies living under the same environmental conditions hibernate at the same time. If the weather warms up immediately after a storm, the grizzlies either move back to foraging areas or they stay in close proximity to the dens and then enter them for the winter with the next big storm. The final movement of the grizzlies to their winter dens has always been during a storm, whether the grizzlies remained close to their dens or were foraging off at some distance. Following the final snowfall that put the grizzlies into hibernation, there have been no tracks evident anywhere throughout the vast areas where the grizzlies roam. Tracks have not even been observed near the den entrances, except in a few cases. This rather simultaneous entering of winter dens during falling snow serves to hide tell-tale signs of the den location and is no doubt a behavior trait favoring survival during a vulnerable period. It is also in contrast to the Yellowstone black bears (Ursus americanus) where hibernation starts earlier and time of entrance into winter dens varies greatly. Table 3 shows the early grizzly bear den-digging dates as determined by means of radiotracking, the date of the final movement to the den area as well as the date of entering the den. Also recorded are weather conditions, presence of storms, amount of snow on ground, maximum and minimum temperatures that accompanied the final movement of the bears to their den area and the date of entering the den for the winter sleep. Minimum temperatures at this time are below 32° F. and undoubtedly the maximum temperatures in the shaded den sites are also below 32° F.

Of all the grizzlies observed prior to hibernation, the only one that did not move to a den site with snow on the ground and during a storm was

weaned yearling grizzly No. 202. This animal moved directly to his den site on October 25-26, 1965. He immediately began digging and preparing his den upon arrival. When he travelled, there was only patchy snow upon the ground and the day was clear. However, prior to this on October 15, 1965, during a snowstorm with 3-4 inches of new snow on the ground, this grizzly left his regular summer and fall haunts and moved to another area. The storm initiated his movement away from his summer and fall foraging area snd precipitated the final move to a den site. During most falls, no lethargy was observed in the grizzlies prior to entering their dens, but in 1965 the grizzlies exhibited a very definite prehibernation lethargy.

PREHIBERNATION LETHARGY

In the fall of 1965, we observed what appeared to be a marked lethargy in grizzlies prior to hibernation. This lethargy was apparent at one time or another in all the grizzlies under observation during late fall. For example, on October 14, 1965, we jumped instrumented grizzly No. 188 from his daybed in lodgepole timber. He moved away slowly, but only after we started talking. He soon stopped and sat down on a wooded hillside. Within a few minutes his head began to sway and the bear slumped to the ground so that he was lying with his muzzle on the ground and turned inward under his body. He was aware of our presence and appeared to be trying to remain awake and alert, but acted almost as though he were drugged. On several occasions he made an effort to raise his head only to slouch forward again, resting his muzzle against the ground. This position with the muzzle of the nose turned back under is very similar to the bears' first reaction after being drugged with succinylcholine chloride (Craighead,

et al., 1960). We moved to within 100 feet of this grizzly before he again rose to his feet and lumbered off. Similar behavior was observed when we jumped instrumented grizzly No. 202 on the same day.

About two weeks later while tracking grizzly No. 202 on November 3, this lethargy was even more pronounced. The grizzly's radio signal led us to the edge of the perpendicular walls of the Yellowstone Canyon. Here a three-bearing fix indicated that the grizzly was directly below us. While attempting to locate the bear with binoculars, we loosened a large rock that crashed into the trees below. Simultaneously with the crash, we heard the roar of a startled grizzly. We spotted the animal in a small opening almost directly below us. The sudden noise brought him to his feet and into view. He had been lying at the entrance of his den. For the next half hour this grizzly stood motionless except for an occasional slow movement of his head when he raised his nose in order to seek our scent. Several times the bear seemed to almost fall asleep when he let the muzzle of his nose slide to the ground and turn back under his body, a behavior identical to that described for grizzly No. 188. The grizzly definitely appeared to be in an advanced lethargic condition. He should have been able to have scented us as the wind movement was favorable, but he gave no indication of detecting us.

On October 25, 1965 we moved in and located the den of grizzly No. 40 while the bear was within. We approached to within 30 feet but the grizzly did not come out. She was apparently somewhat lethargic. At this time, No. 40 did not remain in her den for the winter, but in her lethargic state she stayed close to her den and at times within it. This behavior continued from October 15 to November 11, when she entered the den during

a snowstorm and remained within for the winter. Grizzly No. 40 moved to her den a full month before entering it. It is reasonable to assume that the early onset of lethargy influenced this movement. The fact that she was pregnant may also have been a contributing factor. The apparent lethargic condition of these bears and their early movement to den sites, particularly the movement of No. 202 to a den site without a triggering storm, seemed to indicate that hibernation physiology, possibly including a hypothermic lethargy, had been initiated prior to actual entering of dens or movement to them.

Higher warm-blooded animals have an activity temperature above 36° C. Rectal temperatures of grizzlies and black bears taken in summer and fall have shown a temperature of 37.8-38.4° C. With protracted action of cold, it is possible to go below the lower threshold of activity and a hypothermic lethargy ensues (Eisentraut, 1960). This did not appear to be the case with the grizzlies under observation, as during other fall periods with more prolonged cold they had not exhibited lethargy prior to denning. However, cold did appear to be an influencing factor.

Weather conditions in the fall of 1965 differed from those of the preceding study years and this quite possibly affected grizzly prehibernation behavior and movement to den sites. An early fall period of snow and unusual cold occurred from September 15 through September 28. This was the coldest early period of snow and low temperatures experienced in the course of the study. Ambient temperatures were lower than at the November 1965 time of hibernation. Four to six inches of snow were on the ground at our Canyon laboratory and more at higher elevations. Minimum temperatures dropped to 7° F. This cold spell was then followed by warm,

mild fall weather. The combination of early snow and low temperatures did not stimulate grizzlies to hibernate, but it did disperse some from summer to fall ranges, 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 continuing cold and the environmental stimulus of a final snowstorm caused them to enter their dens on November 11 for their winter sleep.

It is characteristic of grizzlies to bury or cover the carcass of an animal with dirt, grass, and brush. The animal may be one dying of natural causes or more rarely an animal killed by the grizzlies. They are not consistent in burying a carcass, nor are the reasons for the variable behavior readily evident. The subject will not be elaborated here with the exception of reference to lethargic behavior.

In 1960, we observed grizzlies burying or covering the carcasses of elk as early as September 21. This phenomenon continued throughout the fall. On several occasions when we approached grizzlies feeding on carcasses, we found them sleeping either on or beside their food supply. This was observed as early as October 14 and might have been interpreted as an indication of the onset of winter lethargy. However, these animals when alerted always took off on a dead run and were quite active. Apparently sleeping on the carcass was related to the heavy meals the bears had consumed rather than to any physiological changes connected with the hypothermic lethargy of winter sleep, as observed in the fall of 1965.

ENVIRONMENTAL FACTORS AFFECTING PREHIBERNATION BEHAVIOR

In 1961, the grizzlies hibernated on October 21, the earliest date of which we have records. This was the coldest fall period of the entire

study with snow and cold weather starting early and continuing with few breaks until the bears hibernated. The first snowstorm of three to four inches occurred on September 11 and was followed by another snowfall on September 18, adding four to five inches in some areas. September was characterized by periodic snowstorms, with snow on the ground throughout much of the month. However, the lowest minimum temperature for this same period was 19° F., occurring on September 14. This is higher than the low temperature of 7° F. recorded for the 1965 September 18-20 cold spell, after which the grizzlies showed an apparent lethargy prior to hibernating. The average minimum and maximum temperatures for the two falls are somewhat similar. The minimum for September of 1961 was 29° and the maximum 51° F., as compared with 25° and 52° F. in 1965. The October minimum and maximum temperatures in 1961 were 22° and 45° F.; in October 1965, 22° and 56° F. The late fall of 1965 was warmer and definitely not as wintery as in 1961, when the bears hibernated quite early, but was characterized by unusually low temperatures in September followed by relatively warm temperatures in October and November. There is an indication that early snow and continued cold and snow may initiate early hibernation, whereas an early unusual cold spell may initiate hypothermic lethargy prior to entering dens.

Food supply in combination with altitude, latitude and meteorological conditions affect at what time and even whether or not the grizzly will hibernate. A captive grizzly when supplied with adequate food under relatively cold conditions showed no inclination to hibernate. In 1961, when the grizzlies hibernated early, there was a combination of a cold fall coupled with a shortage of food. The whitebark and limber pine nut crops were poor (practically no nuts were produced) to be followed by a

bumper crop the next year. The meadow mouse (Microtus sp.) population was not high and in general the food supply was probably less abundant at this season than during most of the other years. In 1961, on October 19, a number of grizzlies started to feed on an elk carcass in the Sulfur Mountain area in Hayden Valley. A falling barometer and snowstorm on the evening of the 21st continuing into the 22nd started these grizzlies moving to their dens and put them into their hibernation quarters for the remainder of the winter. The grizzlies on the elk carcass consumed a large porportion of this animal, but with deep snow, cold and a general food scarcity they abandoned this ready food supply and took off in the storm to travel to their dens.

In 1966, following storms that did not put the grizzlies into their dens, grizzlies No. 40 and No. 101 with their families continued to leave their den sites and revisit the sparse remains of a buffalo carcass. The presence of this food supply within a relatively short distance of the two dens no doubt influenced the prehibernation behavior of these animals and perhaps delayed their entrance into the dens and into a lethargic state. At least it was one of several factors that kept them active and moving from their dens rather than dozing close to the den entrance until the final storm and cold weather put them into hibernation.

Our observations indicate that prehibernation behavior as well as the time of entering dens are quite definitely influenced by environmental factors. A combination of low temperatures and snowstorms appear to condition the bears and eventually influence the time at which they enter their winter dens. A convenient food supply with relatively high ambient temperatures tends to delay hibernation. On the other hand, adequate

and available food will not deter the bears in the wild condition from entering their dens if snow is accumulating on the ground and snowstorms and severe cold occur at the same time. A fall period with general food scarcity combined with cold weather conditions tends to put the bears into hibernation earlier than usual.

The time of hibernation over an eight year period varied by as much as a month. It therefore appears that light or darkness is not a factor in inducing the grizzlies to hibernate. Kayser (1961) mentions that this was also the conclusion of Johnson (1930) following researches conducted on the ground squirrel (Citellus tridecimlineatus pallidus and C.t. arenicola). By measuring the length of hibernation of these two species, Johnson comes to the conclusion that the length of hibernation is independent of light. Hock (1955) working with Citellus undulatus and studying the different climatic and ecological factors that may be influential, states that there is no relationship between the beginning of hibernation and the temperature, the snowfalls, or the amount of available food. The only close correlation observed is between illumination and hibernation. It appears that the findings of Hock working with a "physiological" hibernator are just the opposite to those we have found with the grizzly, an "ecological" hibernator.

Grizzlies appear much more prone to cover or bury carcasses of animals in late fall than during the summer period. This trait also seems to vary one fall period to another. To some extent burying serves to protect the food from ravens, magpies and coyotes that usually wait nearby for a chance to feed when the grizzly leaves. A partial and reasonable explanation for this burying of food may be that den digging is instinctive behavior for the grizzly. Certainly their long powerful front claws are

well adapted for both digging for food and excavating a shelter. In fall, environmental conditions may stimulate a need or instinct to dig more than at other seasons. Thus the grizzlies not only dig their dens and gather boughs for beds, but the bears tend to excavate dirt and to uproot grass and herbaceous vegetation to cover their food supplies. It may also be significant that when the grizzlies move to their dens with falling barometers and in snowstorms, only to remain outside with subsequent clearing and warming temperatures, they busy themselves with a "housecleaning" type of digging both within and outside the den.

EMERGENCE FROM HIBERNATION

In general the Yellowstone grizzlies remain in their winter dens from the time they enter them in late October or November until about early April. During this time the bears are largely inactive although an occasional animal does come out in midwinter. Sometimes this is in response to a nearby food supply as was the case with a grizzly that came out in the latter part of February 1967 in the Old Faithful area. The bear was attracted to the carcass of an elk that had died not far from the den. The usual procedure for the grizzly is to fast from the time they enter their dens until they leave them in spring. Some grizzlies emerge from their dens as much as three weeks to a month before they leave the den site for spring feeding areas. Often when they first emerge the snow is too deep for the bears to travel and they wait in the vicinity of the dens until sunny days with warming temperatures, followed by chilly nights, produced a crust on the snow that will support their weight.

In the spring of 1965, number 40 and her yearling came out of their den in late March and then built bough beds on the snow within several hundred feet of the den entrance. The bears slept on these beds and were covered by snow from subsequent storms. As the snow piled up over the sleeping grizzlies, their breathing produced an air shaft to the surface (Fig. 13). Apparently the bears continued in a lethargic state and were still hibernating but on bough beds on the snow surface rather than within the den. Perhaps one reason for early emergence from the den is that in the spring of the year, the outside air temperatures, at least during the day, are often warmer than those within the den. At 10:45 a.m. on April 28, 1965 the air temperature inside the den of No. 40 was 32° F. The air temperature in the shade, outside of the den and three feet above the snow was 40° F. The ambient temperature in the sun was 50° F. Two years later, this sow emerged from hibernation with yearlings. On this occasion they took off without building bough beds as was the case in the spring of 1965.

Table 1

GRIZZLY BEAR DENS
YELLOWSTONE NATIONAL PARK

DESIGNATION OF GRIZZLY NO.	SEX	YEAR DEN USED	DEN LOCATION	VEGETATION TYPE	SOIL STRUCTURE	DEN ELEVATION	SPECIES DEN TREE	DEN CHAMBER MEASUREMENTS (INCHES) L	W	HT	DEN ENTRANCE MEASUREMENTS (INCHES) L	W	HT	TOTAL LENGTH	DEN LINING
164	F	1963*	Upper Alum Creek	Lodgepole Pine	Soft earth	8,200	Lodge-pole	59	53	48	60	17	40	119	Conifer boughs
158	M	1964	Upper Trout Creek	Lodgepole Pine	Packed soil Gravel layer	8,400	Spruce	64	60	60	32	30	42	96	Conifer boughs
40	F	1964	Upper Alum Creek	Lodgepole Pine Spruce-Fir	Packed soil	8,200	Spruce	48	42	48	36	30	30	84	Conifer boughs
40	F (3)	1965	Upper Alum Creek Beach Lake	Lodgepole Pine	Packed soil	8,200	None	54	54	36	66	33	21	120	Grass Moss Rootlets
40	F	1966	Lower Trout Creek	Lodgepole Pine Spruce-Fir	Loose soil	8,000	Dead Stump	60	85	28	30	17	20	90	Conifer boughs
202	M	1965	Yellow-stone Canyon	Spruce-Fir	Rocky (talus)	7,800	Log (1)	47	43	26	--	--	--	66	Conifer boughs
202	M	1966	Yellow-stone Canyon	Spruce-Fir	Rocky (talus)	7,800	Log	43	37	28	--	--	--	63	Conifer boughs
101	F	1966	Lower Trout Creek	Lodgepole Pine	Sandy soil	8,000	White-bark Pine	54	48	30	12	14	36	66	None (2)
101	F	1967	Hedges Peak	Spruce-Fir Whitebark Pine	Packed soil Rocks	9,200	Dead Spruce	63	56	40	45	15	54	108	Fir boughs
187	F	1967	Ice Lake	Lodgepole Pine	Packed soil	8,100	White-bark Pine	--	--	--	36	21	27	--	None (2)

1. Attempted earlier to dig den at base of tree
2. Den abandoned before lining
3. Female pregnant
* Signs of use the previous year

Table 2

GRIZZLY BEAR DENS INACTIVE
YELLOWSTONE NATIONAL PARK
UNKNOWN GRIZZLIES

DEN LOCATION	VEGETATION TYPE	SOIL STRUCTURE	DEN ELEVATION	SPECIES DEN TREE	DEN CHAMBER L W HT	MEASUREMENTS ENTRANCE L W HT	TOTAL LENGTH	DEN LINING
					INCHES			
Upper Trout Creek	Lodgepole Pine	Hard Compacted	8,200	Spruce	43 63 43	64 26 26	107	Conifer Boughs
Absaroka Range Mist Creek	Whitebark Pine	Rocky	9,000	Whitebark Pine	54 60 36	-- -- --	54	Conifer Boughs
Lower Trout Creek	Lodgepole Pine Spruce-fir	Loose Soil	8,000	None	70 52 30	20 27 19	90	Conifer Boughs
Yellowstone Canyon, S. side	Spruce-fir	Natural[1] Rock Cave	7,800	None	33 57 36	54 77 52	87	Scattering of boughs
Yellowstone Canyon, N. side	Douglas-fir	Fine-rock Soil	7,600	Matted Vegetation	-- 48 --	-- -- --	96	Den Collapsed
Ice Lake Area	Lodgepole Pine	Packed Soil	8,100	Mat of Vaccinium scoparium	-- 30 24	-- -- --	84	Den Collapsed

1. Used as a daybed or daytime lair but not as a winter den

Table 3

GRIZZLY BEAR PREHIBERNATION PHENOLOGY
YELLOWSTONE NATIONAL PARK

DESIGNATION OF GRIZZLY NO.	SEX	AGE	DEN DIGGING ACTIVITY	DATE OF FINAL MOVEMENT TO DEN AREA	WEATHER CONDITIONS PREVAILING	TEMP. °F. MAX.	MIN.	DATE GRIZZLY ENTERED DEN	WEATHER CONDITIONS PREVAILING	TEMP. °F. MAX.	MIN.
164	Young adult female	--	Prior to final trek to den	1963 November 4	Snowing, 4-6 inches on ground	36	28	November 5	Snow storm	31	16
150	Adult female with 3 cubs	--	Prior to final trek to den	1963 November 4	Snowing, 4-6 inches on ground	36	28	November 4	Snow Storm	36	28
40	Female with cub	6 1/2	September 8 (2)	1964 November 1 New den	Snowing, 12-18 inches on ground	45	32	November 10	Snow Storm	40	24
158	Male Yearling with adult sow and littermates	1 1/2	Prior to final trek to den	1964 October 29-30	Snowing, 12-18 inches on ground	58	38	November 10	Snow Storm	40	24
40	Adult female pregnant	7 1/2	September 3	1965 October 15-16	Snowing, 3-4 inches new snow	54 41	30 30	November 11	Snow Storm	43	28
202	Weaned Yearling male	1 1/2	October 27-29. No previous preparation	1965 October 15 left regular haunts	Snowing, 3-4 inches new snow	54	30				
				October 25-26 Moved to den site	No snow Clear	55 63	26 25	November 11	Snow Storm	43	28
88	Weaned Yearling male	1 1/2	After October 15	1965 October 15	Snowing, 3-4 inches new snow	54	30	Probably November 11	Snow Storm	43	28
40	Adult female with 2 cubs	8 1/2	Prior to final trek to den November 2 Some digging	1966 November 15	Snowing, 12 inches snow on ground	40	20	November 21	Snow Storm	38	26
202	Young male	2 1/2	October 10-11	1966 November 6	Snowing, 5 inches snow on ground	38	29	November 21	Snow Storm	38	26
101	Adult female with 1 cub	9 1/2	Some digging November 8	1966 November 14	Snowing, 10-12 inches snow on ground	45	24	Probably (1) November 21	Snow Storm	38	26
120	Adult female	--	Prior to final trek to den	1966 About November 1	Snowing. Snow on ground	40	6	Probably November 21	Snow Storm	38	26
187	Adult female pregnant	4 1/2	September 16	1967 October 27	Snowing	51	10	Probably (1) November 19	Snow Storm	32	25
101	Adult female 1 yearling	10 1/2	Approximately October 11	1967 October 27	Snowing	51	10	Den abandoned (2) November 2-6			
101	Adult female 1 yearling	10 1/2	November 7-11 New den	1967 November 2-6 moved to new den site	Snowing, 10-12 inches snow on ground	51	10	New den November 19	Snow Storm	32	25

1. Den abandoned. New den not located
2. Den abandoned. New den located



Fig. 1. Female No. 40 moving to winter den. This bear was instrumented and monitored for seven consecutive years.



Fig. 2. Yearling grizzly color-marked and fited with a radio collar.

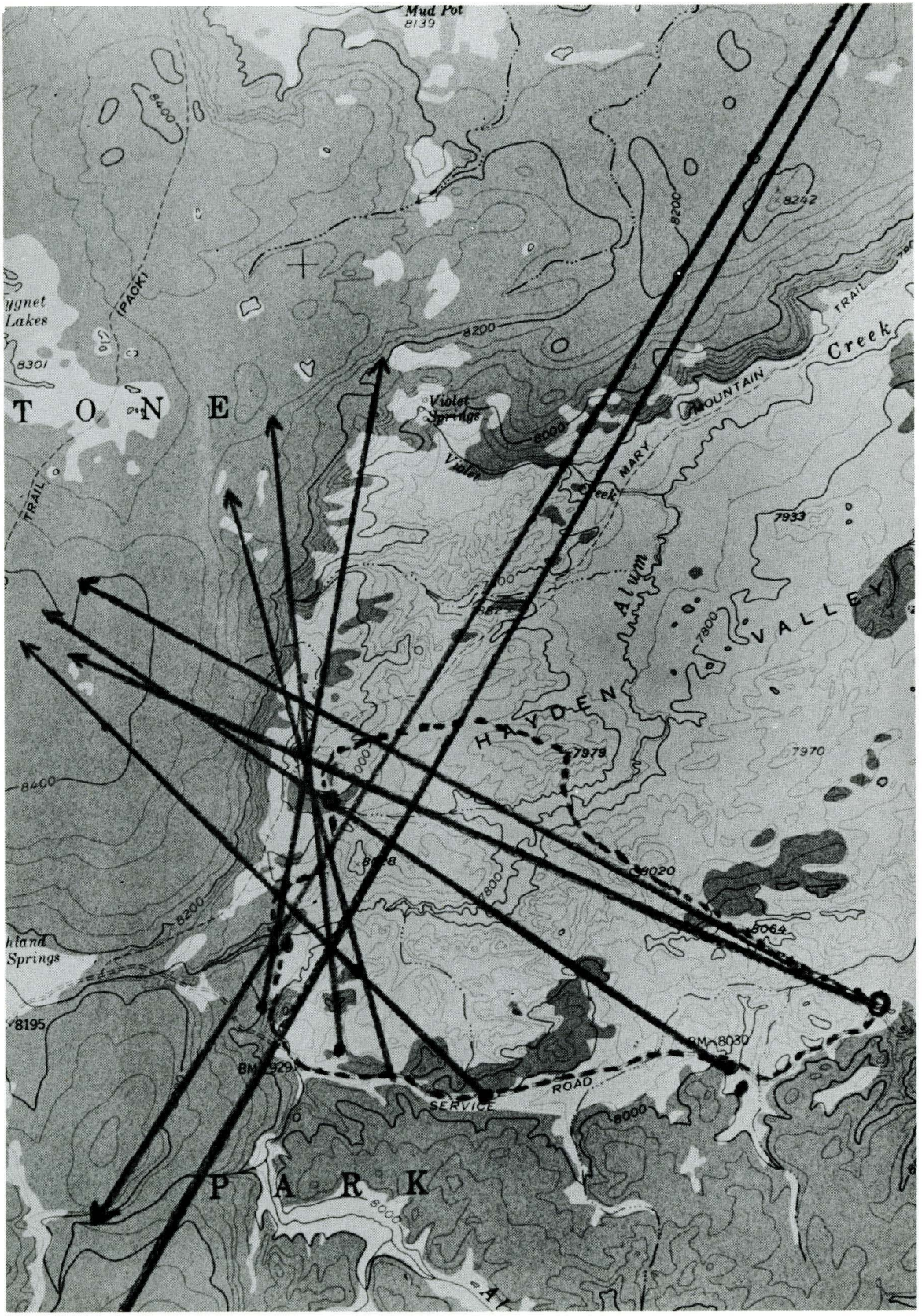

Fig. 3. Bearings made on transmitter signal in order to locate instrumented grizzly.



Fig.13. Bough bed constructed on the snow in March several hundred feet from the winter den.



Fig. 4. Lining of winter den. Depth of lining varied from several inches to 14 inches.



Fig. 5. Den excavated at base of tree. Roots frequently limit size of the entrance.



Fig. 6. Den constructed under a horizontal log on a steep talus slope



Fig. 11. Winter dens were normally used only once. This den was used for two consecutive years.



Fig. 12. Winter den caved in after use. Old dens were frequently found in the vicinity of new dens.



Fig. 7. Entrance way through roots to den chamber. Observer is outside looking into den. obstructing roots are chewed off by the bear.



Figure 8

Den constructed so the bed lay slightly above the entrance creating a heat trap and dead-air space.

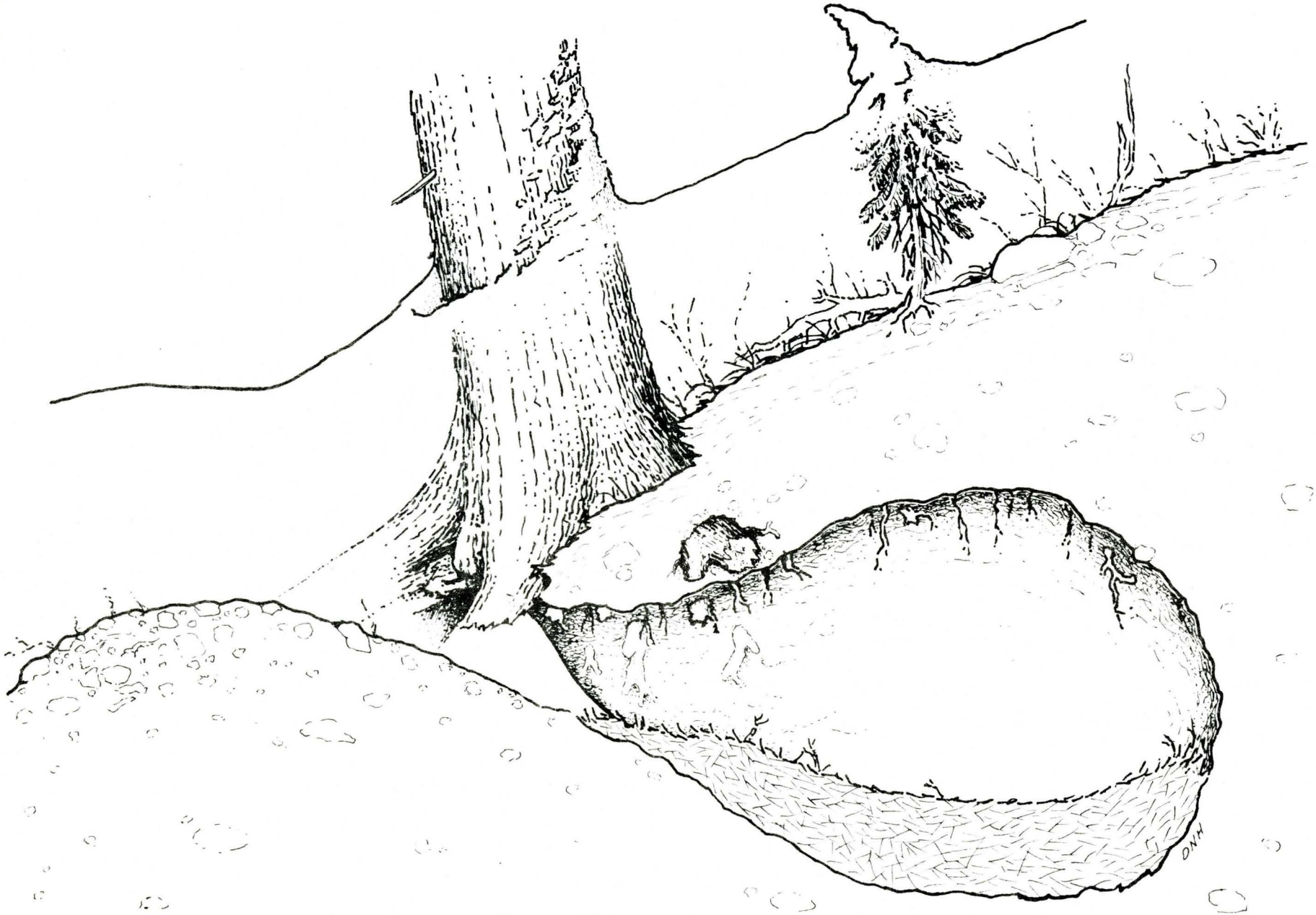

Figure 9

Den with bed lower than entrance.
Such dens were generally covered with five to ten feet of snow.
They held water after the snow melted.



Figure 10

Black Bear Den
A Natural Cave with a bed 18" deep
and 30" in diameter



Fig. 14. Nearly vertical den entrance with den chamber lying directly beneath the tree.

LITERATURE CITED

Couturier, Marcel A. J. 1954. L'ours Brun, Chapter 16 Gite, Tanieke Sommeil Hivernal, Grenoble, France.

Craighead, J. J., M. Hornocker, W. Woodgerd and F. C. Craighead, Jr. 1960. Trapping, immobilizing and color-marking grizzly bears. Trans. N. Am. Wildl. Conf. 25:347-363.

Craighead, Frank C., Jr., John J. Craighead and Richard S. Davies. 1963. Radiotracking of Grizzly Bears, Bio-telemetry, Pergamon Press, pp. 133-148.

Craighead, Frank C., Jr., John J. Craighead. 1965. Tracking Grizzly Bears, BioScience, Vol. 15, No. 2, pp. 88-92.

Craighead, Frank C., Jr., John J. Craighead. 1960. Seventh Yellowstone Field Research Expedition. Pub. No. 45. Atmospheric Sciences Research Center, State University of New York at Albany.

Eisentraut, M. 1933. Winterstarre, Winterschlaf und Winterruhe, Mitt. Zool. Mus. Berlin 19, 48-63.

Eisentraut, Martin. 1960. Heat Regulation in Primitive Mammals and in Tropical Species, Mammalian Hibernation edited by Lyman, C. P. and A. R. Dawe.

Erickson, A. W., John Nellor and George A. Petrides. 1964. The black bear in Michigan, Research Bulletin 4, Michigan State University, Agric. Exper. Sta.

Hock, R. J. 1955. Photoperiod as Stimulus for Onset of Hibernation. Fed. Proc. 14, No. 236.

Hock, Raymond J. 1960. Seasonal variations in physiologic functions of Arctic ground squirrels and black bears, Mammalian Hibernation, Bulletin of the Museum of Comparative Zoology, Harvard College, pp. 155-171.

Johnson, G. E. 1930. Hibernation of the Thirteen-lined Ground Squirrel (Citellus tridecimlineatus) V. Food Light, Confined Air, Pre-cooling, Castration and Fatness in Relation to Production of Hibernation. Biol. Bull. 59, 114-127; Referred to by Ch. Kayser, 1961.

Kalabukhov, N. I. 1956. The Hibernation of Animals. Reference from Ch. Kayser, 1961.

Ch. Kayser, 1961. The Physiology of Natural Hibernation. Pergamon Press.

Lyman and Dawe. 1960. Mammalian Hibernation, Bull. Museum of Comparative Zoology, Harvard College. Vol. 124.

Matson, J. R. 1946. Notes on Dormancy in the Black Bear. J. Mammalogy. 27, 203-212.

Morrison, Peter. 1960. Some Interrelations Between Weight and Hibernation Function, Mammalian Hibernation, Bull. of the Museum of Comparative Zoology, Harvard College, pp. 75-91.

Varney, Joel R. 1963. Special Tracking Project Report, Philco Corporation, Western Development Laboratories, Palo Alto, Calif.

ACKNOWLEDGEMENTS

This phase of a long-range ecological study of the grizzly bear could not have been conducted or completed without the help of numerous individuals and support from a variety of organizations. We extend special thanks and credit to Joel Varney who designed and constructed the radiotracking equipment. Thanks are also extended 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 tracking grizzly bears to their winter dens or den sites.

Special thanks are also due Mr. Lemuel Garrison, former superintendent of Yellowstone National Park, Dr. Melvin M. Payne, President, National Geographic Society, and to Mr. Frank H. Goodyear, Treasurer of the Environmental Research Institute. All, in different ways encouraged us in our research efforts.

The National Geographic Society supported this study throughout its entirety and it was also supported by Research Grant GB-2672 from the National Science Foundation and continuing Grant AT (45-1) 1929 from the Atomic Energy Commission.

We gratefully acknowledge the following organization for financial aid: The National Geographic Society, the National Science Foundation, the Atomic Energy Commission, the Environmental Research Institute, Philco Corporation. We extend thanks and appreciation for help and cooperation to the National Park Service, the University of Montana, the Montana Fish and Game Department, the State University of New York at Albany (Atmospheric Sciences Research Center), and the Yellowstone Park Company.

Title Page

Radiotracking Grizzly Bears

by

Dr. Frank C. Craighead Jr.
Environmental Research Institute

and

Dr. John J. Craighead
U. S. Fish & Wildlife Service
Montana State University

R 9

, full of portent & meaning,

Radiotracking Grizzly Bears

Beep, beep, beep came in loud & clear in the crisp fall air, full of portent & ~~meaning~~

Summer had left the high country of Yellowstone National Park; bison, elk, and mule deer were on the move and the gray-streaked skies belching snow flurries behind 10,240 foot Mt. Washburn emphasized the change in seasons. From our vantage point overlooking Hayden Valley we could hear the high-pitched ~~voices~~ howling of coyotes and the challenging bugling of bull elk. Canada geese "honked" ~~from~~ up river and the distinctive calls of sandhill cranes and ravens carried across the valley.

Normally we would have been attuned to these wildland voices, however, John, Maurice Hornocker and I were listening instead to a pulsed high-pitched "~~Beep-Beep-Beep~~ signal of a sophisticated man-made sound". The repetitive metallic ~~sound~~ beeps completely lacked any quality of wildness; it stirred no deep primitive instincts of the chase, nor did it join us in a oneness with nature.

Yet this beeping voice coming to us in the vastness of Hayden Valley thrilled us as few sounds had. The vibrant pulsed signal though strange and new in the Yellowstone wilderness told us we were listening to a grizzly bear just as surely as the distant honking told us Canada Geese were on the wing. The beep was more specific than the honk of the goose or the gutteral caw of the raven for it emanated from one particular grizzly bear within the 3,000 square miles of the Park. It informed us we were monitoring ~~via radio waves~~ the first free-roaming grizzly sow ~~No. 40~~ to be tracked by radio, number 40, one of ~~some 200 similar~~ the 164 grizzly bears ~~inhabiting~~ the Park and adjacent country ~~in~~ individually we had captured and marked.

The signal coming from the directional receiver beside me started as an invisible, soundless radio wave that ~~emanated~~ spread in all directions from a tiny transistorized transmitter suspended from the neck of a grizzly bear. The radio frequency was changed to an audio frequency in the receiver beside me. The pulsed signal spilling into the

19

Footnote (insert x)

~~This research program has been coordinated through the Montana Cooperative Wildlife Research Unit and the Environmental Research Institute~~

In addition to the organizations mentioned

The research program on the grizzly bear has been a cooperative effort, ~~with~~ the National Park Service, the U.S. Fish and Wildlife Service, Montana State University, The Montana State Fish and Game Department , the Boone and Crockett Club, the New York Zoological Society, the American Museum of Natural History, the Yellowstone Park Company, and the Wildlife Management Institute, ~~the Environmental Research Institute~~ all have contributed in one way or another. ~~The work has been~~ coordinated and administered jointly through the Montana Cooperative Wildlife Research Unit and The Environmental Research Institute, Montana State University

afternoon air at 70 beeps per minute had the potential of leading us across the sage-grass valley, through heavy lodgepole timber to grizzly sow No. 40 some four miles distant. It had also the potential to inform us of the exact location of No. 40 at any hour or minute of the day or night for a period of 90 days or more.

Tracking grizzlies by radio was merely an idea - a dream - in 1959 when we initiated an ecological study of this formidable but threatened carnivore (See National Geographic). At that time we realized that new research methods must be used if we were to reveal secrets of this wilderness inhabitant that was active both day and night, wandered over thousands of square miles of rough terrain and each fall crawled into some remote cave or windfall to "sleep" away half the year.

Supported in part by the National Geographic's Committee for Research and Exploration, the National Science Foundation, and aided by Philco electronic engineers we set out to "bug" the bear.

The principles of electronics, and a year of experimental work dictated that sooner or later we would hear this signal. Such reasoning, however, did not prepare us for the emotional impact of tracking and locating our first instrumented grizzly.

As the signal came in, I slowly rotated the loop antenna of the receiver to obtain the strongest signal as well as the weakest signal or null. The position of the loop antenna indicated the direction of the signal source and thus the bear. "She is nearly due west" commented John, "but can we "home in" on her"? "It's a good start just to know she's out there somewhere", said Maurice. It was indeed for we were now not just hoping to cross paths with a grizzly bear but we intended to confront a particular grizzly at a specific time and place, the meeting to be determined on how fast and accurately our electronic equipment would lead us to her.

A Rendezvous

We climbed a long sloping hill in the indicated direction, checking with the receiver as we went. John and Maurice followed closely behind, carrying cameras, binoculars and a scope. We contoured the hill passing through lodgepole pines into open parkland, ~~in a zigzag course~~ in a fair-line course. We ascended one hill, then another. Before topping the last rise the strength of the signal increased. Was the grizzly just over the knoll, or was she in the valley beyond still some distance away? It was not just an academic question. For the first time in our study of the grizzly, we now had the advantage of surprise on our side, especially when moving into the wind. Grizzlies are short-sighted and cannot readily discern a man beyond 100 yards; their sense of smell, however, is extremely keen. Though we carried a firearm, we had never yet had to use it for defense, and hoped we never would; but our purpose was to get close to grizzlies and observe them without being detected. It could be and it had been dangerous, for a grizzly if jumped or startled at close range might charge as readily as run. Relief was mixed with excitement when we cautiously peered over the hill and saw a grizzly, head lowered, plodding along the valley floor unaware of our presence.

"That should be No. 40", we exclaimed in unison. But assuming the obvious was not enough; only certainty would suffice at this stage of our research project. John's exclamation that he could see the colored collar that contained the transmitter and served as an antenna was confirmed by Maurice as he followed the bear's movements with the scope.

We all realized that several years of preparation and work had climaxed and that we were experiencing a major accomplishment in our efforts to use electronic equipment to study the approximately 200 grizzlies inhabiting the Park and adjacent country.

improved equipment and

Two years later with the experience of instrumenting and tracking 13 grizzlies, the pulsed beep would be as familiar to us as the coyote's howl. A signal pulsed at ~~100~~ 62 "beeps" per minute would mean we were on the track of No. 164 while 50 beeps would tell us that it was No. 7 that lay bedded only 100 feet ahead of us in lodgepole downfall. These signals would lead us over miles of rough terrain to rendezvous with grizzlies in their intimate moments of napping, catching rodents, digging tubers, seeking pine nuts, frolicking in new-fallen snow, defending kills, battling for mates, and finally one entering its winter den.

would guide us to

Instrumenting a Grizzly

The life of a radio-packing grizzly is not noticeably affected by the collar containing transmitter, battery pack and antenna. The bear adjusts quickly to this instrument of science and so too, do his companions. Other bears show little or no curiosity, accepting their strangly marked companion with a casual sniff. Making a debut as a free-roaming electronic instrument of science is, however, ~~another matter~~ not a casual affair. It is quite an experience for bear and scientist alike, and begins when the tailgate of a culvert trap slams shut behind a hungry grizzly. Or it can start when a small propulsive drug-laden syringe fired from a gun strikes a free-roaming animal as it feeds on a bait. The impact of the dart may pass unnoticed or the bear may depart in haste. In either case, the drug soon takes effect. With the nerve impulses to its skeletal muscles blocked, the bear becomes temporarily paralyzed. In five years, we have immobilized 164 individual grizzly bears, some a number of times. Yet we can still vividly recall ~~our experience~~ immobilizing of instrumenting No. 40 because this was another first in a procedure now routine.

Number 40 was trapped the night of September 21, 1962. The next morning we immobilized her. The drug, succinylcholine chloride, that Maurice administered would keep her inert for about 15 minutes. But our first attempt to put a radio on a bear would require nearly ~~three and a half hours~~ an hour. In retrospect ~~those~~ that hour seemed a part of the present. I could recall Maurice saying, "I think she's coming out of it." "O.K., the anesthesia is ready," and with this remark John knelt over No. 40 and injected pentobarbital sodium ~~directly into the lungs~~. The bear coughed and in 10 minutes was fully anesthetized. The ~~routine~~ systematic procedures we used on all bears were quickly applied. Number 40 was first weighed. She, having tipped the scales at 340 lbs, had gained 60 pounds since she had been initially captured in a previous year. Her colored ear markers and numbered ear tags were checked. "The left ear marker missing", called Maurice. Total length 65 inches, neck circumference 28 inches, general condition excellent, age four years. Harry Reynolds and Mike Stephen, other members of our team helped to take dental casts and a blood sample.

The previous night we had worked late completing the radio collar. The battery pack had been dipped in plastic rubber to waterproof it. The 2 oz. transmitter, 14 oz. 7-cell battery pack and a section of the loop antenna were wrapped in fiberglass cloth and coated with resin. The battery terminal was soldered and then coated with orthodontic acrylic. The entire assembly was then sanded, ~~taped~~, and color-coded with Krylon paint. The brightly colored collar that John handed me as I knelt by grizzly No. 40 weighed about 2 lbs. and was as waterproof, shockproof, and bearproof as we could make it. Harry voiced the skepticism we all felt, "Do you think a grizzly will keep that thing on?" We had gambled time, money, and two years of work that this powerful carnivore would in fact tolerate a collar. There was no need to speculate further; we would have our answer soon. I fitted the loop snugly around the bear's neck, cut the antenna to proper size, and bolted it

securely. I glanced at the field strength indicator. The needle moved in short rhythmic strokes. Shortening the antenna had slightly altered the signal strength. I called to Mike "Let's doublecheck the ~~indicator~~ signal strength with the directional receiver."

The Count-down

Mike carried the receiver a half mile up the valley and communicated back to us by walkie-talkie that he could barely hear a faint signal. Prior to instrumenting we had received a strong signal at a half mile. I adjusted the antenna-tuning capacitor. John, Maurice, and I eyed the needle on the field strength indicator. The needle moved over a short arc and fluctuated. We needed a long arc indicating a strong steady pulse. Mike called in, "Audio signal still weak." We rechecked everything. The acrylic sealing the battery terminal was still wet - perhaps there was a short. We waited for it to harden. Snow was beginning to cover the ground and the wind was sharp. Number 40's respiration rate had more than doubled. She would soon come out of the anesthesia. We worked desperately to find the source of trouble. I had visions of her getting up with our work incomplete. Mike called in, "It's colder than hell out here, what's holding things up?" Maurice ignored the query. "How is the signal now?" "No good", came in loud and clear. The grizzly raised her head. "We'll have to give it up," John said. We all knew the signs; we had experienced our share of close calls from arousing grizzlies. We withdrew in a quick but orderly retreat. Number 40 got unsteadily to her feet. What had gone wrong? As our experimental animal headed south for the nearest timber, Mike's voice boomed in on the walkie talkie. "You've got it now, the signal's great!" With No. 40 lying on her side, signal transmission had been poor; up and moving, signal strength had improved. All through the evening the beep told us where No. 40 was in the

Insert A - P7

Vital Statistics

Prior to this breakthrough we had lived intimately with the Yellowstone grizzlies from spring until fall. We were accumulating population statistics--the hows and whys of bear demography. By marking and then observing and recapturing individual grizzlies we had learned the age structure of the population. For instance, we now know that over a period of time, 20 per cent of the 200 grizzlies in Yellowstone will be cubs, 11 per cent yearlings, 7 per cent 2-year olds, 14 per cent four and five year olds, with adults constituting 47 per cent of the total. In grizzly society there is no problem of boy meeting girl with a sex ratio of one to one. However, only about one-third of the adult sows are candidates for motherhood each year. The average crop of 34 cubs produced annually is fathered by a few large aggressive boars. Polygamy is the rule, monogamy the rare execption. Fathers play no role in the family life and are difficult to identify as fathers, both sexes being promiscuous.

The average litter size over a five year period has been 2.2 cubs per mother with a maximum yearly average of 2.5. The largest litter we have recorded is four, with triplets occurring frequently. The

annual increase in the bear population from cubs born each year has averaged about 20 per cent of the total population. The annual death rate in the population has also been about 20 per cent. With births annually equalling deaths, the grizzly population has been holding its own. The greatest mortality occurs among cubs. Only about 50 per cent of the cubs attaining the age of nine months survive until they ~~have~~ are one and one-half years old. The causes of these early deaths are still unknown. As in all animal populations, the young are vulnerable. Many grizzlies do not live two years. With this and much additional information now in the files, we can construct actuarial tables for bears--determine the mean life span, mortality by age classes, and expectation of further life. The grizzly as a species needs a life insurance policy and we can now write it with a high degree of confidence in our data.

From these vital statistics will evolve a management program that will keep the grizzly from the verge of extinction.

swirling snow storms around us and where she was for the next full month. We were launched on a program that would give us new information on grizzly bear movements, size of summer ranges, food habits, and habitat preferences. We would soon be able to compare the diurnal and nocturnal activity of grizzlies and add greatly to our knowledge of behavior patterns, bear-man relationships and pre- and post-"hibernation" activity.

The use of radio as a data-gathering tool is enabling us to gather information from a distance of many miles with a minimum of time, effort, and manpower, and to intercept at will certain animals at predetermined positions in time and space, thus tremendously expanding the range and scope of our observational powers.

INSERT A

Prior to this breakthrough we had lived intimately with the Yellowstone grizzlies from spring until fall. (GET SUMMARY SHEET AND 1965 QUARTERLY)

The Spring Debut

With the coming of the vernal equinox, the sun gradually warms the high Yellowstone country, and triggers a new surge of energy and activity in the bio-mass. The grizzlies begin to stir, no longer sleeping so soundly. In grizzly society the adult boars and sows with yearlings and two-year-olds are the first to greet the spring, traveling for miles over the still deep but rapidly melting snow. Then from snug winter quarters mothers emerge with tiny cubs born in January. Sows with playful yearlings at their sides make snow tracks telling of wrestling matches and playful tussles. The "deep sleep" of winter is over.

For a time the bears wander, forage, and rest in the general vicinity of their winter quarters. They pounce on field mice exposed by the receding snow, seek the sedge meadows for tender emerging shoots, dig the soft

soil of the drier meadows and mountain slopes for bulbs of the early-blooming spring beauty, or graze the clovers and other "greens". An ancient bison or an elk that has succumbed to the rigors of winter will attract and hold them until the frozen flesh is gone and the converging tracks in the snow are replaced by the emerging greenery of spring.

But sooner or later most of the grizzlies inhabiting Yellowstone and surrounding country start to move or migrate toward the high central portions of the park - into the open and lush meadows of Hayden Valley and Pelican Creek. Some move north from the distant shores of Jackson Lake in Teton National Park and the Thoroughfare country of the Teton Wilderness. Others come from the high jagged country to the northeast surrounding Cooke City, Montana, or from the Gallatin big game country to the west. This general movement and concentrating of grizzlies is definitely influenced by food supply, The buildup is well advanced in June and early July when the grizzlies are mating.

Both the abundance of succulent plants and plant tubers as well as tasty exotic morsels from garbage dumps.

Top of the Social Set

This temporary summer increase in number of bears per unit of area, results in some interesting behavior. Over the years a social structure or hierarchy has developed which serves to diminish competition. Each bear, from the powerful aggressive male that dominates the grizzly society, down to the insecure orphaned cub or yearling, finds his place in the social organization. Aggressive behavior or assertion of dominance determines the individual's position. Relative positions change from year to year. Sows with cubs are more aggressive than barren ones. Each year approximately a third of the sows have cubs, and so these animals ~~obtain~~ attain a temporarily higher social status. They defer only to the large aggressive males.

~~When we began our study~~ In 1959, the dominant bear in the Hayden Valley area was Old Scarface, a veteran of numerous battles. At this time

he was slipping from top place in the social hierarchy, as indicated by his deferring to Cutlip - an obvious challenger to his position, But also an old bear. Cutlip's reign was short, just a week. When confronted by a younger, slightly smaller bear, he attempted to bluff; when this failed he retreated on the run from his tough aggressive newcomer. Old Scarface, however, elected to fight the new challenger. He moved in on him stiff-legged, head lowered as he had challenged other contenders so many times in the past. The fight was short and furious but Scarface went down in defeat. Respect and deference was immediately transferred to the new champion that we named Inge and later designated as Number 12 when we captured and marked him. After this demotion Scarface was never seen again and presumably died. Cutlip in turn, disappeared after 1961.

Number 12 clearly dominated the Trout Creek population for the next three years. However, his reign was not without crises. In early June of 1962, No. 12's once dark shiny coat was matted and dull; he moved like an enfeebled animal, his vigor and strength gone. The transformation was startling. What could have happened over winter to this champion?

Might is Right

When he lost a fight to Whitespot, a large but less aggressive male, we wondered if he would survive the coming winter? However, prior to hibernation he had regained his strength and with it his confidence and vigor. The following spring he emerged in good shape and during the summer he bested all competitors to regain the dominant position for yet another year.

The first encounter was with Short-Ear, a powerful boar. Inge had a lady friend at the time but so too did his rival. Head lowered he moved slowly and deliberately toward Short-Ear. Short-Ear retreated on the run with Inge in close pursuit. The two sows were left

without escorts. Short-Ear finally stood his ground and Inge seized him by the throat, rotated half around throwing his 750 pound adversary to the ground. The downed bear quickly regained his feet; the two antagonists locked jaws and cuffed one another with powerful blows. Inge was on the attack; Short-Ear fought a defensive battle, finally turned tail again and ran for a half mile. Inge pursued, then tired of the chase and returned to his lady friend and they disappeared over the hill, leaving Short-Ear's sow alone and deserted on the field of combat.

Two days later Inge pursued No. 88, sinking his canines deep into the rump of this contender. No. 88 stopped short and Inge's momentum carried him over his opponent breaking him to the ground. He seized his adversary's right thigh as he lay sprawled on his side and shook this 700 pounder like a terrier shakes a rat. Eight-eight broke away and his huge jaws clamped on Inge's jowls. Inge roared, reared back rising to his full height and in turn fought free. A great red gash marred the side of his face. The two stood on hind legs face to face, jaws wide apart parrying like monstrous boxers. They locked jaws, each levering to throw the other to the ground. Eight-eight maneuvered to the left trying to gain the advantage of some high sloping ground. Inge headed him off and slapped his adversary across the shoulder with a lightning-fast swipe from his right paw, then lunged for his throat. No. 88 staggered back and to one side from the blow but rose to full height as Inge came ~~at his throat.~~ on. The two stood exchanging bites and blows emitting growls and roars that could be heard a half mile away. Both dropped to all fours eyeing one another warily but Eighty-eight did not retreat. Inge then deliberately turned his back moving aside to claim his sow, No. 65. His adversary did not take advantage of this opportunity signifying the contest was over. Neither contestant appeared to be seriously injured, but both showed the scars of battle and Number 88 backed slowly away - a concession of defeat in bear society.

Is This Fight Necessary

We observed only a few of Inge's fights but perhaps the most crucial encounter came at the end of the 1963 breeding season when whitespot ~~Scarneck~~, a huge boar with a light spot on his neck and who had bested Inge at the close of the previous season, made his first seasonal appearance in the valley. It was mid July and the urge to fight was diminishing. Yet when these two old competitors met it was apparent that they would have to fight or in the way of bears acknowledge one another's social position. Even from a distance both seemed aware of the other's presence.

Inge roused himself from a nap and put a close competitor, Short-Ear, to flight. whitespot ~~Scarneck~~ walked stiff-legged toward a large dark boar, then quickened his pace and chased him away. This cleared the field of all but the two dominant personalities. With head lowered Inge now moved toward whitespot ~~Scarneck~~ but slowly as though reluctant to close with him. whitespot ~~Scarneck~~ appeared equally reticent and even strolled to one side perhaps looking for a way out. Inge, however, doggedly closed the distance. Both seemed to ignore the other yet each was very much aware of the other's presence. The intervening distance narrowed 100 feet, 75, then 50. Tension mounted as the distance closed. With the two bears face to face, whitespot ~~Scarneck~~ turned and moved slowly and majestically to one side, thus acknowledging Inge's superiority.

Inge continued on his course, by-passing him without even a turn of the head and making no attempt to give chase or further test his victory. It appeared to us that these two powerful grizzlies respected one another, having clashed in combat at other times and places. Had they met at the height of the mating season, however, they would no doubt have fought. This was the last challenge to Inge's dominance in the bear community but another year it might take very little to tip the scales in favor of a

larger more determined challenger. The price of the champion is a more stressful, less serene, perhaps shorter life.

Your Number Please

Following our first 1959 season of study, some 30 of the grizzlies that moved into Hayden Valley in the spring wore the small colored ear markers we had inserted the previous summer. By the fall of 1961 another 47 were sporting these markers, increasing by 45 in 1962 and totaling 164 by the time the snows arrived in 1963. Each marker was color-coded to identify an individual bear. Some bears became old acquaintances or had unusual character traits and we naturally gave them names as well as numbers to differentiate them more readily from the less distinguished personalities in the population. Each spring as the bears emerged from the deep sleep we had to check their color markings and get reacquainted, record what sows had become mothers over winter, which ones had returned with yearlings and which ones were candidates for motherhood next spring.

Early in 1960 grizzly sow No. 7, with her three yearlings, No. 6 and No. 51, and one unmarked littermate were observed grazing in a small meadow near Norris Junction. The sow's green markers were in good condition and unmistakeably identified her. She and her family, which we designated as Family-Number 2, were observed in the routines of a grizzly's life. Gradually they moved east until they eventually arrived in Hayden Valley some 17 miles distant as the raven flies. Cub No. 6 arrived with her. She was of special interest as the first cub we had captured and marked. Thus, she came to be known as the "First Cub." In 1962 she was observed breeding as a three-year-old but had no offspring the following year. She thus furnished us with factual information on breeding age and we anticipate that she ~~will~~ may appear with a litter of cubs in 1964. In the meantime her mother, No. 7, has produced another litter. This second family we have followed closely with the aid of radio transmitters.

Bear No. 1, the first grizzly we had immobilized and marked, did not show up until late in the season when she was recaptured ~~near Old Faithful.~~ in the vicinity of Firehole River. Grizzly No. 2 spent the summer in the area where initially captured. No. 5 had either been orphaned or weaned as an early yearling when we marked her in 1959. We named her "Lonesome." Soon after we marked her, she was adopted by a female with only one cub. Presumably, she also hibernated with her. At any rate, she reappeared in 1960 with her stepmother and yearling playmate. This was the first of numerous observations we were to make on the adoption of orphan cubs by sows with families of their own.

One by one, other marked families or marked individuals showed up during the course of the summer. We came to know the Grizzled sow and the Rip-nose sow, both with litters of three cubs. Cutlip, Inge, and other big boars moved back to the valley. ~~Fathers play no role in the family life and are difficult to identify as fathers for both sexes are promiscuous.~~ Along with the new families came a mother and her yearlings - a family of bears we had not marked the previous summer. We trapped the mother and one yearling and shot and immobilized the other with a drug-filled dart. This latter bear became No. 37, the littermate, No. 38, and the mother, No. 39. In a single day we had added another completely marked family to our growing list. It bore the unlucky number 13; the family was short-lived but in some respects unique.

A Family Tree

No. 37 was destined to make grizzly history as one of the first bears to be studied by radio. A closer look at this family and its members will show how we study the grizzly population in Yellowstone. On July 3 the mother weaned her yearlings and from that time they were on their own. Mother and yearlings usually travel, feed, and sleep together throughout the second summer, but No. 37 and his brother were not to know so secure a

family life. However, they had each other and they remained inseparable during 1960 for mutual protection and moral support.

In June when initially captured, they were yearlings weighing within five pounds of one another - 145 and 140 pounds respectively. When No. 37 was retrapped late in August of the same summer he had gained exactly 100 pounds in a period of 54 days. ~~This was a 59 per cent increase over his June 29 weight.~~ Before releasing him we put a self-adjusting braided rope collar around his neck, ~~This~~ containing a mock-up radio transmitter. The purpose of this experiment was to see if a collar might more suitable ~~way~~ for ~~of~~ eventually attaching a radio to a grizzly bear. ~~We got an~~ The answer came about a year later when we retrapped No. 37, still wearing the collar, ~~and~~ in good condition, ~~and he had~~ apparently he had made no serious effort to remove it. On September 12, 1961, we again retrapped this bear instrumenting him at that time with a radio transmitter built by Philco's Western Development Laboratories. We had put our first such radio on No. 40 a week earlier and thus No. 37 became the second grizzly to be instrumented. Somehow he became known as Beep.

In the meantime both he and his brother were providing us with some interesting information as they grew and developed. As a "long" yearling Beep weighed 245 pounds before going into hibernation and may have reached a high of 275, but by June 27th of his second year he had reduced to a slim 215 pounds, losing weight during the spring months as most bears do. In less than three summer months he had increased to 315 lbs. and a year later he tipped the scales at 440 lbs. as a three-year-old. This is more than ~~100~~ 150 lbs. over the average fall weight we have so far determined for male ~~four~~ three year-olds. Though both Beep and his brother, No. 38, weighed the same as yearlings, there was a hundred pounds difference between them as fall two-

year-olds - illustrating the tremendous variability in growth rate that can occur in young bears.

We retrapped No. 38 and transported him across Yellowstone Lake leaving him on Promontory Point. Three days later he was back at Pelican Creek, taking a circuitous shoreline trek covering 31 miles. Late in the fall of 1961 Beep was captured south of West Thumb and released 40 airline miles to the north near Crystal Creek.

The next spring we saw him back near West Thumb and from here he wandered over to the Old Faithful area where we again retrapped him. This time we instrumented him with a radio for the second time and began tracking him even more closely. The natural and induced movements of No. 37 and many other marked grizzlies have shown us that grizzlies may travel airline distances of 25 to 60 miles over mountainous terrain. Their daily movements may exceed 15 miles, and some have traveled as far as 35 miles over extremely rugged terrain in less than two days. These wanderings take the grizzlies into the hinterland of Yellowstone and beyond the protection of the Park boundaries. ~~These movements influence the grizzly population in a number of ways.~~

Holding Their Own

For example, the legal shooting of Yellowstone grizzlies by hunters outside the Park boundaries accounts for 42 per cent of the bear deaths. Both Beep and his brother, No. 38, met death in this manner. In the fall of 1961, while foraging for food in the high country around Cooke City, Montana, No. 38 was dropped by a hunter's gun. Number 37 was shot in Teton Forest south of Yellowstone. The cubs produced each year constitute an average 20 per cent annual increase in the population. However this increase is offset by about the same number of deaths each year among the older bears . They die from

numerous causes including hunting. The Yellowstone population, therefore, is not decreasing nor is it "exploding"; numbers have been stable, the population holding its own.

Hunting grizzlies adjacent to the Park is keeping their numbers within the limits that Yellowstone Park can support. However, a temporary reduction in hunting outside the Park would enable the grizzly populations to increase in the surrounding forested areas. Grizzlies currently emigrating from Yellowstone are killed about as fast as they leave the protected area.

The type of information provided by family No. 13 when added to that obtained from forty-one marked other families, as well as 164 individuals, is resulting in a quantity of information that can be averaged and analyzed. From such data generalities are deduced. Thus the life and death story and the trials and tribulations of an entire grizzly population is unfolding.

A Chorus of Beeps

By the summer of 1963 the radiotracking system was complete. Our laboratory at Canyon had become our Base Station equipped with receivers and a motor-driven five-element antenna with direction indicator. From the laboratory we monitored the instrumented grizzlies day and night, regularly picking up their signals 10 to 12 miles away. Under favorable conditions the big antenna pulled in signals from a distance of 20 miles. Supplementing this was a three-element antenna comprising our hilltop Field Station 8 miles to the south in Hayden Valley, and also two radio-equipped vehicles or mobile tracking units. With the mobile tracking units, we located and followed grizzlies that wandered to distant parts of the Park. Our three portable tracking receivers with loop antennas weighed only 2½ lbs. apiece. With them we picked up the radio signals from

↑ after Philco's engineer Joel Varney had perfected them.

Insert B -P-17

On one such occasion, Joel, Maurice and I jumped number 40 from her daytime bed in dense timber when only 40 feet away. A more aggressive grizzly would almost surely have charged but ~~Marion, the~~ this barren sow, even more surprised than we, ~~did not. After her first short~~ sprint ~~she turned~~ ed away, then ~~and~~ stopped & looked manacingly back. For nearly a minute she kept us motionless and in suspense while apparently deciding whether to defend her daytime retreat or move off. Shortly after her dark form had disappeared in the still darker timber, the wilderness silence was broken by a voice over our walkie talkie communication system. Hoke Franciscus, tracking his first grizzly from our field station, came in quietly with volume low. "There's a change in the signal. I believe the grizzly is moving."

"Ten-four," we whispered back. "You're telling us! We just stepped on her. She's heading your way."

Then several minutes later, with ~~our~~ the grizzly's signal diminishing in loudness, came another message from Hoke definitely in a relieved tone of voice. ~~definitely in a relieved tone of voice.~~ "Grizzly sighted, moving away to the east. ~~at right angle to my position. apparently quite rapidly.~~ Signal improving, signal good."

grizzlies 3 to 4 miles away and followed the pulsed signals on foot until we either sighted or jumped them, usually at distances under 100 yards. The waterproof, shockproof transmitters we hung on the bears sent out differently pulsed signals which served to identify each instrumented grizzly.

The inevitable day arrived when we first simultaneously monitored the signals from a number of instrumented grizzlies - No. 40, the barren sow, at 74 pulses per minute; Pegleg, No. 76, a roaming boar, at 94 per minute; No. 75, the Belligerent Sow, at 62 pulses per minute, and No. 7, the Sour Creek Sow, at the slow rate of 50 per minute. The simultaneous reception of all four signals sounded like a spring chorus of tree frogs, an agglomeration of sound that at first seemed to defy orderly separation. However, by tuning the receiver and rotating the antenna to the point of maximum signal reception, the individual signals were isolated, the pulses counted, and the general direction of each bear determined. Bearings from other locations and other receivers were then obtained and the intersections plotted on maps. The intersections pinpointed the position of each grizzly bear.

A signal periodically varying in loudness or strength informed us that a grizzly was active and moving about. A signal of constant loudness, especially during daylight hours, often indicated a resting or sleeping bear. An intermittent signal usually denoted that a grizzly was active, frequently traveling, and had placed a barrier such as a ridge, hill, or dense timber between itself and our receivers. For example, the daily activity pattern of No. 40 included eating and sleeping habits that were quite regular. After determining this by radiotracking and visual

observation, we could then infer certain things in the daily life of this bear from the character of the signals we received.

No. 40 frequented a daytime retreat in a dense lodgepole forest. Her bed was a foot-deep excavation in a low swale among the pines nine miles from Base. It was her practice to "curl up" in bed with her entire body below the ground level. Resting in this manner, the signal emanating from her collar antenna came in loud and clear on our Base receivers only when she raised her head. When she lowered it, the shielding effect of the ground at this distance was sufficient to prevent signal reception. The radio told us that No. 40 regularly began feeding about 5 P.M. and foraged most of the night, returning to her bed by 6 or 7 A.M. After lying down she normally raised and lowered her head a number of times getting comfortable in bed. The signal at this time became erratic but then disappeared altogether as she dropped her head to doze. Throughout the day No. 40's signal appeared or disappeared depending on whether the grizzly slept with her head low, raised it to look around or stood up to move about. In this way, information on position, behavior and animal movement was gathered, verified visually, and then monitored daily from a distance.

Getting the Jump on a Grizzly

In addition to this, the radiotracking technique was unique in that an observer was not present to influence the actions or behavior of the subject except at times when we "moved in" to verify what the beeping radio signal told us. Still another advantage was our ability to locate and follow the movements of the grizzlies at night when they are most active, a feat that had hitherto been impossible. We were realizing the primary function of our big game tracking system which was to extend the

range and scope of the field biologists' observational powers as well as to reduce the logistic problems and output of human energy that have always been limiting factors in studies of this kind.

Prior to the development of this research tool, the grizzly bears in Yellowstone roaming over ~~15,000 square miles of~~ rough country, 85 to 90 percent wooded, had all the advantages when it came to evading man. Now we have turned the tables. We can arrange to rendezvous with a grizzly, we alone being aware of the other's presence and location. Let's re-enact a day of tracking grizzly No. 150 and her three cubs.

On October 6 we routinely instrumented this bear, then monitored her signal day and night until November 3. On October 10 the radio signal became weak and erratic. We decided to investigate. From the hilltop Field Station we obtained a loud clear signal with our portable receivers at 275 degrees. We left the hilltop, striking off toward the signal source and the intersection of our bearings. With the help of landmarks we followed our course, checking occasionally with our directional receivers and compass. We knew our exact location ~~when we reached~~ on the top of hill 8020, on our topographic map, ~~so~~ turned on the directional receiver, picked up the pulsed signal, rotated the loop antenna to the null point where the signal disappeared and took a bearing with our compass, then proceeded on.

By 1:15 we had splashed through the warm algae-laden water of Alum Creek and from a ridge to the north we saw four grizzlies feeding at the edge of timber a mile away. Our scope brought them close enough to see that they were grazing and that they were not the family we were seeking. By 2:30 P.M. it was evident that we were closing in on the instrumented grizzly and her cubs. The signal ~~peak~~ was ~~strong~~.

I regularly rotated the receiver to get the direction of maximum signal and null. The loop pointed to the timber ahead of us. [redacted] and I

entered it with our faces into the wind following the "null". We moved slowly, alert to sounds and movements, expecting to see the grizzly at any moment. At 2:40 P.M. with the volume turned down the signal "boomed in," a sure indication that the hunted animal was quite close, probably within a hundred yards judging from previous experiences of this kind. I peered ahead through the timber and cautioned John that there were no trees that could be readily climbed. I thought the beeping signal sounded inordinately loud in the silence of the lodgepole forest.

Too Close for Comfort

Then I saw our quarry in the dark shade to my right, back light shining through her guardhairs silhouetting her upper body and emphasizing the raised hairs on her hump. Both John and I saw the grizzly an instant before she saw us or at least before she identified us as men. I glimpsed the bright colored collar as she turned her head, and caught the slight movement of John's rising gun. The air was still, so she did not scent us. She was unaware of our presence carrying no scent to her.

We both "froze"; she took a long intent look, then turned giving her alarm wuff to her cubs as she retreated. Fortunately, we had not moved between the sow and her cubs or her ears would have dropped and the pattern of activity would have been quite different. When it was safe to move, I paced off the jumping distance at 140 feet. The airline distance we had tracked her since leaving the hilltop station was three miles. We had probably travelled four on the ground. OVER

A Grizzly Shangri La

This land of thermal activity, geysers and hot flowing streams turned out to be a "pre-hibernation" foraging area and retreat of this family. It was the nucleus of Number 150's summer range which through radiotracking we were to find embraced an area of about 27 square miles in the Alum Creek drainage of Hayden Valley. It was a strangely beautiful

From the base of a lodgepole pine, we watched this family steal the winter meat cache of a red squirrel, and bathe in the nearby stream. The cubs frolicked around their mother who lay relaxed with her huge head resting on her forepaws. Wrestling matches were interspersed with trips to the snack bar. Mother would come to a sitting posture then slowly recline on her back with all four feet in the air. ~~while the cubs nuzzled~~ The cubs would nuzzle in a "laughbone" manner that only a doting grizzly sow could tolerate. When grizzly cubs nurse they make a ~~loud~~ buzzing ~~sound~~ noise that sounds like a muffled jack-hammer in action. This particular meal ended when the sow abruptly rose & gently swatted one cub that failed to leave the chow line. The sow grazed the succulent meadow vegetation while the cubs curled up together and took a nap. A passing raven dipped in flight as ~~he~~ it passed over the family and a coyote scolded them briefly from a nearby ~~ra~~ knoll. The afternoon passed in feeding, playing & sleeping until a large boar came out of the timber. The sow rose to her full height more in the wind. The three cubs stood on their hind legs ~~beside her~~ trying to peer over the tall meadow grass. A tranquil scene ~~that suddenly~~ had suddenly ~~became charged with~~ been transformed to a panorama of action. The sow whirled half around and bounded across the stream like a giant ~~ferret~~ ferret; the cubs rising & dropping like puppets on a string. On the far side of the meadow all four rose on hind legs again to sniff the air; then retreated to the timber. The boar, unaware of the commotion he had created, shuffled to the stream & drank. We retreated upwind the radio signal beeping ~~once~~ on the hair of 150 # her cubs as they moved toward the warm waters of Adam Creek.

home, that in morning and evening was transformed by air temperature changes into a fantastic valley spewing fog-like plumes of water vapor. ~~In late afternoon~~ On one occasion the rising columns of vapor ~~to the west~~ were silhouetted snow-white against pine timber or the dark shadows of ~~the~~ bluffs, ~~while to the east~~ In another they were pierced by shafts of the rising or setting sun transforming them to pillars of gold. The winding course of the stream was marked by a clinging ominous layer of mist from which emanated occasional guttural rumblings from subterranean discharges of water. Such was the home of ~~150~~ 150, a place that was in time to become almost as familiar to us as it was to this Alum Creek sow and her three cubs.

Moving ~~back down~~ across the upper valley we met three grizzlies at rather close range - a large sow and two yearlings. I dropped to one knee behind a lodge-pole and with binoculars trembling from my excitement tried to identify the colored tag in the ear of the leading yearling 150 feet away. ~~but~~ Almost immediately I gave it up as the bears disappeared behind a log still moving toward us. The sow emerged to see ~~Mike~~ John reach for the comforting feel of some low branches. There was a split second of suspense as she eyed us then turned and ran away with that incredible speed that could have brought her upon us in a charge. Her nervous huff, huff, huff was both an alarm call to her yearlings and a warning to us. When it was safe to move, I paced off the jumping distance at 140 feet.

The family had been grazing the autumn growth of white clover in soil warmed by thermal activity. Signs left by elk and Canada geese told us that the grizzlies had no grazing monopoly in this hothouse garden. A check with our receiver here showed that No. 150 and her cubs were circling toward us and might soon break through the timber into this lush pasture to feed. We moved on and came across five grizzlies around an elk carcass ~~surrounded by five grizzlies~~ - an old bull, perhaps gored in a mating battle with a younger more vigorous

opponent and then pulled down by the bears. We had found others that had met a similar fate during the rutting season.

From a distance we watched the bears pull and tear at the carcass. Three of these were beautifully marked grizzly cubs. One was coal black with a broad white collar that completely encircled his neck. His mother, sow No. 48 had been captured and marked. With her was an orphan cub that belonged to a deceased grizzly. This information was of particular interest because No. 48 had in previous years abandoned two different litters of her own cubs. Now she not only was being a good mother to her own offspring but was caring for the orphan cub she had adopted earlier in the year. This sow had been a notable exception, for motherly care and maternal affection is characteristic of these animals. What had brought about the change in her character and behavior? These observations might give us a clue, at least they posed the question. With the approach of darkness we moved on to our afternoon starting point at the Hilltop Station.

We had been tracking five and a quarter hours covering eight and a half miles of Yellowstone wilderness. In tracking one instrumented grizzly we had actually tracked and observed four if we include the cubs of No. 150. We had seen nine other grizzlies, two of them identified by ear tags and had learned facts of interest about their feeding habits and family relations hips. A single day of radiotracking had directly or indirectly informed us about thirteen different grizzlies.

Before leaving the hilltop, the signal told us that the Alum Creek sow had returned to the area where we had ~~just~~ recently viewed her. Back at base the signal revealed that she remained there all night and close by for nearly a month thereafter. As winter approached, she and her cubs inhabited their Shangri La of ~~about one~~ a few square mile[3] obtaining all subsistence in this wilderness retreat until they went into the deep sleep of winter. This gave us our first real clue concerning how much foraging territory a grizzly family needs. Carrying capacity, as this is termed, has always been difficult for biologists to compute.

Where do they sleep?

Each fall the grizzlies had frustrated all attempts to follow them to their hibernation sites by travelling rapidly and far in falling snow apparently to pre-selected winter sleeping quarters. We were quite certain that snow storms triggered the urge to hibernate, but we had witnessed no pre-hibernation preparations or activity prior to the final storms which might have alerted us. We had trailed them through the snow in the heavy timber only to lose the tracks in the open meadows where the full force of the blizzards fused land and sky. What did they do? Where did they go? In the fall of 1963 these questions were still unanswered.

One objective of developing a radiotracking system was to find this out by tracking a grizzly bear to its hibernation den. In 1961 and 1962 our radiotracking equipment and techniques had not been sufficiently perfected and we lost track of our instrumented bears in the final "triggering" storms when they took off cross country for distant destinations.

By late fall of 1963 the Alum Creek Sow remained our sole hope of locating a grizzly's hibernation site. Peg Leg, No. 76, had evaded our electronic surveillance by travelling rapidly into the rugged mountains and canyons of the northeastern parts of the Park. The signal from the Sour Creek Sow and others had faded as the battery power declined. This was expected. The transmitters had performed their mission of informing us about the summer movements and ranges of these animals. Only No. 150, the Alum Creek Sow, and her cubs were still being continuously monitored.

Improving the odds

But now, as John said, "We must instrument at least one more grizzly to increase our odds for success". Light snows had already fallen and temperatures were dropping. The grizzlies had dispersed throughout the Park, some traveling beyond its borders. Capturing and instrumenting a grizzly had become exceedingly difficult, but in the closing days of October we succeeded in capturing No. 164 whose newly acquired transmitter pulsed at 62 beeps per minute.

Our expectations rose even though No. 164 was located across the Trout Creek divide from No. 150 and continuous tracking of both bears would be difficult. For awhile we kept radio contact then lost her. Our ~~skeleton~~ tracking crew was reduced to three forcing us to concentrate our efforts on No. 150. We continued to monitor her around the clock; our interest quickening when she left Upper Alum Creek where she and her cubs had been for nearly a month. We followed her on foot with the portable receivers. She was moving steadily southward. Surely, we thought, this change in routine of the past weeks presaged a trip to her winter quarters.

With darkness we returned to base and continued to track her from afar. The cubs now big, fat and sporting slick heavy fur coats alternately scampered ahead then trailed behind adjusting their restless energy to their mother's methodical gait. By morning she had stopped moving. Throughout the afternoon and night of November 3 and on into the early hours of November 4 we fought off sleep and continued to monitor a signal from base. With no indication of further movement we took to the field again to investigate.

In late afternoon we had trudged close enough through falling snow to pick up the signal with our portable receiver and obtain an accurate fix - a pencilled X on our topographic map. The grizzly was in a heavily timbered area 12 miles from our Base Station and remained there throughout the night. Around 9:00 A.M. the next day, November 5, the loud clear signal periodically faded and by 9:50 A.M. became quite faint then at 10:15 A.M. disappeared. Our interpretation of these signals - the grizzly was either moving in and out of some kind of shelter such as windfall or cave that attenuated the signal or she was moving away and to the south in the storm.

Maurice, ~~Charlie~~ and I headed into the storm to make visual contact. Our tracking gear, firearms and backpacks had been readied for this occasion so our departure had been rapid. We followed a faint signal on our portable

receivers. Our destination was the radio fix, the pencilled X deep in the Yellowstone wilderness. This was the last known position of our grizzly and as the signal now revealed she was evidently still there. In late morning the storm and jackstraw piles of windfelled trees so slowed our progress that we despaired of ever sighting her. Fortunately, she was not travelling and after a brief halt for lunch our excitement increased as we realized that we were fast closing the distance. Soon the signal was coming in so loud that we had to turn down the receiver volume. We now not only followed our signal but looked for footprints and signs in the snow that would warn us of the grizzly's presence. We stopped often to listen and to peer ahead through the dense pines.

A Moment of Confusion

At one of these stops I automatically counted the signal pulses per minute. Amazement and disbelief engulfed me. Maurice sensing something wrong asked "What's happened?" "It can't be! Impossible!" I exclaimed, suddenly realizing that the signal we had monitored over the last month and had counted and recorded recently as 92 per minute was now thumping in at 62 pulses a minute from a grizzly just ahead of us.

"It's not 150", I said, "The pulse rate is too slow." "It must be," said Maurice. "Perhaps the batteries are spent,". "No," I answered, "The signal is unusually strong. Even if it were weak the variation in pulse rate would be almost undetectable." I counted again, "It's No. 164!" We were closing in on an instrumented bear but not the one we had expected. It was the sow we had instrumented across the mountain and then lost. Where then was the Alum Creek sow and her family of cubs? She had been close by here only a day or so ago and if still in the area we should be getting two signals. All day there had been only one - hers we assumed. This was not the time to solve the enigma. The grizzly we had radio-tagged to increase our

odds had moved over the Trout Creek divide and was just ahead of us. She, just as well as No. 150, could lead us to a hibernation den. We moved forward ~~through the~~ over unbroken snow cognizant of the fact that we had travelled all day through country recently inhabited by grizzlies without seeing a single track. This indicated to us that ~~the~~ instrumented grizzly was at ~~its~~ den. We were now at the pencilled X on our map - the point from which our signal had been coming since we obtained a fix late in the afternoon of November 2.

We approached and examined every likely den site; yet we did not jump a grizzly nor was there any disturbance in the snow other than our own tracks. The woods were silent except for the signal, no flitting Canada Jays, ~~no~~ scolding ~~Chickadees~~. From the top of ~~a pile of~~ fallen timber I ~~could~~ get ~~no accurate~~ bearing - no null to ~~indicate~~ direction regardless of how I rotated the loop antenna. Was the grizzly directly under me? The same thought struck Maurice and he shifted his feet on the slippery logs so he could swing his gun freely. ~~Charlie had put his receiver in his pack to free his hands and~~ I switched my receiver to my left hand. The grizzly could not be more than 100 to 150 feet away but where? A startled grizzly could cover this distance in seconds - far too fast for us to climb trees. We moved another 20 feet and I examined an opening between the fallen logs.

"There it is", whispered Maurice, and I straightened up with a start half expecting to see a charging grizzly. Maurice was pointing downhill to faint traces of dirt on packed snow fifty feet away. This was the only sign in front of the dark cave opening to suggest ~~that~~ a grizzly was inside, but our signal most certainly confirmed it. We circled to approach at an angle affording better visibility. At twenty feet we photographed the dirt entrance that bore directly back into the hillside ~~and~~ At close range confirmed that tracks led in but not away. With this documentary film evidence we silently ~~moved back~~ to a safer distance. The grizzly sow undoubtedly

knew we were present and had retreated deep in her cave as we approached. "I wonder if she has her yearlings with her", said Maurice. "We can't take a chance on disturbing her now", I said. We all agreed, looking at the big lodgepoles towering upward without a branch for thirty feet.

Our mission was completed; we retreated silently and cautiously but with the thrill of accomplishment.

Radiotracking No. 164 to her den provided us with information we had so far been unable to attain using conventional study methods. It served to dramatically emphasize what we already knew - that bio-telemetry was a valuable and practical ecological research technique.

Perhaps it was symbolic that a huge uniquely three-forked lodgepole pine towered directly above the den opening and would serve as a landmark for returning in mid-winter when 10 feet of snow would greatly alter the character of the landscape. We blazed a 60° departure course to the nearest meadow. The reciprocal 240° bearing would lead us back in February when the bear was asleep; the battery and signal dead, and the air temperature below zero.

In Retrospect

In wilderness country one naturally tends to walk in silence often in a reflective mood. Backtracking the many miles to base I reconstructed the happenings of the past few days. It was clear that some time during the last forty-eight hours we had lost the signal from No. 150, the Alum Creek sow, and had picked up 164's without detecting two signals and without realizing that a switch had occurred. The snow storm had started 164 moving over the mountain to her den area. This was an airline distance of 15 miles and she no doubt covered many more on the ground. She had crossed the divide that had shielded her signal, arriving in the den area by November 3 and remained at or near the cave entrance during the afternoon of the 4th. The lack of tracks indicated she had rested outside the entrance on the night

of the 4th and during all of the following day (5th) thus enabling us to pick up her signal mistaking it for the signal of 150. Not until our approach on the afternoon of the 5th did she enter and remain inside the den. This, I thought, confirmed our theory that the grizzlies move directly to their hibernation dens during snow storms, leaving no tell-tale tracks leading to their winter sleeping chambers.

Maurice whose thoughts were ~~on the same track as~~ running parallel to mine shouted over the rising wind. "These grizzlies must use the same dens or hibernation sites year after year." I concurred in silence thinking that in this respect they were similar to the black bears we had marked and observed. From other instrumented grizzlies we have evidence that offspring from the same mother tend to return to the area of their birth to hibernate.

Hibernation sites, once located, can be visited and their occupants studied year after year. The location of more dens will open new areas for research - studies of hibernation phenomena and telemetering of physiological data from sleeping bears.

Darkness and the storm enveloped us before we reached our vehicle. Snow fell all night and on through the next day. The roads were closing to the south, east and north. There were no more roaming grizzlies, no signals, and no bear tracks - only the deep ruts our vehicles left as we bucked snow out of the Park to plowed highways, to our separate journeys home, and to other work where the summer grizzly bear research was a thing to recall with pleasure and satisfaction while planning the next year's endeavors.

GRIZZLIES II
SCHEDULED: August, 1966
Legends: Frank Sartwell

Frank Craighead

Credit under cut--Kodachrome (c) National Geographic Society

Do we need to qualify and say "ruled the northwest of No. Amer?"

BOLD
Deposed monarch, the grizzly ruled North America as king--until the repeating rifle overcame his size and strength. To help save the bear, the authors conduct a unique study to fill out the blanks in his life history. Hanging radio transmitters on the animals and tracking their movements, they garner new knowledge of grizzly numbers, range, hibernation, breeding, and mortaility. Here naturalists at Castle Geyser in Yellowstone National Park zero in on a rambling transistor.

CORRECT LOCATION?

p. 100

FS:CP:jlw
4/18/66

23 picas 9/10

I'd leave first statement out. It is in text. Once is enough.

BOLD

Slogging through snow toward a bear's den, Craighead researchers follow beeping signals caught by a loop antenna. They hold rifles at ready against the sudden charge of a jumped grizzly. During the seven-year project, backed by the National Geographic Society, no tracker has had to shoot a bear, although some of the men have climbed trees in a hurry. Ingemar, boss bear of Yellowstone's Hayden Valley sprawls from knockout drops shot into him by a drug-loaded rifle. One man plucks out the dart while others struggle to turn Ingemar over and slip the red and yellow radio collar around his huge neck.

(credit p. 103) Kodachromes (c) National Geographic Society

p. 102-103

FS:CP:jlw
4/18/66

10 lines at 16 picas;
5 lines at 9 1/2 picas

BOLD

Station BEAR takes shape in the hands of engineer Joel Varney of the Philco Corporation. Weighing only two ounces, the transmitter can report a grizzly's whereabouts to antennas up to 20 miles distant. At first such a unit had a two-month life but improvements have lengthened it to a full year. Wearing his transmitter, a bear heads for tall timber (below). Team at right pinpoints a grizzly signal with a portable antenna.

Ektachrome (right) and Kodachromes (c) N. G. S.

p. 105

FS:CP:jlw
4/18/66

11 picas 9/10

Kodachromes (c) National Geographic Society

BOLD

Electronics finds the hidden den of No. 40 and her cub, first grizzlies ever radio-tracked to a winter home. Man-shy bears leave no trails to their ~~nests~~ dens as they travel ~~move in only~~ during snowstorms. After the residents left in spring, Frank Craighead returned to measure the den. Roots hold up its ceiling. Often grizzlies line retreats with evergreen boughs to insulate them. Occasionally, an inexperienced yearling digs a faulty hole and dies when the roof caves in under heavy snow.

No record whatsoever by some hunter?

"nests" - O.K. as synonym for "den"?

(?)

comment (?)

FS:CP:hlw
4/18/66

16 picas 9/10

Kodachrome (c) National Geographic Society

O.K. or receivers?

(?)

BOLD

Where the bears are. Radio monitors, fixing grizzly positions, enable the Craigheads to draw exact ranges on their map. Plots outlined in different colors show travels of individual bears. Crosses indicate radio contacts with the animals. Map reveals that some use only a few square miles of Hayden Valley in the center of the park (right); others ramble over as much as 168 square miles, leaving the map on occasion. "In the course of a life time," Frank Craighead says, "some grizzlies may travel over most of Yellowstone country." Bears leaving the protection of the park risk gunfire from hunters.

DESCRIPTIONS + PROCEDURES OK?

BASED ON 1963 FIGURES + MAP

Frank: quote O.K.?

p. 107

FS:CP:jlw
4/18/66

20 picas 9/10

BOLD

Putting away the leftovers, a well-fed grizzly covers the carcass of a winter-killed elk with dirt and grass to thwart scavengers such as the coyote in foreground. Berries, nuts, plant roots, field mice, pocket gophers, fish and snakes also suit the grizzly's palate.

(?) only kill in winter?

Kodachrome by Frank & John Craighead (c) N. G. S.

p. 109

FS :CP:jlw
4/18/66

16 picas 10/16
ragged right
cal bold italic

BOLD

Fearsome jaws gape as John Craighead and Maurice Hornocker rush to take a dental cast of an adult before the drug wears off. Thus they can study the age of a bear by its teeth without having to kill the animal.

p. 110 lower

FS:CP:jlw
4/18/66

14 picas 9/10

takes a blod

BOLD

Eight hundred pounds of muscle and claw, Bruno lies powerless from drugs as the team takes a blood sample. Red collar holds radio that enabled the Craigheads to track him for three months. On the plotting table at the project's headquarters, X marks a bear. To get one line, John Craighead plots a direction bearing from a rotating antenna on the roof of the Yellowstone laboratory; a portable antenna gives the second bearing. Radio collars for bears, hanging above, flank bright plastic markers used to mark elk. Unpredictable as all his relatives, the thrashing cub in a weighing sling at right awakens from the drug too soon ...and angrily protests the indignity.

p. 110-111

FS:CP:jlw
4/18/66

30 picas 9/10

LATER MODEL THAN ORIGINAL 2 MONTH UNITS?
(SEE P 105)

No. 40

BOLD

Unhappy but helpless, Marion growls as Harry Reynolds and Bill Staniger tatoo her number. The drug deprives the sow of the use of muscles but does not make her unconscious. Dental compound on the lips show that she has been tooth-printed.

completely?

p. 111 lower

FS:CP:jlw
4/18/66

14 picas 9/10

Marion? she
zn? = she?
Names of men correctly spelled?
of muscle control?

Ms. p. 2:19 "alerted by scent or sound"

scent

?

BOLD

Infuriated, half-drugged yearling chases John Craighead around his tripod. Eye-

or smell?

? sight affected by the drug, she charges toward sounds and finally "trees" a now-smiling

? John on the hood of a car. Such incidents helped researchers determine how long

various drugs remain effective. Collar of white fur rings the bear's neck.

p. 112- 113

FS:CP:jlw
4/18/66

28 picas 9/10

Kodachromes (c) National Geographic Society

BOLD

Splashing across a creek; four

cubs--a rarity among litters--

hurry to catch up with their

mother. The Craighead study

shows an average of 2.5 young

bears per litter. Born no bigger

than squirrels, cubs stay close

to mother who teaches them all

they know; father plays no part

in the rearing. Barren sows

sometimes adopt orphan cubs. (?)

p. 113

FS:CP:jlw
4/18/66

10 picas 9/10

BOLD

Scouting for danger in a spring-bright meadow, a sow rises to full height. Fewer than half of the cubs born survive as long as 18 months. Average Yellowstone adult lives less than six years.

BOLD

Silver amid sunset gold, a large boar ambles into a future that depends largely on what the project learns of his kind. Greater knowledge of his habits can make for better protection.

p. 114

FS:CP:jlw
4/18/66

22 picas 9/10

GRIZZLIES II credit-p. 115
Ektachrome (above) and Kodachrome (c) N. G. S.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

Trailing Yellowstone's Transistorized Grizzlies

Article & photographs by
FRANK and JOHN CRAIGHEAD

FEARSOME OR FROLICSOME—a grizzly bear can be both. Rage succeeds roguishness in this mighty mammal with alarming suddenness, and, when disturbed, unpredictable *Ursus horribilis* deserves its reputation as the most feared and respected of North American carnivores.

Our own respect for the grizzly took a big leap forward on a sobering occasion when for the first time we, the pursuers, became the pursued!

On a quiet summer afternoon we were following a gruff old sow and her two cubs through forests of dense lodgepole pine in the heart of Yellowstone National Park. Though closing in on our quarry, we were unobserved, for we were tracking the bear family by radio. Earlier, we had immobilized the sow with a "shot"—one of the hypodermic variety, in a dart fired from a gun—and then had instrumented her with a collar transmitter. It broadcast her whereabouts by means of telltale signals that we picked up on portable receivers.

"Beep, beep," came the signal from our directional receiver. Even dips and rises in terrain at the head of Alum Creek did not prevent the radio pulses from reaching us. We knew by the strength of the beeps that we were very close to overtaking the bears.

Deposed monarch, the grizzly ruled the West until the repeating rifle overcame his size and strength. To help save the species, the authors conduct a unique study to fill out the blanks in his life history. Hanging radio transmitters on the animals and tracking their movements, they garner new knowledge of grizzly numbers, movements, hibernation, breeding, mortality, and social behavior. John Craighead (above, left) and Maurice Hornocker test equipment in below-zero temperatures at Castle Geyser in Yellowstone National Park.

GRIZZLIES—August—FINAL FOR RELEASE 1—May 9, 1966

254 **Slogging along an invisible trail,** Craighead researchers follow beeping signals from a broadcasting bear. They carry rifles against an unexpected charge by a grizzly from its den. During the seven-year project, backed by the National Geographic Society, no tracker has had to shoot a bear, although some of the men have climbed trees in a hurry. Ingemar (below), boss bear of Yellowstone's Hayden Valley, sprawls from a knockout drug shot into him with a syringe dart.

Station BEAR takes shape in the hands of engineer Joel Varney of the Philco Corporation. The transmitter, weighing only two ounces, can report a grizzly's whereabouts to antennas up to 20 miles distant. At first such a unit had a two-month life; improvements have lengthened it to a full year. Wearing her transmitter, a bear heads for tall timber (below). Team at right zeros in on a grizzly with portable antenna.

EKTACHROME (RIGHT) AND KODACHROMES © N.G.S.

Early in October we tracked down No. 40 in our first successful radio pursuit. As the "beep, beep" from our portable receivers led us across the grasslands of Hayden Valley (opposite), we kept a sharp eye all around us. Shortsighted grizzlies cannot discern a man much beyond 100 yards, but their senses of smell and hearing are extremely keen. If jumped or startled at close range, grizzlies are just as likely to charge as to run—and curiosity often brings them close. We usually carry defensive firearms, but we have never yet had to use them.

"She should be right over this hill," I said.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

Vacant apartment: Frank Craighead measures a bear's den in summer. Grizzlies usually dig their dens beneath trees so that roots help support the ceilings. The retreats are sometimes lined with evergreen boughs to insulate them.

Shh! Bears sleeping. ~~Prior to~~ The Craighead's use ~~of~~ electronic equipment ~~a bear had never been tracked to his winter abode~~. The program confirmed that grizzlies head for hibernation during snowstorms, leaving no trails.

Sure enough, when we cautiously peered over the hilltop, there was our grizzly, head lowered, plodding along the valley floor. She was obviously unaware of our presence. Radio had given us a sixth sense that surpassed her own powers of scent, sight, and hearing.

"That's No. 40 all right," said John as he sighted the telltale red and blue of the collar through his scope.

For the first time a grizzly bear had been tracked by radio. It was the breakthrough we needed. We knew then that electronics could be used to gain vital new information about Yellowstone's grizzlies.

Since then, the pulsed beeps from our radio bears have become as familiar to us as the cawing of the mountain ravens. The signals have led us to rendezvous with grizzlies in their most intimate moments. We have found them napping, frolicking in new-fallen snow, defending kills, swimming at night, battling for mates, and holed up in their winter hideouts. We feel as if we now have a wide-screen view of grizzly life, whereas previously we had been peering at it through a pinhole.

By the summer of 1963 our radio-tracking system was complete. Base Station at Canyon Village was equipped with receivers and a

KODACHROME AND MAP (BELOW) © N.G.S.

Where the bears are: Radio-direction finders enable the Craigheads to plot precise grizzly positions on their field map. Areas outlined in different colors show ranges of individual bears. Crosses indicate radio fixes and contacts with the animals. Some use only a few square miles of Hayden Valley in the center of the park (right); others ramble over as much as 168 square miles. "In the course of a lifetime," Frank Craighead says, "a grizzly may travel over most of Yellowstone and adjacent country." Bears leaving the protection of the national park risk death from hunters.

motor-driven, five-element antenna with direction indicator. We monitored the instrumented grizzlies day and night, regularly picking up their individual signals 10 to 12 miles away—occasionally as far as 20 miles.

Scientists "Tune In" on Den-bound Bear

Supplementing this was the three-element antenna and receiver at our hilltop Field Station, eight miles south in Hayden Valley, and also two radio-equipped vehicles. With these units we followed grizzlies that wandered to distant parts of the park.

After engineer Joel Varney of the Philco Corporation perfected them, our hand-carried tracking receivers weighed only two-and-a-half pounds apiece. With these we picked up signals from grizzlies three to four miles away and stalked the bears on foot.

Our pioneer success in tracking a grizzly to its den came on a gray November day as snow sifted down across Hayden Valley and its surrounding pine forests.

For the park's restless grizzlies, the snow triggered a biological alarm, just as it had for countless centuries. Made lethargic by winter's approach, the burly animals dispersed from fall feeding grounds and sought lonely sites in the forest, where many weeks earlier they had excavated individual dens that

would shelter them during their six months' sleep.

On the morning of November 5, John, Maurice Hornocker, Charlie Ridenour, and I clambered over jackstraw piles of wind-felled trees in upper Trout Creek, almost at the geographic center of Yellowstone Park.

"Beep, beep!" came the pulse from the transistorized transmitter attached to the neck of a grizzly. No bugling of elk, coyotes' howl, or honking of geese ever stirred us more.

We were following the most recent addition to our now-lengthy roster of instrumented grizzlies. This was No. 164. Her individual radio "call" was 62 beeps a minute.

As we pressed on after lunch, we began to look for footprints in the snow, and expected to glimpse a dark form moving through the dense lodgepole pines, lustrous silver-brown fur rippling over layers of fat and muscle.

"Beep, beep, beep!" Steadily the electronic beat came to us from No. 164. Apart from the insistent radio signal, utter stillness muffled the forest. The deep wingbeats of a great gray owl made no sound. Raucous Canada jays and scolding pine squirrels had fallen silent, as though watching our pursuit.

Rotating the loop antenna of my receiver, I tried, from atop a heap of fallen timber, to take a bearing by finding the "null" position

PUTTING AWAY LEFTOVERS, ***a well-fed grizzly covers the carcass of a winter-killed bull elk with dirt and grass to thwart scavengers such as the coyote in foreground. The grizzly's keen sense of smell enables it to detect and locate carrion from afar. Berries, nuts, plant roots, field mice, gophers, and fish also suit the bear's palate.***

KODACHROME BY FRANK AND JOHN CRAIGHEAD © N.G.S.

Eight hundred pounds of muscle and claw, Bruno lies powerless from drugs as the team takes a blood sample. Red collar holds radio that enabled the Craigheads to track him for more than a month. On the plotting table at the project's headquarters, X marks a bear. To get one line, John Craighead plots a direction bearing from a rotating antenna on the roof of the Yel-

—the attitude of the wire loop that voided the signal. But I found no ~~silent~~ sector.

Was the grizzly directly under me? The same thought struck Maurice. He braced his feet on the slippery logs to give himself balance to swing his gun freely.

The signal was now so loud that the silvertip could not be more than 100 to 150 feet away. But where? A startled grizzly could cover this distance in seconds—and cuff us to kingdom come with her terrible claws. We moved with utmost caution now.

"There it is!" whispered Maurice, pointing to traces of dirt on packed snow 50 feet away. This litter in front of a cave was the clue to a grizzly huddled within—that plus the signal

Fearsome jaws gape as John Craighead and Maurice Hornocker rush to take a dental impression of a grizzly before the drug wears off. Thus they can study the age of a bear by the size and condition of its teeth, without having to kill the animal.

lowstone laboratory; a portable antenna or mobile tracking unit gives the second bearing. Radio collars for bears, hanging above, flank bright plastic flags used to mark elk. Unpredictable as all his relatives, the thrashing cub in a weighing sling at right awakens from the drug too soon—and angrily protests the indignity. A second dose quieted him.

KODACHROMES © N.G.S.

from

our receiver, now beeping loud and clear.

We saw that No. 164's fresh tracks led into the cave but not away from it. The grizzly sow had just recently arrived, was certainly still awake, and therefore aware that she had visitors. Our approach undoubtedly had made her withdraw deep into her den.

"Wonder if she has her yearlings with her," mused Maurice.

"We sure can't take a chance on riling her now," I said, and there were nods of agreement as we looked around at the big lodgepoles. Our best defense against a charge would be to climb a tree; most adult grizzlies can't, But the lowest branches on these straight trunks were 30 feet from the ground.

Unhappy but helpless, Marian growls as Harry Reynolds and Bill Staniger tattoo her identification number. The drug deprives the sow of the use of muscles but does not make her unconscious. Dental compound on the lips shows she has been "tooth-printed."

GRIZZLIES — August — FINAL FOR RELEASE 1 — May 9, 1966

Half-drugged yearling chases John Craighead around his tripod. Eyesight still affected, she charges toward sounds and finally "trees" a now-smiling John on the hood

So we let well enough alone, content that our primary mission was accomplished. We retreated silently, with the thrill of having confirmed our suspicion that grizzlies move to their hibernation dens during snowstorms. Thus they leave no telltale path. Only by radio-tracking could we have gained this information. Our success with No. 164 offered proof of biotelemetry as an invaluable tool in behavioral research.

In the fall of 1964 and again in 1965, we instrumented about a dozen grizzlies, seeking information on prehibernation behavior, den construction, and home ranges. We tracked to their dens a young mother with her cub, and an old, ill-tempered grizzly with three large yearlings. We followed a pregnant sow to her winter hideout, as well as a weaned male yearling. All had dug dens. None used natural shelters.

All these dens were lined with boughs and lay on slopes, with their entrances facing north. This minimizes accumulation of water in the dens during occasional winter thaws.

Grizzlies dig their dens at the base of large trees, with the entrance located between thick, steeply descending roots. One we found empty was a split-level den: The bedchamber lay at a higher level than the entrance. Warm air was thus trapped, as in an Eskimo igloo. Was this construction accidental or by design?

We believe that dens dug by inexperienced weaned yearlings may occasionally cave in while being used. Death by smothering could result. Could this partly account for the high winter mortality of young bears?

One Bear Dies for Each One Born

Since immobilizing our first bears in 1959, we have determined the age structure of the Yellowstone population. We now know that at a given time 49 percent will be cubs, 12 percent yearlings, 10 percent two-year-olds, 14 percent three-, four-, and five-year-olds, and adults the remaining 47 percent.

Only about a third of the adult sows are candidates for motherhood each year, because females taking care of cubs will not mate. Not until the youngsters are weaned, some as yearlings and some as two-year-olds, will the sows accept the attentions of the boars. The average annual crop of 34 cubs is fathered by

of a car. Such incidents help researchers determine how long various drugs remain effective. Collar of white fur ringing the young bear's neck is an uncommon marking.

a few large, aggressive boars. Male parents play no other role in the family life.

Average litter size over a five-year period has been 2.2 cubs per mother, with a maximum yearly average of 2.5. The largest litter we have recorded is four (below), although triplets occur frequently. The annual increase in population has averaged about 20 percent, a proportion identical to the death rate.

Our files now brim with information from which we can construct actuarial tables for bears—mean life span, mortality by age classes, and life expectancy. Now we can write the terms for a badly needed grizzly life-insurance policy. These statistics give backbone to a management program that can help save the grizzly from extinction.

This information has not been gleaned without some risk. Time and again we have been treed by bears, twice by tough No. 39.

Grizzlies especially hate to be disturbed from the day beds that they hollow out of soft earth. Once we followed one of our transistorized bears, No. 75, to where she lay bedded down with her two yearlings for a siesta. At our approach, the old and belligerent sow gave a warning "woof" to her young, and the family took off at a run. We found copious saliva smeared around the edge of the bed, suggesting that the mother bear had been drooling with nervousness at our approach. Her decision to flee rather than to attack was fortunate for us.

Brawny Males Top Grizzly "Peck Order"

Over the years a ladder structure, or hierarchy, has developed in grizzly society. Each bear, from the aggressive, dominant male down to the insecure orphaned cub or yearling, finds his place in the group. Relative positions change from year to year. Sows with cubs are more aggressive than barren ones and attain a temporarily higher social status. They defer only to the large aggressive males.

Especially in the mating season, in June and early July, the big boars wage fierce battles, competing for mates and for ruling rank.

Old Scarface, veteran of many contests, yielded to Cutlip, then briefly rewon his place as top boar—only to lose a short and vicious battle to Inge. For three years, 1960 to 1963, Inge (No. 12) dominated the grizzly ranks of

KODACHROMES BY LANCE CRAIGHEAD (ABOVE) AND FRANK AND JOHN CRAIGHEAD © N.G.S.

Splashing across a creek, four cubs hurry to catch up with their mother. Quads are rare; the Craighead study shows that litters average 2.2 young. No bigger than squirrels at birth, cubs stay close to mother, who protects and nurses them; father plays no part in the rearing. Sows sometimes adopt orphan cubs.

Silver amid sunset gold, a large sow ambles into a more secure future, thanks to information gained by the research project. Greater knowledge assures greater protection.

Alerted by man scent, a sow rises to full height in a spring-bright meadow. Fewer than one-third of all cubs survive as long as 18 months. Yellowstone grizzlies live an average of less than six years, a maximum of 25 to 30.

Trout Creek and Hayden Valley. We saw him lose one fight to Whitespot, a bear he later faced down in a rematch. Inge vanquished Short-Ear, a powerful boar, and then we watched him knock off No. 88.

What a battle! Inge rushed his adversary and sank his canines deep into 88's rump. The momentum carried him over his opponent. Even though sprawled on his side, Inge seized 88's right thigh and shook the 700-pound boar as a terrier shakes a rat.

Eighty-eight broke away, and his huge jaws clamped on Inge's jowls. Inge roared, reared back to his full height, and fought free. A great red gash marred the side of his face.

The two stood on hind legs, face to face, jaws agape, parrying like monstrous boxers. Then they locked jaws, each levering to throw the other to the ground. Inge slapped his adversary across the shoulder with a lightning-fast swipe from his right paw, then lunged for 88's throat. Eighty-eight staggered back, but gave bite for bite and blow for blow. The combatants' growls and roars could be heard half a mile away.

Both silvertips dropped to all fours—and then Inge deliberately turned his back on the challenger, moving aside to claim his sow, No. 65. Eighty-eight made no further move. The contest was over. Inge reigned supreme.

By

~~In the~~ combining of biology and electronics biotelemetry has opened up ~~new~~ new avenues of research. It is providing new insight and understanding of animal life. It may provide a better chance of saving the grizzly from extinction.

Combining biology and electronics has opened new avenues of research ~~thus providing~~. The more we can learn about the grizzly the better the chance ~~there is~~ of saving this great animal from extinction.

EKTACHROME (ABOVE) AND KODACHROME © N.G.S.

(41)

Last summer we experimented with a new kind of transmitter. A bear was instrumented with a thermistor—an electrical gadget whose resistance varies with the temperature. The thermistor controls the pulse rate of the transmitter signal. Thus temperature can be read in the changing frequency of the beeps.

Bears Traced From Shade to Sun

Recording a sharp rise in temperature, the radio signal told us, for example, when a bear moved from dense shade into the warmth of bright sunshine. If a low temperature report persisted from a single location, we concluded that the grizzly had lain down in a cool, moist place. Fluctuations in readings charted the animal's wanderings through forest and sunny open meadow.

(42)

Another year we plan to insert thermistors into the body tissue itself of some bears (in such a way, of course, as to cause minimum discomfort). This will give us body temperatures. We hope also to telemeter heartbeat rates and take an electrocardiogram, using an external transmitter.

There seems no end to the avenues of inquiry that electronics have opened up. And the more we can learn, the better chance there will be of saving this great animal from extinction. THE END

(We have done (43)

new ending (44)

GRIZZLIES—August—FINAL FOR RELEASE 1—May 9, 1966

267-1

8,200 and 9,000 feet. Most of them are dug in early fall in advance of hibernation. A bear may winter in the same site year after year, even in the same den in successive years.

• These omnivorous animals usually seek the most abundant and most easily garnered foods, whether they be huckleberries, pine nuts, a winter-killed elk, roots of plants, field mice, or pocket gophers.

• Some bears, during the lush summer feeding, gain an average of three pounds a day.

How to "Bug" a Half-ton Bear

The life, liberty, and pursuit of happiness of a grizzly are not noticeably affected when it acquires a collar antenna, radio transmitter, and battery pack.

For bear and scientist alike, excitement begins when the tail gate of a culvert trap slams shut behind a hungry and angry grizzly—or when a drug-laden syringe fired from a gun strikes the free-roaming animal as it feeds on a bait.

We still can vividly recall instrumenting Marian, the first bear we rigged with a radio transmitter and No. 40 in our overall tagging program (page 263). We trapped her on the night of September 21, 1961, and the next morning immobilized her. With a hypodermic dart Maurice Hornocker administered the succinylcholine chloride; it would keep her inert—though fully conscious—for about 15 minutes. Then John injected pentobarbital sodium. The bear coughed and in 10 minutes was fully anesthetized.

The previous night we had worked late completing her radio collar. The seven-cell battery pack, good for as long as two months (later for up to a year), had been waterproofed by dipping it in silicone rubber. The two-ounce transmitter, battery pack, and a section of the loop antenna had been wrapped in glass-fiber cloth and coated with resin. As with all our instrumented subjects, we color-coded the entire assembly with spray paint for ready identification.

The collar that John handed me as I knelt by grizzly No. 40 weighed about two pounds and was as waterproof, shockproof, and bear-proof as we could make it. I fitted the loop snug around the bear's neck, cut the antenna to fit snugly, and bolted it securely.

With No. 40 lying on her side, signal transmission was poor, but it improved when she got up and began moving. A swirling snowstorm swallowed our first radio-carrying bear.

Suddenly, on both our receivers, the rhythmic signal came in loud and clear—but from directly behind us. Our quarry had circled back soundlessly, and now she was tracking *us!*

Soon we doubled back on our trail, moving cautiously. But at our approach the wary grizzly, alerted by scent or sound, faded into the forest with her young and was gone.

Bears Balk at Close-quarters Study

Tracking grizzlies by radio was only a dream in 1959, when we began an ecological study of this dangerous animal whose very unpredictability had long balked research at close quarters. Yet such study was needed, for the grizzly is a threatened species south of Canada.

We realized that it would take entirely new methods to keep tabs on the comings and goings of wilderness inhabitants that were active both day and night, wandering over thousands of square miles of rough terrain, and curling up each fall in remote caves or windfalls to snooze away half the year.

Many institutions, including the National Geographic Society, the National Science Foundation, and the Philco Corporation, have helped sponsor the breakthrough. The program is administered by the Montana Cooperative Wildlife Research Unit (John is its leader) at Montana State University, and by the Environmental Research Institute, whose activities I direct.*

One man plucks out the dart, while others struggle to roll Ingemar over and slip the red-and-yellow radio collar around his 44-inch neck.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

The usual "communication" between man and grizzly is through a rifle bullet, .30 caliber or larger, by which the two-legged hunter asserts himself over the bear's lethal power. Now, through the use of tranquilizers and anesthetics, and by the magical link of radio, John and I have learned life-and-death details of an entire grizzly population.

In seven years of work we have captured, measured, and physically examined 391 grizzlies. We have color-marked 212 and instrumented 29 with radios. More than a hundred bears have been recaptured, some many times. Fifty families have been observed in the wild. Some genealogies run for nine years, to the third generation.

By radio-tracking and by visual sighting of tagged bears, we have learned such things as these:

- Yellowstone's grizzlies, 200 to 250 strong, are holding their own despite man's intrusion on their domain.
- In grizzlies, both sexes are promiscuous. There is no "boy-meets-girl" problem; males and females are equally numerous.
- Only 60 percent of the cubs born survive the first year and a half of life. A few bears live to 25 or 30, but the average life span is only five or six years. Necessary control measures within the park account for 18 percent of mortalities. Hunters take a much heavier toll outside the protected park. Other bears fall victim to starvation and the elements, to disease and old age.
- When grizzly cubs nurse, they make a buzzing sound, like the muffled staccato of a jackhammer.
- Dominance based on size, aggressiveness, and experience is the key to the stratification of grizzly society.
- Grizzly winter dens have been found at elevations between

*The Craighead brothers reported their first findings in "Knocking Out Grizzly Bears for Their Own Good," NATIONAL GEOGRAPHIC, August, 1960. The Society has participated in this study of grizzlies through eight grants from its Committee for Research and Exploration. The authors told of other wildlife in "Bright Dyes Reveal Secrets of Canada Geese," December, 1957; "Wildlife Adventuring in Jackson Hole," January, 1956; and "Cloud Gardens in the Tetons," June, 1948.

*In addition to the organizations mentioned, the National Park Service, U. S. Fish and Wildlife Service, Montana State Fish and Game Department, Boone and Crockett Club, New York Zoological Society, American Museum of Natural History, Yellowstone Park Company, and Wildlife Management Institute have contributed to the project in one way or another.

Frank Craighead AHB

Edited by AHB, 3/21/66
Copy-edited by EJL, 3/23/66
Mimeoed by bb, 3/24/66
Revised by AHB, 4/11/66
Typed by mab, 4/11/66
Copy-edited by ACF, 4/13/66
Mimeoed by pal, 4/14/66

TRAILING YELLOWSTONE'S TRANSISTORIZED GRIZZLIES

by

Frank and John Craighead

(Note: This copy substitutes for mimeographed version of 3/24/66).

Fearsome or frolicsome--a grizzly bear can be both. ~~But with~~ (a grizzly's ~~Ursus horribilis~~) ~~you just never know.~~

(1) Rage succeeds ~~roguishness~~ indifference in this mighty mammal with alarming suddenness, and ~~any mo-~~ when disturbed ment ~~the~~ unpredictable (Ursus horribilis) ~~silvertip~~ can live up to ~~his~~ its reputation as the most feared and respected of North American carnivores.

Our own respect for the grizzly took a ~~great~~ leap forward on a ~~chilling~~ sobering occasion when for the first time we, the pursuers, became the pursued.

On a quiet summer afternoon we were following a gruff old sow and her two cubs through forests of dense lodgepole pine in the heart of Yellowstone National Park. Though ~~gaining~~ "closing in" on our quarry, we were unobserved, for we were tracking the bear family by radio. Earlier, we had immobilized the sow with a "shot"--one of the hypodermic variety, fired from a gun--and then had instrumented her with a collar-transmitter. It broadcast her whereabouts

(2) by means of ~~bell-tale~~ radio signals which we picked up on portable receivers.

"Beep, beep," came the signal from ~~but even~~ with our ~~portable~~ directional receivers. ~~directional loop antennas~~, Even dips and rises in terrain at the head of Alum Creek ~~caused~~ did not prevent the radio pulse ~~to~~ from reach us, ~~intermittently~~. We knew, ~~though~~, by the strength

of the beeps that we were close to overtaking the bears and then by the fading signal that we had "jumped" them.

"I think I've lost her," John said, during a particularly long interval of radio silence. My brother rotated the antenna slowly and carefully, seeking the vagrant beat.

Suddenly on both our receivers the rhythmic signal, came in loud and clear, but from directly behind us. Our inquisitive quarry, detecting the human presence, had circled back soundlessly, and now was tracking us!

For a short distance we kept on, with a wry appreciation of the switch in roles. Yet we knew that without the radio's forewarning we might have suffered a nasty surprise.

Soon we doubled back on our trail, moving cautiously lest we stumble over the sow and her cubs. But at our approach the wary grizzly, alerted by scent or sound, faded into the forest with her young and was gone.

(SH) Bears Balk at Close-Quarters Study

Tracking grizzlies by radio was only a dream in 1959, when we began an ecological study of this dangerous animal whose very unpredictability had previously defied research at close quarters.

We realized that it would take entirely new

methods--some kind of breakthrough--to keep tabs on the comings and goings of a wilderness inhabitant that were active both day and night, wandering over thousands of square miles of rough terrain, and curling up each fall into some remote caves or windfall to snooze away half the year.

South of Canada, the grizzly is a seriously threatened species. The National Geographic Society, the National Science Foundation, Philco and other helped sponsor Montana, still with perhaps 1,000 unprotected bears, joined with the National Geographic Society in sponsoring our study program administered through the Montana Cooperative Wildlife Research Unit (John is its leader) at Montana State University and The Environmental Research Institute, whose activities I direct.* I am president, also gave support.*

(5) COLLABORATORS

credits
Small type bottom page 2
orig. announcement should be included

*The Craighead brothers reported their first findings in "Knocking Out Grizzly Bears for Their Own Good," National Geographic, August, 1960. The Society has participated in this continuing study of grizzlies through eight grants from its Committee for Research and Exploration.

The usual "communication" between man and grizzly is through a rifle bullet, caliber .30 or larger, by which the two-legged hunter asserts himself over the bear's lethal power. Now, through the use of tranquilizers and anesthetics, and by the magical link of radio, John and I have learned life and death details

(6)

Naomi Hornaday, Bob Kruft, Joel Varney, Lobo Francisco, Morgan Berthong and University Students and our assistants and collaborators

of an entire grizzly population.

In seven years of work we have captured, measured, and physically examined 391 grizzlies. We have color-marked 212 and instrumented 29 with radios. More than 100 bears have been recaptured, some many times. Fifty families have been observed in the wild. Some genealogies run for nine years, to the third generation.

By radio tracking and by visual sighting of tagged bears, we have learned such things as these:

. Yellowstone's grizzlies, 200 to 250 strong, are holding their own despite man's intrusion on their domain.

. In grizzlies, both sexes are promiscuous. Males and females are equally numerous. There is no "boy-meets-girl" problem.

. Only 60 percent of the cubs born survive the first year and a half of life. A few bears live to 25 or 30, but the average life span is only five or six years. Necessary control measures within the park account for 18 percent of mortalities. Outside the park, hunters take the heaviest toll. Others fall victim to starvation and the elements, to disease and old age.

. When grizzly cubs nurse, they make a buzzing sound, like the muffled staccato of a jackhammer.

. Dominance based on ~~because of~~ size, aggressiveness, and ~~leadership~~ experience is the key to the stratification of grizzly society. He approaches lonely grizzly is a social animal.

. Grizzly winter dens have been found at elevations between 8,200 and 9,000 feet. Most of them probably are dug in advance of hibernation in ~~summer or~~ early fall, ~~one bear, as far as we can determine, will never use another's den, but~~ a bear may hibernate in the same site year after year, even in the same den in successive years.

. These omnivorous animals are not fastidious so eat whatever they find. ~~tend to select one food at a given time or place--~~Usually they seek the most abundant and easily garnered food, whether they be huckleberries, pine nuts, a winter-killed elk, ~~tuberous~~ roots of plants, field mice, or pocket gophers.

. Some bears, during the lush summer feeding ~~time~~, gain an average of three pounds a day.

Research: Please chec average weight.
JS

(SH) How to "Bug" a Half-ton Bear

(8)

The love ~~life~~, family duties ~~liberty~~, and general behavior ~~pursuit of happiness~~ of a grizzly are not noticeably affected when it acquires a collar ~~containing a~~ antenna, radio transmitter and battery pack, ~~and antenna.~~

For bear and scientist alike, excitement begins when the tail-gate of a culvert trap slams shut behind a hungry and angry grizzly--or when a drug-laden syringe fired from a gun strikes the free-roaming animal as it feeds

on ~~a~~ bait.

We still can vividly recall instrumenting No. 40, the first bear we rigged with a radio transmitter. We trapped her on the night of September 21, 1961, and the next morning immobilized her. ~~With a hypodermic dart Maurice Hornocker administered the~~ with a dose of succinylcholine chloride; ~~it would keep her inert though fully conscious for about 15 minutes. Then~~ followed by John injected pentobarbital sodium. ~~The bear coughed and~~ In 10 minutes the bear was fully anesthetized.

The previous night we had worked late completing the radio collar. The seven-cell battery pack, good for a transmitting life of ~~up to~~ three months, had been waterproofed by dipping it in silicone rubber. ~~compound.~~ The two-ounce transmitter, battery pack, and a section of the loop antenna had been wrapped in fiberglass cloth and coated with resin. As with all our instrumented subjects, we color-coded the entire assembly with tape or spray paint for ready identification.

The collar that John handed me as I knelt by grizzly No. 40 weighed about two pounds and was as waterproof, shockproof, and bearproof as we could make it. I fitted the loop snug around the bear's neck, cut the antenna to proper size, and bolted it securely.

With No. 40 lying on her side, signal trans-

(We had very little trouble of this manner for our bear "collaborators".)

(9)

(10)

(11)

Authors — want color? (different colors for each)

(12)

Later models were merely slipped over the bears' heads.

mission was poor, but it improved when she got up and began moving. A swirling snowstorm swallowed our first radio-carrying bear.

(SH) Beeping Transmitter Leads to Target

Early in October we tracked down No. 40 in our first successful radio pursuit. As the "beep, beep" from our portable receivers led us across the sagebrush and grasslands of Hayden Valley we kept a sharp eye all around us. Grizzlies are short-sighted and cannot readily discern a man beyond 100 yards; their sense of smell, however, is extremely keen. If jumped or startled at close range, a grizzly is about as likely to charge as run. Curiosity often triggers attack. Though we usually carry a firearm, we have never yet had to use it for defense.

"She should be right over this hill," I said.

Sure enough, when we cautiously peered over the hilltop, we saw our grizzly, head lowered, plodding along the valley floor. Though we were spotted she was unconcerned, obviously unaware of our presence. Radio had given us a sixth sense that surpassed her own powers of scent, sight, and hearing.

"That's Number 40 all right," said John as through his scope he sighted the identifying red and blue (?) of the collar.

-7a-

For the first time a grizzly bear had been tracked by radio. ~~Many people had said it could not be done, and there had been times when we wondered ourselves.~~ We didn't give a cheer, but we felt like it.

Since then, the pulsed beeps from our radio bears have become as familiar to us as the cawing of the mountain ravens. The signals have led us to rendezvous with griz-

It was a major accomplishment in the use of electronics to study Yellowstone grizzlies.

(16)

zlies in their most intimate moments. We have found them napping, frolicking in new-fallen snow, swimming at night, defending kills, battling for mates, digging dens and holed up in their winter dens. We felt as if we now have a wide-screen view of grizzly life, whereas previously we had been peering at it through a pinhole.

By the summer of 1963 our radio-tracking system was complete. Base Station at Canyon was equipped with receivers and a motor-driven, five-element antenna with direction indicator. From Canyon we monitored the instrumented grizzlies day and night, regularly picking up their differently pulsed signals 10 to 12 miles away--occasionally up to 20 miles.

Supplementing this was a three-element antenna and receiver comprising our hilltop Field Station, eight miles south in Hayden Valley, and also two radio-equipped vehicles. With these mobile tracking units with which we followed grizzlies that wandered to distant parts of the park.

Our three portable tracking receivers, had both unidirectional sense antennas and They loop antennas, weighed only two-and-a-half pounds apiece after engineer Joel Varney of the Philco Corporation perfected them. With these we picked up radio signals from grizzlies three to four miles away and stalked the bears on foot using a combination of strongest signal and "null" to give us direction.

(SH) Scientists "Tune in" on Den-bound Bear

Our pioneer success in tracking a grizzly to its den came on a gray November day as snow sifted down across the grasslands of Hayden Valley and its surrounding pine forests.

For the park's restless grizzlies, the snow triggered ~~a warning in~~ a biological clock, just as it had for countless centuries. ~~Alerted~~ Inside lethargic by winter's approach, the burly animals dispersed from ~~summer~~ fall feeding gathering grounds and sought lonely ~~places in the forest to build~~ forest sites where earlier they had excavated ~~the individual~~ dens that would shelter them during their six months' sleep.

22

On the morning of November 5, John, Maurice, Charlie Rideman

23

~~Hornocker,~~ and I clambered over jackstraw piles of wind-felled trees in upper Trout Creek ~~Valley~~ almost at the geographic center of Yellowstone Park.

"Beep, beep!" came the high-pitched pulse from the tiny transistorized transmitter attached to the neck of a grizzly. No bugling of elk, coyotes' howl, or honking of geese ever stirred us more.

We were following the most recent addition to our now-lengthy roster of instrumented ~~"transistorized"~~ grizzlies. This was No. 164. Her individual radio "call" was 62 beeps a minute.

As we pressed on after lunch, we began to look for footprints in the snow, and expected to ~~see~~ glimpse a dark form moving through the dense lodgepole pines, lustrous ~~reddish~~ silver-brown fur rippling over ~~layers of~~ fat and muscle.

"Beep, beep, beep!" Steadily the electronic beat came to us from No. 164. ~~(We had long since run out of nicknames for our bear "collaborators.")~~ Apart from the insistent radio signal, utter stillness muffled the forest. The deep wingbeats of a great gray owl made no sound. Raucous Canada jays and scolding pine squirrels had fallen silent.

(24)

Rotating the loop antenna of my receiver I tried, from atop a heap of fallen timber, to find the "null" position--the attitude of the wire loop that voided the signal. A course at right angles to the antenna should then lead us to the bear. But I found no silent sector.

(25)

Was the grizzly directly under me? The same thought struck Maurice. He braced his feet on the slippery logs to give himself balance to swing his ~~shotgun~~ gun freely.

The signal ~~had become~~ was now so loud that the silvertip could not be more than 100 to 150 feet away, but where? A startled ~~600-pound~~ grizzly could cover this distance in seconds--and ~~cuff~~ fatally attack us before we could even start on a run. us to kingdom come with her terrible claws.

(moderate 350)

(26)

We moved with utmost caution now.

(SH) Dirt at Entrance Betrays Lair

"There it is!" ~~hissed~~ whispered Maurice, and pointed to traces of dirt on packed snow 50 feet away. This litter in front of a cave opening was the ~~key clue~~ indicator to a grizzly huddled within. That, plus the ~~radio signal,~~ beeping signal loud and clear with volume down. Without radio, ~~we all agreed,~~ it was unlikely that 10 men ~~couldn't~~ could have found the den, even if the search had been limited to the surrounding square mile.

~~We saw that~~ No. 164's fresh tracks led into the cave but not away from it. The grizzly sow had just arrived, was certainly still awake, and therefore ~~must have been~~ aware that she had visitors. Our approach undoubtedly made her withdraw deep into her den.

"Wonder if she has her yearlings with her," mused Maurice.

"We sure can't take a chance on riling her now," I said, and there were nods of agreement as we looked around at the big lodgepoles. Our best defense against a charge would be to climb a tree; grizzlies ~~don't~~ can't. But the lowest branches on these straight trunks were 30 feet from the ground.

So we let well enough alone, content that our primary mission was accomplished. We

retreated silently and cautiously, with the thrill of having confirmed our suspicions ~~our theory~~ that grizzlies move directly to their hibernation dens during snowstorms. Thus they leave no telltale path. ~~Only~~ By radio tracking ~~could~~ we had on prehibernation behavior and den location. have gained ~~this~~ information and Our success with No. 164 offered ~~the~~ strongest ~~possible~~ proof of biotelemetry as an invaluable new tool in behavioral research.

(30)

In the fall of 1964 and ~~again in~~ 1965, we instrumented ~~more than~~ about a dozen grizzlies, seeking more information on prehibernation behavior, den construction, and home ranges. We tracked to their dens a young mother with her cub, and an old, ill-tempered grizzly with three large yearlings. We followed a pregnant sow to her winter hideout, as well as a weaned male yearling. All had dug dens. None used natural shelters.

(31)

dens have been lined with boughs and all
All of ~~these dens~~ were situated on slopes with ~~the~~ entrances facing north. This minimizes ~~melting and~~ the accumulation of water in the dens during occasional winter thaws.

(32)

The dug
Grizzlies ~~dig~~ their dens at the base of large trees with the entrance located between thick, steeply descending roots.

One we found empty was a split-level den: The bedchamber lay at a higher level than the entrance. Warm air was thus trapped, as in

Keep
~~Possible cut~~

an Eskimo igloo. Was this construction accidental or by design?

We believe that dens dug by inexperienced weaned yearlings may occasionally cave in while being used. Death by smothering could result. Could this partially account for the high winter mortality of young bears?

(33)

~~Possible cut~~ cut

(SH) One Bear Dies for Each One Born

Since immobilizing our first bears in 1959, we have determined the age structure of the Yellowstone population.

We now know, for instance, that at a given time 21 percent of the grizzlies in Yellowstone will be cubs, 11 percent yearlings, 7 percent two-year-olds, 14 percent three four- and five-year olds, with adults constituting 47 percent of the total. 3

Only about a third of the adult sows are candidates for motherhood each year, because females taking care of cubs are not receptive to a mate. Not until the youngsters are weaned, some as yearlings and some as two-year-olds, will the sows accept the attentions of the boars. The average crop of 34 cubs produced annually is fathered by a few large, aggressive boars. Male parents play no other role in the family life.

(34)

Average litter size over a five-year period

has been 2.2 cubs per mother with a maximum yearly average of 2.5. The largest litter we have recorded is four, although triplets occur frequently. The annual increase in population from cubs born each year has averaged about 20 percent, a proportion identical to the death rate.

(35)

Our files now brim with statistical information from which we can construct actuarial tables for bears--mean life span, mortality by age classes, and life expectancy. Now we can write the terms for a badly needed grizzly life-insurance policy. These vital statistics give backbone to a management program that can help save the grizzly from extinction.

(36)

This information has not been gleaned without some risk. Time and again we have been treed by bears — twice by belligerent #39.

(37)

Grizzlies especially hate to be disturbed on the day-beds that they hollow out of soft earth, ~~and leaves~~. Once we followed one of our transistorized bears, No. 75, to where she lay bedded down with her two yearlings, ~~for a siesta.~~ At our close approach, the old and belligerent sow gave a warning "woof" to her young, and the family took off at a run. We found copious saliva smeared around the edge of the bed, suggesting that the mother bear

(38)

had been drooling with nervousness at our approach. ~~Probably she had to make a close decision, whether to attack or flee.~~ Her decision to flee rather than was fortunate for us.

(SH) Brawny Males Top "Pecking Order"

Over the ~~ages~~ years a ladder structure or hierarchy has developed in Yellowstone grizzly society. Each bear, from the aggressive, dominant male down to the insecure orphaned cub or yearling, finds his place in the group.

Relative positions change from year to year. Sows with cubs are more aggressive than barren ones and attain a temporarily higher social status. They defer only to the large aggressive males.

Especially in the mating season, in June ~~an~~ and early July, the big boars wage fierce battles, competing for mates and for ruling rank.

Old Scarface, veteran of many contests, yielded to Cutlip, then briefly rewon his place as top boar only to lose a short and vicious battle to Inge. For three years, 1960 to 1963, Inge (No. 12) dominated the grizzly communities of Trout Creek and Hayden Valley. We saw him lose one fight to Whitespot, a bear he later faced down in a rematch. Inge vanquished Short-Ear, a powerful boar, and then we watched him knock off No. 88 in bloody combat.

39

What a battle! Inge rushed his adversary and sank his canines deep into 88's rump. Inge's momentum carried him over his opponent, tumbling the attacker to the ground. But Inge seized 88's right thigh and shook the 700-pound boar as a terrier shakes a rat.

Eighty-eight broke away and his huge jaws clamped on Inge's jowls. Inge roared, reared back to his full height, and fought free. A great red gash marred the side of his face.

The two stood on hind legs, face to face, jaws agape, parrying like monstrous boxers. Then they locked jaws, each levering to throw the other to the ground. Inge slapped his adversary across the shoulder with a lightning-fast swipe from his right paw, then lunged for 88's throat. Eighty-eight staggered back, but gave bite for bite and blow for blow. The combatants' growls and roars could be heard a half mile away.

Both silvertips dropped to all fours--and then Inge deliberately turned his back on the challenger, moving aside to claim his sow, No. 65. Eighty-eight made no move to take advantage of this opening. The contest was over. Inge reigned supreme.

(SH) Thermistors Help in "I Spy" Game

Last summer we experimented with a new kind of ~~instrumentation.~~ transmitter. ~~To the collars of two~~ bears ~~we attached~~ was instrumented with a transmitter controlled by a thermistors ~~-~~ electrical gadgets whose resistance varies with the temperature. The thermistor controls the pulse rate of the transmitter signal. Thus variations in temperature can be read in the changing frequency of the beeps.

Recording a sharp rise in temperature, the ~~thermistor readings~~ radio signal told us, for example, when a bear moved from dense shade to bright sunshine. If a low temperature report persisted from a single location, we could conclude that the grizzly had lain down in a cool, moist place. ~~When the bear rose again and started walking, the~~ fluctuations in readings would ~~follow~~ thus permit us to follow the animal's wanderings through forest and open meadow.

Another year we plan to insert thermistors into the deep tissues of some bears (in such a way, of course, as to cause minimum discomfort to the host). We have done this with elk. This will give us body-temperature readings. We hope also to ~~implant~~ telemeter ~~transducers which will register~~ heart beat and ~~blood pressure~~ temporary electrocardiogram using externally attached transmitters.

There seems no end to the avenues of inquiry that open up. ~~Yet each year, when we leave the sleepy silvertips of Yellowstone,~~

And the more we can learn the better chance there will be of saving this great animal from extinction.

THE END

GRIZZLIES II-Revised Legend-p. 262-263

BOLD

Big boss Bruno, 800 pounds of muscle and claw, lies powerless from drugs as the team takes a blood sample. Red collar holds (the) radio that enabled the Craigheads to track him "over some of the most heavily timbered and rugged country in Yellowstone," Frank reported. "We followed this grizzly day and night and slept wherever darkness overtook us." On the plotting table at the project's Yellowstone headquarters, X marks a bear. John Craighead ~~takes one line~~ determines direction from rotating antenna on the roof; a mobile tracking unit gives the second bearing. ~~Unpredictable as all his relatives,~~ the bear ~~thrashing cub~~ in a weighing sling at right awakens from the drug too soon-- and ~~angrily~~ protests the indignity. ~~Second shot quieted him.~~

information on growth between captures.

√ Re weighings provides yearly & seasonal

p. 262-263

5/12/66

30 picas 9/10

GRIZZLIES II-Revised Legend-p. 257

BOLD

Beeping bug, a two-ounce radio transmitter constructed by Joel Varney of the Philco Corporation can report the movements of a grizzly to antennas up to 20 miles away. Wearing such a transmitter the bear below heads for tall timber. But he disappears only from sight. Broadcasting all the while, his ambling course goes on record when picked up by the ~~mobile~~ directional antenna at right.

p. 257

5/12/66

11 picas 9/10

BOLD

Vacant apartment: Frank Craighead measures den of #164 ~~bear's den~~ in summer after being led ~~tipped off~~ to its location by a radio-bearing bear the winter before ~~(last)~~. Grizzlies usually dig their dens beneath trees where ~~so that~~ roots support the ceilings.

BOLD Den of mother and cub

~~Shh! Bear sleeping.~~ But the ~~his~~ radio never rests. Beeping away, it led and the tracking party Bob Ruff to this snow-shrouded hideaway. The mother bear ~~had hoped for more~~ sought but did not find privacy, having travelled ~~lumbered~~ to her ~~his~~ hibernating home during a snowstorm thus ~~so as to~~ leave very ~~no~~ trails.

5/12/66 16 picas 9/10

BOLD

Where the bears are: on the Craighead's field map outlines in different colors show the area of wanderings by some of the grizzlies wearing radios; identifying numbers of the bugged bears appear alongside their plots. Crosses indicated personal contacts and radio fixes. Radio tracking reveals that a few animals used only 10 to 12 square miles of Hayden Valley. But one bear, Peg-leg, foraged over 168 square miles; heavy red marks a part of his range. During a week-long ramble (dotted line on map at right), Peg-leg traveled 100 miles and swam the Yellowstone River twice, once after descending the precipitous Grand Canyon of the Yellowstone.

20 picas 9/10

Frank Craighead

AHB

Edited by AHB, 3/21/66
Copy-edited by EJL, 3/23/66
Mimeoed by bb, 3/24/66
Revised by AHB, 4/11/66
Typed by mab, 4/11/66
Copy-edited by ACF, 4/13/66
Mimeoed by pal, 4/14/66

For John Craighead
(Includes Frank's changes)

Frank—
John asked me to send you this copy & the text containing both his suggested changes and yours.
Andy
5/12/66

TRAILING YELLOWSTONE'S TRANSISTORIZED GRIZZLIES

by

Frank and John Craighead

(Note: This copy substitutes for mimeographed version of 3/24/66).

Fearsome or frolicsome--a grizzly bear can be both. ~~But with~~ a grizzly ~~there's no telling which you just never know.~~

Rage succeeds ~~roguishness~~ indifference in this mighty mammal with alarming suddenness, and ~~any mo-~~ when disturbed ment ~~the~~ unpredictable ~~silvertip~~ Ursus horribilis can live up to ~~his~~ its reputation as the most feared and respected of North American carnivores.

~~Our own respect for the grizzly took a great leap forward on a~~ ~~chilling~~ sobering occasion ~~when for the first time we, the pursuers, became the pursued.~~

On a quiet summer afternoon we were following a gruff old sow and her two cubs through forests of dense lodgepole pine in the heart of Yellowstone National Park. Though ~~gaining~~ "closing in" on our quarry, we were unobserved, for we were tracking the bear family by radio. Earlier, we had immobilized the sow with a "shot"--one of the hypodermic variety, fired from a gun--and then had instrumented her with a collar-transmitter. It broadcast her whereabouts by means of ~~tell-tale~~ radio signals which we picked up on portable receivers.

A "beep, beep," signal came ~~the signal~~ from ~~but even with our portable directional loop antennas~~ directional receivers. Even on the steep hills & valleys ~~dips and rises in terrain~~ at the head of Alum Creek ~~caused~~ did not prevent the radio pulse ~~to~~ from reach us ~~intermittently~~. We knew, ~~though~~, by the strength

our considerable respect for the grizzly increased as it has done with each encounter.

of the beeps that we were close to overtaking the bears and then by the fading signal that we had "jumped" them.

"I think I've lost her," John said, during a particularly long interval of radio silence. My brother rotated the antenna slowly and carefully, seeking the vagrant beat.

Suddenly on both our receivers the rhythmic signal, came in loud and clear, but from directly behind us. Our quarry, detecting the human presence, had circled back, got the wind in her favor, soundlessly, and now was tracking us!

For a short distance we kept on, with a very appreciation of the switch in roles. Yet we knew that without the radio's forewarning we might have suffered a nasty surprise.

Soon we doubled back on our trail, moving cautiously lest we stumble over the sow and her cubs. But at our approach the wary grizzly, alerted by scent or sound, faded into the forest with her young and was gone.

(SH) Bears Balk at Close-Quarters Study

Tracking grizzlies by radio was only a dream in 1959, when we began an ecological study of this dangerous animal whose very unpredictability had previously deterred research at close quarters.

We realized that it would take entirely new

methods--some kind of breakthrough--to keep tabs on the comings and goings of a wilderness inhabitant that ~~was~~ were active both day and night, wandering over thousands of square miles of rough terrain, and ~~crawling~~ curling up each fall into some remote caves or windfall to snooze away half the year.

South of Canada, the grizzly is a seriously threatened species. Montana, still with perhaps 1,000 unprotected bears, joined with the National Geographic Society in sponsoring our study program administered through the Montana Cooperative Wildlife Research Unit (John is its leader) and through at Montana State University and The Environmental Research Institute, ~~of which I am president~~ whose activities I direct,* also gave support.*

*The Craighead brothers reported their first findings in "Knocking Out Grizzly Bears for Their Own Good," National Geographic, August, 1960. The Society has participated in this continuing study of grizzlies through eight grants from its Committee for Research and Exploration.

The usual "communication" between man and grizzly is through a rifle bullet, caliber .30 or larger, by which the two-legged hunter asserts himself over the bear's lethal power. Now, through the use of tranquilizers and anesthetics, and by the magical link of radio, John, and I, and our assistants and collaborators have learned life and death details

the National Geographic Society, the National Science Foundation, Philand other helpful sponsor Corporation, the Natl. Park Servi

credits
* Small type bottom page 2 orig. manuscript
should be included (MUST BE) J-D-C.

Harold Hornocker, Bob Kuehl, Joel Vaurey, Gabe Franciscus, Morgan Berthrong, and University Stroke

of an entire grizzly population.

In seven years of work we have captured, measured, and physically examined 391 grizzlies. We have color-marked 212 and instrumented ~~27~~ 29 with radios. More than 100 bears have been recaptured, some many times. Fifty families have been color marked and observed in the wild. Some genealogies run for nine years, to the third generation. By summer we will be marking the fourth generation of some of these.

By radio tracking and by visual sighting of tagged bears, we have learned such things as these:

. Yellowstone's grizzlies, ~~200~~ 170 to ~~250~~ 200 strong, ? are holding their own despite man's intrusion on their domain.

OK ~~. In grizzlies, both sexes are promiscuous.~~ OK ~~Males and females are equally numerous.~~ ~~There is no "boy-meets-girl" problem.~~ as cubs, ~~(age)~~ they are equally numerous (364) Females predominate among adults.

. Only ~~20~~ 60 percent of the cubs born survive the first year and a half of life. A few bears live to 25 or 30, but the average life span ~~is~~ may be only five or six years. Necessary control measures within the park account for 18 percent of mortalities, when bears roam outside the park - about 40 percent. Hunters take the heaviest toll. Others fall victim to starvation and the elements, to disease, ~~and~~ old age and mortal combat.

. When grizzly cubs nurse, they make a buzzing sound, like the muffled staccato of a jackhammer. They are weaned as yearlings or 2-year olds.

based on -5-

. Dominance ~~because of~~ size, aggressiveness,
and ~~leadership~~ experience is the key to the stratifi-
cation of grizzly society. Lonely grizzly is a social animal
. Grizzly winter dens ~~are~~ have been found at elevations be-
tween 8,200 and 9,000 feet. Most of them
probably are dug in advance of "hibernation" late summer or in early
fall; ~~one bear, as far as we can determine,~~
~~will never use another's den, but a~~ bear may
hibernate in the same site year after year, but not normally the same den in
. These omnivorous animals are not fastidious so ~~tend to select one~~
food ~~at a given time or place~~--usually they seek
most abundant and easily garnered foods, whether they
~~it~~ be huckleberries, pine nuts, ~~a winter-~~
~~killed elk, tuberous~~ carrion roots of plants, field
mice, ~~or~~ pocket gophers, or elk.
. Some bears, during the lush summer feeding,
~~time,~~ gain an average of three pounds a day, attaining maximum weight in late fall.
still well padded following the winter sleep they weigh least in mid July.

Research: Please chec
average weight.
JS

(SH) How to "Bug" a Half-ton Bear

The love life, family duties, ~~liberty~~, and general behavior ~~pursuit of happiness~~
of a grizzly are not noticeably affected when
it acquires a collar ~~containing a~~ antenna, radio trans-
mitter and battery pack, ~~and antenna.~~

For bear and scientist alike, excitement
begins when the tail-gate of a culvert trap
slams shut behind a hungry ~~and angry~~ then startled, roaring grizzly--
or when a drug-laden syringe fired from a gun
strikes the free-roaming animal, ~~as it feeds~~

~~on of bait~~.

We still can vividly recall instrumenting No. 40, the first bear we rigged with a radio transmitter. We trapped her on the night of September 21, 1961, and the next morning immobilized her. ~~With a hypodermic dart Maurice Hornocker administered the~~ with a dose of succinylcholine chloride; ~~it would keep her inert though fully conscious for about 15 minutes. Then~~ followed by John injected pentobarbital sodium. ~~The bear coughed and~~ In ~~20~~ 15 minutes the bear was fully anesthetized.

(We had flying since run out of nicknames for our bear "collaborators".)

The previous night we had worked late completing the radio collar. The seven-cell battery pack, good for ~~up to~~ a transmitting life of three months, had been waterproofed by dipping it in silicone rubber. ~~compound~~. The two-ounce transmitter, battery pack, and a section of the loop antenna had been wrapped in fiberglass cloth and coated with resin. As with all our instrumented subjects, we color-coded the entire assembly with ~~spray paint~~ tape of various colored for ready identification.

Authors — What color? (different colors for each)

The collar that John handed me as I knelt by grizzly No. 40 weighed about two pounds and was as waterproof, shockproof, and bearproof as we could make it. I fitted the loop snug around the bear's neck, cut the antenna to proper size, and bolted it securely. Later models were merely slipped over the bear's head.

With No. 40 lying on her side, signal trans-

mission was poor, but it improved when she got up and began moving. A swirling snowstorm swallowed our first radio-carrying bear, but not the signal which was receiving in the warmth of our cab 15 miles away.

(SH) Beeping Transmitter Leads to Target

Early in October we tracked down No. 40 in our first successful radio pursuit. As the "beep, beep" from our portable receivers led us mile after mile across the sagebrush and grasslands of Hayden Valley we kept a sharp eye all around us. Grizzlies are short-sighted and cannot readily discern a man beyond 200 yards; their sense of smell, however, is extremely keen. If jumped or startled at close range, a grizzly is ~~just~~ about as likely to charge as run. Curiosity often encourages the approach which at times ~~often~~ triggers attack. Though we ~~always~~ usually carry a ~~pistol or shotgun~~ firearm, we have never yet had to use it for defense.

"~~He~~ She should be right over this ~~hill~~ rise," I said.

Sure enough, when we cautiously peered over the hilltop, ~~there was~~ we saw our grizzly, head lowered, plodding along the valley floor. ~~She was quite close, unconcerned,~~ She was obviously unaware of our presence. Radio had given us a sixth sense that surpassed her own powers of scent, sight, and hearing.

"That's Number 40 all right," said John as through his ~~radio~~ scope he sighted the ~~telltale~~ identifying red and blue (#) of the collar.

For the first time a grizzly bear had been tracked by radio. ~~Many people had said it could not be done, and there had been times when we wondered ourselves~~ Our crew of researchers didn't give all a cheer, but we felt like it.

Since then, the pulsed beeps from our radio bears have become as familiar to us as the cawing of the mountain ravens. The signals have led us to rendezvous with griz-

It was a major accomplishment in the use of electronics to study Yellowstone grizzlies.

zlies in their most intimate moments. We have found ~~would find~~ them napping, frolicking in new-fallen snow, swimming at night, defending kills, battling for mates, digging dens and holed up in their winter caves. We feel ~~felt~~ as if we now have ~~had~~ a wide-screen view of grizzly life, whereas previously we had ~~would~~ been peering at it through a keyhole ~~pinhole~~.

By the summer of 1963 our radio-tracking system was complete. Base Station at Canyon was equipped with receivers and a motor-driven, five-element antenna with direction indicator. From Canyon we monitored the instrumented grizzlies day and night, regularly picking up their differently pitched signals 10 to 12 miles away--occasionally up to 20 miles.

Supplementing this was a three-element antenna and receiver comprising our hilltop Field Station, eight miles south in Hayden Valley, and also two radio-equipped vehicles. ~~With these mobile tracking units~~ with which we followed grizzlies that wandered to distant parts of the park.

Our ~~these~~ portable tracking receivers, ~~with~~ had both unidirectional sense and (UNI-directional) loop antennas. They weighed only two-and-a-half pounds ~~apiece~~ after engineer Joel Varney of the Philco Corporation perfected them. With these we picked up radio signals from grizzlies three to four miles away and stalked the bears on foot using a combination of strongest signal and "null" to give us direction.

(SH) Scientists "Tune in" on Den-bound Bear

Our pioneer success in tracking a grizzly to its den came on a gray November day as snow sifted down ~~across~~ the grasslands of ~~Hayden Valley and its surrounding pine forests.~~ on the high Yellowstone plateau.

For the park's restless grizzlies, the snow and low temperature triggered ~~a warning in~~ a biological clock, just as it had for countless centuries. ~~Alerted~~ Becoming lethargic ~~by~~ as winter's approach, the burly animals dispersed from ~~summer~~ fall feeding grounds and gathering grounds and forest sites where earlier they had excavated sought lonely ~~places in the forest to build the individual~~ dens that would shelter them during their six months' sleep.

On the morning of November 5, John, Maurice, Charlie Ridenour Hornocker, and I clambered over jackstraw piles of wind-felled trees in Trout Creek ~~Valley~~ almost at the geographic center of Yellowstone Park.

~~"Beep, beep!" came~~ The high-pitched pulsing "beep" from the tiny transistorized transmitter ~~attached~~ was direct ~~to the neck of a~~ communication with a grizzly. No bugling of elk, coyotes' howl, or honking of geese ever stirred us more.

We were following the most recent addition to our now-lengthy roster of "transistorized" instrumented grizzlies. This was No. 164. Her individual radio "call" was 62 beeps a minute. about 15 miles en-route to a den.

As we pressed on after lunch, we ~~began to~~ hopefully look at for footprints in the snow, ~~and expected~~ anticipating a glimpse of ~~to see~~ a dark form moving through the dense lodgepole pines, ~~lustrous reddish-brown fur~~ silver ~~rippling over layers of fat and muscle~~. ~~"Beep, beep, beep!"~~ ~~Steadily the electronic~~ beat came to us ~~from No. 164~~. ~~(We had long since run out of nicknames for our bear collaborators.")~~. Apart from ~~the~~ 164's insistent radio signal, utter stillness muffled the forest. The deep wingbeats of a great gray owl made no sound. The ~~R~~raucous Canada jays and scolding pine squirrels had fallen silent.

Rotating the loop antenna of my receiver I tried, from atop a heap of fallen timber, to find the "null" position--the attitude of the wire loop that voided the signal. A course at right angles to the antenna should then lead us to the bear. But I found no silent sector.

Was the grizzly in the downfall ~~directly~~ under me? The same thought struck Maurice. He braced his feet on the slippery logs ~~to give himself bal-~~ so he could ~~ance to~~ swing his ~~shot~~gun freely.

The signal ~~had become~~ was now so loud that the silver-tip could ~~not be~~ surely no more than 100 to 150 feet be under us away, but where? A startled ~~600-pound~~ grizzly could cover this distance in seconds--and ~~cuff us to kingdom come with her terrible claws~~ fatally attack us before we could even start on a run.

(underscored) 350

Too much

Sounds like a child's toy cook set.

But falling snow covered her tracks. An instinct long born, insured that she would not be tracked to her winter retreat.

We moved with utmost caution now.

(SH) Dirt at Entrance Betrays Lair

"There it is!" ~~hissed~~ whispered Maurice, and pointed to traces of dirt on packed snow 50 feet away. This litter in front of a cave opening was the ~~key clue to~~ indicator that a grizzly lay huddled within. That, plus the ~~radio signal,~~ beeping signal loud and clear with volume down. Without radio, ~~we all agreed,~~ it was unlikely that 10 men ~~couldn't~~ could have found the den, even if the search had been limited to the surrounding square mile.

~~We saw that~~ No. 164's fresh tracks led into the cave but not away from it. The grizzly sow had recently arrived, was certainly still awake, and therefore ~~must have been~~ aware that she had visitors. Our approach undoubtedly made her withdraw deep into her den.

"Wonder if she has her yearlings with her," mused Maurice.

"We ~~see~~ can't take a chance on riling her now," I said, and there were nods of agreement as we looked around at the ~~big~~ limbless lodgepoles. Our best defense against a charge would be to climb a tree; grizzlies ~~don't~~ can't. But the lowest branches on these straight trunks were 30 feet from the ground.

So we let well enough alone, content that our primary mission was accomplished. We

retreated silently and cautiously, with the thrill of having confirmed our suspicions ~~our theory~~ that grizzlies move directly to their hibernation dens during snowstorms. Thus they leave no telltale path. ~~Only~~ By radio tracking ~~could~~ we had gained ~~this~~ information on prehibernation behavior and den locations. ~~and~~ Our success with No. 164 offered ~~the~~ strongest ~~possible~~ proof of biotelemetry as an invaluable new tool in animal behavioral research.

In the fall of 1964 and ~~again in~~ 1965, we instrumented ~~more than~~ about a dozen grizzlies, seeking more information on prehibernation behavior, den construction, and home ranges. We tracked to their dens a young mother with her cub, and an old, ill-tempered grizzly with three large yearlings. We followed a pregnant sow to her winter hideout, as well as a weaned male yearling. All had dug dens. None used natural shelters. ~~All of these dens~~ dens have been lined with boughs ~~and~~ ~~all~~ must have been were situated on slopes with ~~the~~ entrances facing north. This minimizes ~~melting and~~ the accumulation of water in the dens during occasional winter thaws.

delete → The Grizzlies dug their dens at the base of large trees with ~~the~~ entrance located between thick, steeply descending roots.

One we found empty was a split-level den: The bedchamber lay ~~also~~ higher ~~level~~ than the entrance. ~~Warm air~~ was thus trapped, as in

Air warmed by body heat of the bear

at the base of large trees and all insures a deep insulating snow blanket and

Keep

~~Possible cut~~

an Eskimo igloo. Was this construction accidental or by design?

We believe that dens dug by inexperienced weaned yearlings may occasionally cave in while being used. Death by smothering could result. Could this partially account for the high winter mortality of young bears?

(SH) One Bear Dies for Each One Born

Since immobilizing our first bears in 1959, we have determined the age structure of the Yellowstone population.

We now know, for instance, that ~~at a given~~ a cross-section of the 170 odd grizzlies in Yellowstone ~~the population would show~~ ~~time~~ 19 ~~percent of the grizzlies in Yellowstone will~~ be cubs, 12 percent yearlings, 10 percent two-year-olds, 14 percent three and four-year olds, with adults constituting 45 percent of the total.

Only about a third of the adult sows are candidates for motherhood each year, because females taking care of cubs or yearlings are not receptive to a mate. Not until the youngsters are weaned, some as yearlings and some as two-year-olds, will the sows accept the attentions of the boars. The average crop of 33 cubs produced annually is fathered by a few large, aggressive males. Male parents play no other role in the family life.

Average litter size over a five-year period

~~Possible cut~~ cut

3

has been 2.2 cubs per mother with a maximum yearly average of 2.6. The largest litter we have recorded is four, although triplets occur frequently. The annual increase in population from cubs born each year has averaged about 20 percent, a proportion identical to the death rate.

Our files now brim with statistical information from which we can construct actuarial tables for bears--mean life span, mortality by age classes, and life expectancy. Now we can write the terms for a badly needed grizzly life-insurance policy. These vital statistics give backbone to a management program that can help save the grizzly from extinction.

This information has not been gleaned without some risk. Time and again we have been treed by bears—twice by the belligerent sow #39.

Grizzlies especially object to be disturbed on the day-beds they dig in soft earth. Once we followed a transistorized bear, No. 75, to where she lay bedded down with her two yearlings. At our close approach, the old and belligerent sow gave a warning "woof" to her young, and the family took off at a gallop. We found copious saliva smeared around the edge of the bed, suggesting that the mother bear

had been ~~standing with~~ nervousness at our approach. ~~Probably she had to make a close decision, whether to attack or flee~~ Her close to the roller than That she fled rather than attack was obviously a fortunate event for us.

(SH) Brawny Males Top "Pecking Order"

Over the ~~ages a ladder structure~~ years a pyramid or hierarchy has developed in Yellowstone grizzly society. Each bear, from the aggressive, dominant male down to the insecure orphaned cub or yearling, finds his place in the group. Inherent aggressiveness determines the order, however, Relative positions change from year to year. Sows ~~with~~ have cubs ~~are~~ they become more aggressive than barren when ones and attain a temporarily higher social status. They defer only to the large aggressive males.

Especially in the mating season, in June ~~an~~ and early July, the big boars wage fierce battles, competing for mates and for ruling rank.

Old Scarface, veteran of many contests, yielded to Cutlip, then briefly rewon his place as top boar only to lose a short and vicious battle to Inge. For ~~three~~ four years, 1960 to 196~~3~~4, Inge (No. 12) has dominated the grizzly communities of Trout Creek and Hayden Valley and thereby earned a name. We saw him lose one fight to ~~Whitespot~~ Scarneck, a bear he later faced down in a rematch. Inge vanquished Short-Ear, a powerful boar, and then we watched him ~~knock off~~ thrash No. 88 in bloody combat.

It was a great battle!

~~What a battle!~~ Inge rushed his adversary and sank his canines deep into 88's rump. Inge's momentum carried him over his opponent, tumbling the attacker to the ground. But Inge recovered + seized 88's right thigh and shook the 700-pound boar as a terrier shakes a rat.

Eighty-eight broke away and his huge jaws clamped on Inge's jowls. The boss bear ~~Inge~~ roared, reared back to his full height, and fought free. A great red gash marred the side of his face.

The two stood on hind legs, face to face, jaws agape, parrying like monstrous boxers. Then they locked jaws, each levering to throw the other to the ground. Inge slapped his adversary across the shoulder with a lightning-fast swipe from his huge right paw, then lunged for 88's throat. Eighty-eight staggered back, now bleeding from several deep wounds, but gave bite for bite and blow for blow. The combatants' growls and roars could be heard a half mile away.

88 lowered his head + looked aside.

Both silvertips dropped to all fours. ~~and~~ ~~then~~ Inge, ~~deliberately~~ turned his back on the challenger, moving ~~away~~ to claim his sow, ~~No. 65.~~ looked past Inge Awakening. Eighty-eight ~~made~~ no move to take advantage of this opening. The contest was over. The subtle communication between the combatants settled the fight short of death with Inge still supreme. ~~Inge reigned supreme.~~

read this sign of submission and

(SH) Thermistors Help in "I Spy" Game

Last summer we experimented with a new kind of ~~instrumentation.~~ transmitter ~~To the collars of two~~ was instrumented with a transmitter controlled by a bears ~~we attached~~ thermistors - electrical component gadgets whose resistance varies with the temperature. The thermistor controls the pulse rate of the transmitter signal. Thus variations in temperature can be read in the changing frequency of the beeps.

Recording a sharp rise in temperature, the ~~thermistor readings~~ radio signal told us, for example, when a bear moved from dense shade to bright sunshine. If a low temperature report persisted from a single location, we could conclude that the grizzly had lain down in a cool, moist place. ~~When the bear rose again and started walking, the~~ fluctuations in readings would ~~follow~~ transmitter follow the animal's wanderings through forest and open meadow.

Telemetered body temperature + heart beat can be translated into bear activity.

Another year we plan to insert thermistors into the deep tissues of some bears (in such a way, of course, as to cause minimum discomfort to the host). We have done this with elk. This will give us body-temperature readings. We hope also to ~~imprint~~ telemeter ~~transducers which will register~~ heart beat and ~~blood pressure~~ general activity using externally attached transmitters.

during the bears active period + during the deep sleep.

~~There seems no end to the~~ Many new avenues of inquiry ~~that~~ are now open. ~~Yet each year, when we leave the sleepy silvertips of Yellowstone,~~

And the more we and our research team learn the better chance there will be of saving this great animal from extinction.

TABLE I

RADIO-TAGGED GRIZZLIES
1961-1965

Bear No.	Sex and age	Tracking Dates		Animal Tracking Days	Remarks
6	5-year old female	1964	7/10-8/5	18	First cub captured and marked. Daughter of #7. Radio removed after 18 days.
7	Adult female	1963	7/26-8/12	18	Grizzly removed loose fitting collar. Recovered collar August 10.
			9/2-9/27	26 44	Tracked to fall range, last signal weak.
14	Adult male	1964	9/5-10/15	41	Large boar weighing 890 lbs. Would go 1000 lbs. by hibernation time. Transmitter functioning on last date but tracking discontinued.
34	Adult female	1964	7/23-8/25	34	Sow with 2 yearlings. Left summer range for fall range with transmitter still functioning.
37	Immature male	1961	9/30-9/31	1	Bear moved beyond range of receivers, collar missing when retrapped.
		1962	10/4-10/18	15 16	Transmitter functioning, bear lost journeying to hibernation area. Shot by hunter in spring of '63.
40	3-year old female	1961	9/22-10/22	32	Transmitter still functioning, receiver range inadequate. Bear hibernated.
	4-year old	1962	9/8-9/17	10	Transmitter no longer functioning, but still on bear. Removed by bear during hibernation.
	5-year old	1963	8/7-9/4	29	Transmitter no longer functioning but still on bear at time of hibernation.
	6-year old	1964	9/4-11/9	67	Tracked to hibernation den with cub, transmitter still functioning. Bear's first litter.
	7-year old female	1965	6/28-9/6	71	Removed 1964 collar and reinstrumented with a temperature sensitive transmitter.
			10/13-11/16	35 244	Reinstrumented and tracked to den, transmitter functioning after 11/16.
75	Old Adult female	1963	8/16-9/28	44	Bear immobilized and transmitter removed, still functioning well.
76	Young adult male	1963	8/26-9/22	28	Sow with two yearlings. Lost signal, bear traveling, transmitter functioning.
96	Young adult female	1962	8/17-8/19	2	Lost signal, bear traveled to distant portion of park. No mobile tracking units
		1963	7/12-7/17	6 8	Sow with cubs. Transmitter battery pack shorted by water.
150	Adult female	1963	10/6-11/3	29	Sow with cubs. Transmitter still functioning, bear hibernated, lost during hibernation trek.
		1964	8/11-11/4	4 33	Sow with yearlings. Trouble instrumenting at night, bear lost collar.
158	Male yearling	1964	10/11-11/9	30	Yearling with sow and 2 yearling littermates. Tracked to hibernation den, transmitter still functioning.
164		1963	10/26-11/5	11	Transmitter still functioning, bear hibernated, den located.
170	Adult female	1964	7/3-7/13	11	Sow with two cubs tracked in release and homing experiment. Transmitter removed after 11 days.
188	Weaned male yearling	1965	10/2-10/20	19	Bear lost while moving to hibernation area. Transmitter still functioning. Checked for signal over 40 day period.
194	Orphan yearling male	1964	10/16-10/18	3	Lost track of animal while following others. Transmitter recovered in spring.
		1965	9/16-10/15	31 34	Dropped collar was located & retrieved.
202	Weaned male yearling	1965	9/17-9/24 10/5-11/21	8 47 55	Tracked to hibernation den. Transmitter functioning when monitoring was stopped.
206	Large adult male	1965	8/2-8/5	4	Bear lost collar. Transmitter retrieved 8/17
210	Large adult male	1965	8/26-9/24	30	Bear moved far and fast to fall range. Unable to continue tracking.

Total - 733 Tracking days

18 different grizzlies
29 instrumentings