IUCN Publications new series No. 23

Bears

—Their Biology and Management

Papers and Proceedings
of the International Conference on
Bear Research and Management

CALGARY, ALBERTA, CANADA

6-9 November 1970

Published with the financial assistance of the
World Wildlife Fund

Union Internationale
pour la Conservation de la Nature
et de ses Ressources

International Union
for Conservation of Nature
and Natural Resources

Morges, Switzerland, 1972

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(Photo. K.Kamori)

In the bear park on Hokkaido.

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bears — their biology and management

A selection of papers and discussion from the

Second International Conference on Bear Research and Management

held at the

University of Calgary, Alberta, Canada

6 to 9 November 1970

under the sponsorship of the

Environmental Sciences Centre (Kananaskis) and the University of Calgary

Edited by
Stephen Herrero, Ph.D.

and published by the

International Union for Conservation of Nature and Natural Resources, Morges, Switzerland, 1972

Bear Proceedings

PRINTED BY Unwin Brothers Limited
THE GRESHAM PRESS OLD WOKING SURREY ENGLAND

Produced by 'Uneoprint'

A member of the Staples Printing Group (UO3614)

Prefatory Note

Presentation of papers and discussion occupied the period 6 November to 8 November 1970, following which a field trip was held on the 9th. The papers were delivered to one of five topical panels. A discussion followed each series of papers.

At the conference banquet on the evening of 7 November a special paper on 'The Status and conservation of bears (Ursidae) of the world—1970' was presented by Dr. Ian McTaggart Cowan.

Papers and their authors are listed in the Table of Contents which follows, under the headings of the five panels under which they were presented. The name of the chairman of each panel is also included.

Four other papers, whose authors—Dr. Curry-Lindahl, Dr. Kistchinski and Dr. Uspenski—were unfortunately unable to attend the conference, could not be presented during the sessions of the relevant panels. They make a valuable additional contribution to the material published in this volume.

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Introduction to the Biology and Management of Bears

STEPHEN HERRERO

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Bears have fascinated man for many thousands of years. Howell (1965) suggested the man-cave bear relationship gave rise to the best known and most durable form of animal worship, the Cult of the Bear, which had its start back in Neanderthal times and persisted until the late Paleolithic—covering a span of some 40, 000 years. Since then men have hunted and shot bears, tamed bears, continued to worship bears, studied bears, and have been intrigued by their behaviour and appearance in zoos, circuses, along roadsides and in their natural environment.

Bears are difficult subjects for scientific study. For most of the year individual bears are either solitary or exist only in small groups, occasionally congregating at choice feeding spots. Most species are wary of man and possess acute senses which enable them to avoid man. Bears are usually challenging animals to observe under natural conditions. Their power, size, relative secretiveness and certain humanoid characteristics (ability to stand on their hind legs, plantigrade feet, involved care of the young) partly account for man's interest in them.

It has become clear during the past two decades that if man is to preserve his wildlife heritage, he must either leave significant areas of appropriate habitat completely alone, something which man has not yet been willing to do, or as an alternative man must, through scientific study, come to understand the life cycles of animal species. This understanding of the requirements of each species can then be used as a basis for regulating the activities of man in areas set aside for wildlife preservation, and also for meeting the basic habitat requirements of each species.

Prior to 1970, little scientific study had been done on bears. Available information came primarily from non-scientific sources:

(1) Reports of early travellers in regions inhabited by bears

(THWAITES, R. G. (ed.) 1904. Original journals of Lewis and Clark expedition, 1804-1806. New York, Dodd, Mead & Co.,

COUES, E. (ed.) 1965. New light on the early history of the greater northwest. The manuscript journals of Alexander Henry and David Thompson, 1799-1814. Ross & Haines, Inc., Minneapolis. (Reprint).)

(2) Scholarly literature and historical reviews

(STORER, T. I.,& TEVIS, L. P. 1955. California Grizzly. University of California Press, Berkeley.

COUTURIER, M. A. J. 1954. L'ours brun, *Ursus arctos* L. Grenoble, Isère, France, Marcel Couturier.)

(3) The observations of hunters, some of whom performed excellent and detailed natural history studies of bears

(HIBBEN, F. C. 1950. Hunting American bears. J. B. Lippincott Co., Philadelphia & New York.

MILLS, E. A. 1919. The grizzly: our greatest wild animal. Houghton Mifflin Co., New York.

McCRACKEN, H. 1955. The beast that walks like man. New York, Doubleday & Co., Inc., 1955.)

(4) Observations on captive bears

(HORNADAY, W. T. 1922. The mind and manners of wild animals. Charles Scribner's Sons, New York.)

(5) Detailed natural history studies

(MURIE, A. 1963. A naturalist in Alaska. Natural History Library edition, Doubleday & Co., Garden City, New York. (Reprinted).

The natural history technique as developed by an ex-hunter has had its most recent expression in the work of Andy Russell, who has summarized thirty years of association with the grizzly bear (*Ursus arctos*) in this book *Grizzly Country* (1967).

Beginning in the late 1950's and early 1960's several groups began to apply modern and innovative scientific techniques to the long-term study of bear populations. Most significant among these groups was the Yellowstone National Park study team headed by Drs. John and Frank Craighead. They made the first extensive use of various techniques of capture and marking of individual bears and combined this with the use of radio transmitters which could be attached around the necks of individual bears for long periods of time. These transmitters functioned for years if power sources were renewed. By using these and other research techniques, the Craigheads have been able to determine the movements, reproductive performance, behaviour, habitat preferences and other characteristics of individual animals and of the grizzly bear population in Yellowstone. Most important, through long-term study of this population (the study is now in its twelfth year), the Craigheads are now able to construct life tables through study of the data on fecundity and lifespan gathered from study of individually identified animals. An important supplementary technique here is the ability to determine the age of individual bears through tooth section techniques (Marks and Erickson 1966;Sauer *et al.* 1966).

The Craigheads were the first to institute such comprehensive study of a bear population which for the most part was protected from hunting within a national park. A similar study was begun only a few years later on a hunted population of the big brown bear (*U. arctos*) on Kodiak Island (Troyer 1961; Berns and Hensel, this volume). Both studies are still in progress, which suggests that a minimum of ten years may be necessary to gain a detailed understanding of the characteristics of bear populations.

Present-day bear management techniques in North America are in most instances based on the results of these and other scientific studies. At the management level, however, conflict has sometimes arisen either over interpretation of study results (see papers by the Craigheads and by Mr. Glen Cole in this volume) or over what goals the parks should have with regard to bear management. Recently, one outspoken biologist has expressed the view that grizzly bears should be eliminated from at least Yellowstone and Glacier

National parks in the United States because of their potential to injure human beings (Moment 1968, 1970). Many authors have disagreed with Moment's view, showing that he misrepresented the statistical incidence of injury and that his views are impractical and unpopular (Caras 1969;Herrero 1970a). Nonetheless, his views on the extermination of the grizzly may become prevalent unless the public is educated to appreciate this species. Public education concerning bears should be an important function to be carried out by parks personnel, scientists and wildlife appreciators (Herrero 1970b).

The behaviour of individual bears and the social behaviour of groups of two or more bears is another topic to recently come under scientific study. Here, the techniques developed in the field of ethology have been applied and interpreted against supplementary information from ecological, evolutionary and other studies. The preliminary results of some of these studies are reported in this volume. An M.Sc. thesis done by Hornocker (1962) (as part of the Yellowstone project) investigated some aspects of the social behaviour of the grizzly bear. Other relevant studies not stressed in this volume include a review of bear behaviour done by Meyer-Holzapfel (1957), a recent European study on the role of scent-marking in the European brown bear (Tschanz *et al.* 1970) and a study by Masatomi (1964) on the social behaviour of the Yezo Brown bear (*U. arctos*).

One of the most fascinating characteristics of bears found in the colder parts of temperate regions and in the Arctic is their extended period of winter dormancy or hibernation. Studies have begun to explain the extraordinary physiology of several species of bears during this period. The cubs are born during the dormant phase and several months of nursing and cub care usually take place within the confines of those winter dens which are used for maternity. The female bear during this period neither eats nor drinks and apparently she does not defecate. Scientific study on the physiology of winter dormancy in bears was originally begun by Raymond Hock in the 1950's. For the past several years Dr. G. Edgar Folk, who reports some of his own findings in this volume, has been conducting significant investigations in this area. The actual characteristics of winter dens and factors influencing den site selection have been the subject of detailed investigations which have greatly extended our knowledge of this aspect of the biology of bears (see papers by Lentfer, *et al.;* Craighead & Craighead; Uspenski & Kistchinski, all in this volume; also Harrington 1968).

Certain dimensions of the biology or management of bears were either not discussed or only briefly mentioned at the Second International Conference on Bear Research and Management. Here I would point to economic problems caused by bears, resulting largely from land use competition between bears and the activities of man. Individuals of several species of bears will, under certain circumstances, become predators of livestock or will destroy apiaries (Murie 1948; State of California, 1967; Davenport 1953). Agricultural depredation problems may also develop, and on the northern Japanese island of Hokkaido this problem has reached serious proportions (Inukai, this volume). Bears may also be a major threat to silvicultural activities, and managers of second-growth forests have reported extensive problems with bears stripping bark and eating cambium or otherwise damaging trees (Glover 1955;Pierson 1968). These economic encumbrances generated by bears must, however, be carefully assessed against economic (hunting licences and expenses, travel and lodging expenses of persons interested in observing bears, etc.) and aesthetic benefits derived from bears and the natural areas that they occupy.

Another aspect of bear management not discussed at the conference but still important is the zoo raising, care study, and display of bears. Dr. Heinrich

Dathe of Germany has been a prominent leader in the zoo study and rearing of bears (Dathe 1961,1963).

Finally, I should point out that the studies reported in this volume on the polar bear (*U. maritimus*) are only a representative sample of a large quantity of high quality research which is now being conducted on the polar bear. This work is co-ordinated by scientists from five countries which have polar bear populations (Canada, Denmark, Norway, the United States, and the U.S.S.R.). These representatives meet as a working group under the auspices of the International Union for Conservation of Nature and Natural Resources in Morges, Switzerland. Reports from this group constitute an up-to-date summary of major research projects on the polar bear (Survival Service Commission, 1970).

Certain important studies on bears were either not presented at this conference or were not stressed. Realizing that many other important works, especially those done outside of North America may also deserve mention in this context, but may not have been known to this reviewer, I want to draw the reader's attention to the following:

BRAE, O. E., & BARNES, V. G. 1967. A literature review on black bear populations and activities. National Park Service and Colorado Coop. Wildlife Research Unit, United States.

This is a definitive review of the literature on American black bears up to 1967.

BROMELY, G. 1965. *The bears of the southern far east of USSR.* Izdatel'stvo 'Nauka' Acad. of Sciences of USSR, Siberian branch, Far east subsidiary, Moscow-Leningrad.

Originally published in Russian but now translated by the Canadian Wildlife Service, Ottawa. This work is a comprehensive, book-length summary of the topic.

ERDBRINK, D. P. 1953. *A review of fossil and recent bears of the old world.* Orukkerij Jan de Lange, Netherlands. 2 volumes.

A comprehensive but now somewhat out-of-date review of the phylogeny of European and Asian bears.

ERICKSON, A. W., NELLOR, J. & PETRIDES, G. A. 1964. *The black bear in Michigan.* Research Bull. 4, Mich. St. Univ. Agric. Expt. Sta., East Lansing Mich.

ERICKSON, A. W. 1965. *The black bear in Alaska.* Alaska Dept. of Fish and Game, Juneau, Alaska.

These are two of the many publications by the last-mentioned researcher who has been studying bears, especially the black bear, for over a decade.

JONKEL, C. J. 1967. Black bear population studies. State of Montana Job Completion Rept.#W-98-R-l, 2, 3, 4, 5, 6 Job #B-1.

Dr. Jonkel, in addition to his polar bear studies reported in this volume, has carried out one of the most thorough population studies of the American black bear.

KROTT, P. & KROTT, G. 1962. Zum verhalten das braun bären (*Ursus arctos* L. 1758) in den Alpen. *z. f. Tierpsychol.* **20:** 160-206.

KROTT, P. 1962. A key to ferocity in bears. *Nat. Hist.* LXXI: 64-71.

Dr. Krott studied the behaviour of European brown bear cubs by becoming the 'adopted mother' of two cubs. His study included many days of roaming the Italian Alps with the cubs.

PIERSON, D.J. 1965. Black bear study—population studies. State of Washington, Job Completion Rept., Project No. W 71-R-2.

PIERSON, D. J. & Hartwell, H. D. 1965. Black bear study—population studies. State of Washington, Job Completion Rept., Project No. W 71-R-3.

Mr. Pierson's research was originally stimulated by black bear damage to second growth forest in the state of Washington. The work was detailed and well co-ordinated and contributed significantly toward understanding the movements, home ranges and food habits of this species.

KURTEN, B. 1968. *Pleistocene mammals of Europe* Weidenfeld & Nicolson, London.

Dr. Kurten has been studying the phylogeny of bears and other mammals for many years. The chapter by Herrero in this volume summarizes some of his important work on bears.

RAUSCH, R. L. 1961. Notes on the black bear, *Ursus americanus* Pallas, in Alaska, with particular reference to dentition and growth. *Z.f. Saugetierkunde* **26:** 65-128.

RAUSCH, R. L. 1963. Geographic variations in size in North American brown bears, *Ursus arctos* L., as indicated by condylobasal length. *Can. J. Zool.* **41:** 33-45.

Dr. Rausch is a leading North American authority on speciation and maturation in black and brown bears. His detailed studies of clinical variations in extensive collections of skulls have clarified and negated earlier claims that as many as 80 species of grizzly bears existed in North America.

THENIUS, E. 1959. Ursidenphylogenese und biostratigraphie. *Z. Saugertierkunde* **24:** 78-84.

Dr. Thenius has for many years been conducting detailed investigations into the phylogeny of the European and Asian bears.

Finally, I want to note the obvious North American bias of this introduction and to apologize for any significant research or individuals that I have failed to mention.

The book is dedicated to Dr. Raymond Hock and to Mr. Douglas Pierson, two pioneers in the scientific study of bears, both of whom met unfortunate, accidental death.

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PANEL 1: THE ECOLOGY, POPULATION CHARACTERISTICS, MOVEMENTS AND NATURAL HISTORY OF BEARS

Radio Tracking Brown Bears on Kodiak Island

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SUMMARY

As part of a continuing study on brown bears (*Ursus arctos*), the movement patterns and activities are described on the basis of 247 fixes obtained from 14 radio-equipped bears during the summer and fall seasons of 1967-69 at the Kodiak National Wildlife Refuge, Alaska. The size of individual activity areas established by eight bears averaged 5. 5 square miles and four bears used two activity areas each that averaged 5.7 square miles in size. Activities were associated with food gathering and winter denning. Fix frequency and location indicated that the 14 bears studied spent most or 50 percent of their time in lowland habitat.

INTRODUCTION

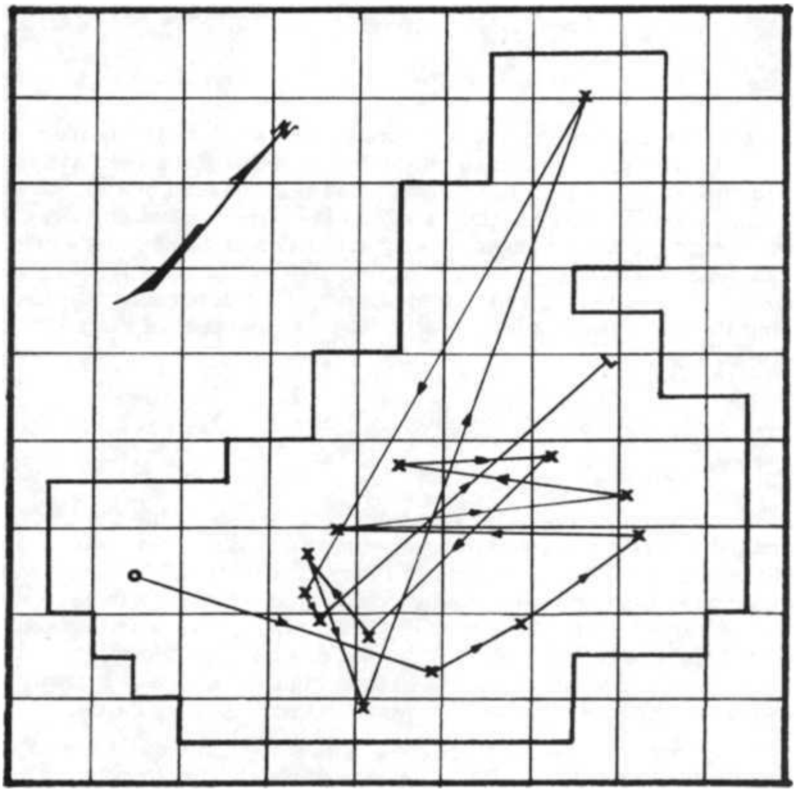
One objective of our long-term investigations was to determine the movement patterns and habitat requirements of brown bears (*Ursus arctos middendorffi*) on the Kodiak National Wildlife Refuge in Alaska. A total of 202 bears were live-trapped during periodic field studies conducted from 1959 to 1966, using techniques described by Troyer & Hensel (1961). Each bear was marked so recoveries and field observations could be the means of obtaining this information. Effectiveness, however, was reduced by a high incidence of marker loss and an excessive time lapse between observation or recovery dates.

A radio tracking study has been in progress since 1967 in an attempt to obtain more refined data (Berns 1968). This paper reports the findings made of movement and habitat use patterns noted during summer and fall seasons of 1967-69. Special credit is given to P. Martin and W. Dodge for their guidance in the use of electronic equipment.

MATERIALS AND METHODS

The 14 bears used in this study included 8 females with young, 4 solitary females and 2 mature males which were captured with the aid of steel traps and drug delivery equipment. A radio transmitter was attached as a collar around the neck of each animal (Tester *et al.* 1964). Movements and behavior of radio-equipped bears were monitored from a receiver mounted in a Piper Supercub aircraft and to a lesser extent by hand-held portable receivers operated by ground crews. As a result of the maritime climate characterizing this region, movements were only monitored from aircraft during favorable flying conditions. A detailed description of equipment specifications and monitoring procedures was given by Berns (1968). A total of 247 fixes obtained from 14 bears was considered adequate to evaluate movements and habitat use during summer and fall periods of study.

The concentration of fix locations indicated that bears made intensive use of certain areas for food gathering and denning purposes. These areas are referred to as *activity areas.* An overlay, divided into quarter section grids (160 acres), was superimposed on a map used to plot the fix locations of each bear. Fix locations were connected with straight lines as shown in Figure 1.



Scale: 1" = 1. 124 mi.

Fig. 1 Method for estimating the size of activity areas included summing the 160-acre squares containing fix locations and straight line connections that occurred inside a boundary. As diagrammed, No. 83, a female with two yearlings, ranged in an area approximately 11.7 square miles in size.

A modification of the Boundary Exclusive Method (Stickel 1954) was used to establish a boundary around an activity area. The summation of squares with fixes and straight line connections provided an estimate as to the size of each activity area. In using this method, movements of each bear were assumed to have extended halfway to the next grid. Grids separated along either axis by more than three vacant grids were considered as outside the active boundary. This procedure has the advantage over that of connecting external locations and measuring the enclosed area, in that it gives use intensity and a submeasurement of home range. It may, however, give an exaggerated activity value and also eliminate a grid in which a bear spent considerable time because it was separated by more than three vacant grids. This could happen when no fixes were obtained while an animal was moving between widely separated areas; we considered such movements as migrations and wanderings.

For the purpose of interpreting habitat usage, the approximate location of fixes was subjectively categorized as made in lowland, midland and upland habitat types. Lowlands may be described as valley bottoms containing lakes and streams bordered by grass and brush communities. Midlands consist of brush-covered foothills and uplands are characterized by open slopes or plateaus favoring alpine vegetative types.

RESULTS AND DISCUSSION

Reproductive, feeding and denning activity are important factors that influence the movements of brown bears on Kodiak Island. We recognized that 12 of the 14 bears studied had established at least one activity area during the summer and fall.

Movements between activity areas best fit the definition of migration since bears traditionally traveled over routes that connect adjacent drainages. Variations in salmon spawning chronology, as accorded by different species (*Oncorhynchus spp.*), appeared to have a marked influence on the migratory habits of brown bears. Movements related to winter denning areas may be termed as migrations while others extending outside areas of intense use may best be described as wanderings. Although brown bears may wander for no apparent purpose, we believed berry crops motivated bears to travel erratically in search of this highly preferred food item.

Seasonal Activity and Movements

The fix data indicated that each of eight bears had a definitive area of activity (Table 1). These areas averaged 5. 5 square miles in size (range: 2. 5 to 11.7 sq. mi.) and provided a source of salmon, a major food item during July, August and late fall. The largest area, approximately 11.7 square miles (Figure 1), was occupied by No. 83, a female with two yearlings. Her activities also differed in that she consistently ranged in the alpine habitat, distant from salmon streams, and presumably denned in the same area.

Seven bears ranged in proximity to salmon streams but four of these apparently wandered to distant foothills to feed on berry fruits. The information presented in Table 2 revealed that four other female bears—3 singletons, 1 female with a yearling-used two activity areas. These areas averaged 5.7 square miles and ranged 1.0 to 13.9 square miles in size. The short term observations of bear No. 50 suggested she had established **a** salmon feeding area prior to migrating 5.7 linear miles in search of a den site. If more extensive observations were made, we would expect salmon feeding would have been the focal point of her activities. The solitary female, No. 516, provided more complete information in that fix locations were recorded from July 20 through the time she denned on about November 17 (Figure 2). The activity areas she occupied were located in

TABLE 1. ACTIVITY AREA DATA FROM EIGHT FEMALE BEARS INSTRUMENTED WITH RADIO TRANSMITTERS

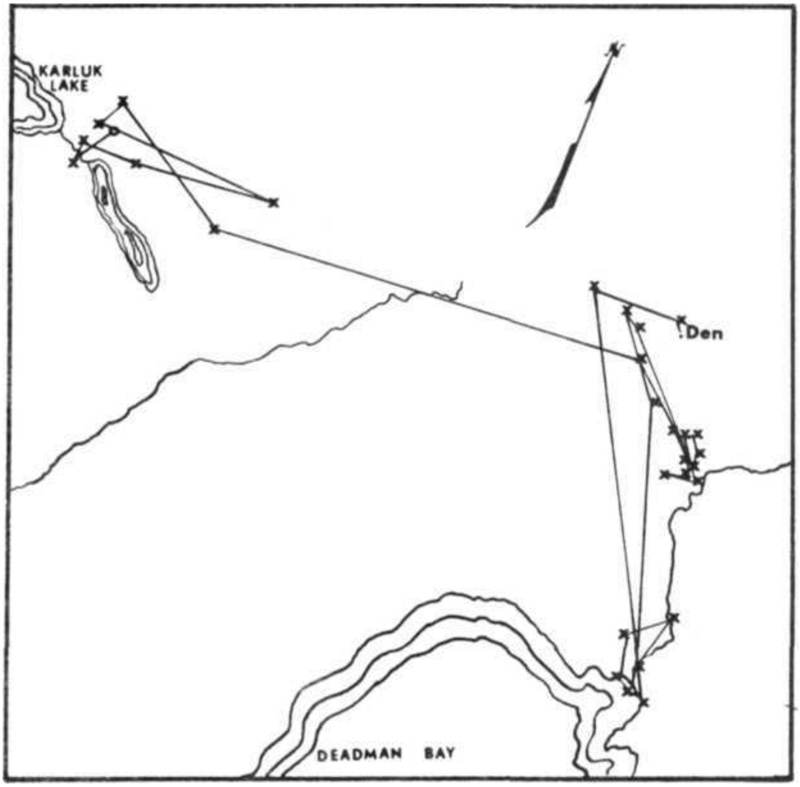
	Activity Area Data			Other Data			
Bear No.	No. Fixes	Period	Size (sq. mi.)	No. Fixes	Period	Linear Miles Moved	Remarks
655	20	7/19-9/5	2.5	–	–	–	Close fix array. Activity—salmon feeding
09	12	8/4-11/9	6.2	–	–	–	Activity—salmon feeding
83	14	8/4-11/9	11.7	–	–	–	Close fix array in alpine habitat. Activity—feeding herbaceous vegetation. Den located near last fix.
33A	20	7/16-8/5	3.8	–	–	–	Close fix array. Activity—salmon feeding
33B	34	8/12-11/7	4.7	2	8/15-9/4	24.0	Moved to adjacent drainage on 2 occasions. Activity—salmon feeding.
38[1]	26	7/15-7/28	7.0	5	8/1-8/7	6.3	Activity—salmon feeding; probable second activity area.
58	15	7/20-10/31	4.1	1	8/12-8/12	15.9	Approx. 10 days outside activity area. Activity—fishing, berry feeding.
87	7	8/3-9/4	4.6	3	9/11-9/24	10.3	Remained in same drainage. Activity-salmon feeding.

[1] Bears listed had yearling cubs except solitary female No. 38.

TABLE 2. ACTIVITY AREA DATA FROM FOUR FEMALE BEARS INSTRUMENTED WITH RADIO TRANSMITTERS

	Activity Area No. 1			Activity Area No. 2			Other Data			
Bear No.	No. Fixes	Period	Size (sq. mi.)	No. Fixes	Period	Size (sq. mi.)	No. Fixes	Period	Linear Miles Moved	Remarks
50[1]	4	10/22-10/24	1.0	3	11/11-12/15	1.5	0	–	5.7	Moved from feeding to denning area; den located 12/15.
42	10	7/21-8/2	7.7	8	8/19-9/17	3.0	5	8/3-8/25	29.4	May have fed on berries while wandering between activity areas.
516	7	7/20-7/28	7.1	22	8/1-11/17	13.9	0	–	4.6	Moved from feeding area to denning area; den located 11/17.
57	7	7/16-9/5	4.0	7	10/8-10/18	7.4	3	8/1-8/2	4.0	Moved from feeding area, wandered 4 miles; moved to denning area.

[1] Bears listed were solitary females except No. 50, a female with one yearling.



Scale: ½" = 1.37 mi.

Fig. 2 Movement pattern of No. 516, a solitary female, from July 7 through November 17, 1968, revealed the use of two activity areas. The Karluk Lake area, 7.1 square miles in size, offered an abundant supply of salmon while the 13.9 square mile area near Deadman Bay provided berries, salmon and a place to den for the winter.

the Karluk Lake and Deadman drainage and covered approximately 7.1 and 13.9 square miles respectively. Activities at Karluk Lake apparently concerned salmon feeding while those at Deadman involved berry-salmon feeding and selecting a place to den for the winter.

Habitat Use

The frequency and percentage of the time 14 bears were located in three habitat categories is given in Table 3. The fact that bears were located 50 percent of the time in lowlands reflects the effort bears expend in preying on salmon. The foothills characterizing midland habitat are evidently used as resting places between forays to salmon streams and, more importantly, to feed on berries. The phenology of Kodiak Island reveals berries mature concurrently with the seasonal decline of major salmon runs. Bears respond by foraging along midlands and traversing the uplands to descend upon the berry thickets found along adjacent foothills. Lowlands are occasionally visited as the means of supplementing berry diets with salmon which spawn in diminishing numbers up to the time bears begin to den for the winter.

Obviously, movements of bears differ according to changes in environmental conditions. Major shifts in habitat use can be expected during times of food scarcity or abundance and the processes of winter denning.

TABLE 3. FREQUENCY AND PERCENT ( ) OF THE TIME BROWN BEARS USED THREE HABITAT CATEGORIES DURING SUMMER AND FALL PERIODS

Bear No.	Sex	Habitat Category			Total No. of Fixes
		Lowland	Midland	Upland	
655	F	20(100)	—	—	20
50	F	3(75)	—	1(25)	4
09	F	1(8)	5(42)	6(50)	12
83	F	4(29)	2(14)	8(57)	14
33A	F	6(30)	12(60)	2(10)	20
33B	F	6(18)	27(80)	1(2)	34
42	F	19(79)	4(17)	1(4)	24
38	F	12(63)	3(16)	4(21)	19
516	F	23(74)	3(10)	5(16)	31
57	F	17(57)	11(37)	1(3)	29
58	F	5(30)	11(64)	1(6)	17
87	F	5(56)	2(22)	2(22)	9
19	M	1(11)	5(56)	3(33)	9
86	M	3(60)	1(20)	1(20)	5
Total No. of fixes		125	86	36	247
Time in habitat category (%)		50	35	15	

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PANEL 1: THE ECOLOGY, POPULATION CHARACTERISTICS, MOVEMENTS AND NATURAL HISTORY OF BEARS

Black Bear Population Dynamics at Cold Lake, Alberta, 1968-70

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SUMMARY

A black bear *(Ursus americanus)* population study was initiated near Cold Lake, Alberta in 1968. In the three succeeding years, 108 individual bears have been captured 210 times. Mean estimates of population on the 80 square mile study area have been 78 in 1968, 79 in 1969, and 78 in 1970. Sex ratios of trapped subadults and in adults in 1968 and 1969 did not differ significantly from a theoretical 50:50. Significant differences in the adult cohort in 1970 were probably due to differences in mobility; the males ranging considerably more than females. The age composition of the black bear population did not differ significantly from other unhunted bear populations. A time-specific life-table analysis disclosed that mortality rates were 26.7% in cubs, 36.7% in yearlings, 37.5% in 2-year olds and 12. *5%* in adults.

INTRODUCTION

Our investigations of black bear population dynamics and ecology began near Cold Lake, Alberta, in May 1968. The purpose of this study is to determine the regulatory mechanisms acting on an unhunted black bear population. The initial phase of this study, in which we are presently involved, is designed to calculate estimates of population, determine rates of age-specific survival and mortality, and document the demographic parameters of the bear population. The second phase of our study is to evaluate the impact of environmental factors on bear population. This phase is directly concerned with population regulation.

We are presently capturing, marking and releasing bears on an eighty square-mile study area bordering the northwest shore of Cold Lake. Each animal is weighed, measured, individually color-marked for field identification and tattooed for permanent identification. In addition a tooth, either P_4 or P_1 is extracted for sectioning and subsequent age determination. During the period 1968-1970, 108 individual bears have been captured 210 times.

The present paper briefly presents our material on population phenomenon to date and presents a resume of future project activities.

POPULATION ESTIMATES

In bear studies previously conducted, estimates of population have been based on a variety of methods, these ranging from Lincoln and Schnabel estimates, in at least two studies, to questionnaires, dump counts, casual observations, numerous census techniques and in many cases to simple guess work (Bray & Barnes 1967).

A basic assumption in the use of marked/unmarked ratios to estimate total numbers is that either the initial marking or subsequent recapture or both be conducted in a random manner. Other prerequisite assumptions were considered fulfilled.

Homogeneity of trap response was tested by comparing the frequency distribution of capture (Table 1, column 2, 4 & 6) with an appropriate Poisson distribution (Table 1, column 3, 5 & 7) for the years 1968-1970. The mean (m) for the Poisson distribution was calculated by completing the O-capture category of the frequency distribution of captures using a 'maximum likelihood technique' described by Hartley (1958). The insignificant chi-square values (Table 1) indicate that we have achieved homogeneity of trap response and can hence utilize our capture data to calculate estimates of population based on Lincoln-index and Schnabel estimates (Table 2). Further, completion of the O-capture category as previously described, afforded us an additional independent estimate of population (Table 2). The Schnabel estimates (Table 2) were modified by calculating the mean estimate from the individual estimates only after the individual estimates had reached a plateau and levelled off.

The resulting mean estimates of population (Table 2) indicate a density of approximately 1 bear/square mile on our study area. This rather high density appears to be a function of diverse habitat types available on the study area. Certainly bears occupy different habitat types throughout the summer period and these appear to be adequately represented on the study area. The estimates also suggest a remarkable degree of stability in population numbers from 1968 to 1970. This stability would, however, be somewhat anticipated for a large carnivore such as the black bear.

TABLE 1. DISTRIBUTION OF TOTAL CAPTURES OF BEARS NEAR COLD LAKE, ALBERTA, Summers, 1968-1970

No. of captures for individual bears	1968 No. of bears	1968 Poisson m=1.20	1969 No. of bears	1969 Poisson m=0.50	1970 No. of bears	1970 Poisson m=0.85
0	?		?		?	
1	24	24.0	32	32.8	34	34.2
2	13	14.4	8	8.2	15	12.8
3	5	5.8	2	1.4	4	4.4
4	2	2.1			1	1
5	1	1				
Totals	45	46.3	42	42.4	54	52.4
Chi-square	0.65		0.11		0.46	

TABLE 2. BLACK BEAR POPULATION ESTIMATES FOR 1968-1970

1968			1969			1970		
Mean date	Numbers estimated	Basis[1]	Mean date	Numbers estimated	Basis[1]	Mean date	Numbers estimated	Basis[1]
June 6	40	A	May 25	91	A	May 25	76	A
July 16	145	A	July 17	56	A	June 21	78	A
Aug. 23	79	A		108	B	July 28	76	A
	76	B		62	C		94	B
	62	C					64	C
Mean	78 ± 47			79±40			78±13	

1) Numbers estimated based on:

A. Lincoln index; retrapping of marked individuals.
B. Completion of O-capture category using a 'maximum likelihood' technique.
C. Modified Schnabel.

SEX RATIOS

There was no significant difference in sex ratios of trapped bears in 1968 and 1969 (Table 3). The 35: 19 sex ratio in 1970 is, I feel, a function of mobility differences between males and females, particularly during the breeding season. Our movement data indicates that adult males are the most mobile cohort in the bear population, particularly during the breeding season. Likewise, females with cubs are very sedentary and are difficult to trap at different baited snare locations. The sex ratio of subadults does not differ significantly from the theoretical 50:50 and we can see no factor which would induce sex-specific mortality on adult females.

TABLE 3. SEX RATIOS BY AGE GROUPS FOR BLACK BEAR POPULATION 1968-1970

	1968		1969		1970		
	No. Males	No. Females	No. Males	No. Females	No. Males	No. Females	Total
Cubs	6	4	2	3	4	2	21
Yearlings	1	1	6	3	4	3	18
Older	18	17	16	12	27	14	104
Totals	25	22	24	18	35	19	143

AGE RATIOS

To make our data comparable to that of other workers, the age cohorts are indicated as cubs, yearlings and older animals (Table 3). This breakdown is convenient in that yearlings can be fairly accurately aged from weight alone. Tooth sectioning is not yet completed.

The age composition of our black bear population does not appear to be appreciably different from the age composition data published by Troyer & Hensel (1964) for Alaskan brown bear or Hornocker (1962) for a Yellowstone grizzly population.

MORTALITY RATES

A time-specific life-table analysis was used to compute mortality rates from population age composition data obtained from known-age animals (Table 4). A basic assumption in a life-table approach of this type is that the population is stationary and age stable with fixed rates of birth and death. Our population estimates and age composition data suggest that our bear population may indeed meet these assumptions. Pooling the data for 1968 and 1969 would further reduce any distortions from varying birth rates.

The life-table analysis discloses a mortality rate of 26.7% in cubs, 36.7% in yearlings and 37.5% in 2-year olds. Upon reaching maturity, this mortality

TABLE 4. TIME SPECIFIC LIFE-TABLE ANALYSIS OF AGE COMPOSITION DATA

Age	Number alive l_x	Number dying d_x	Mortality q_x
c	15	4	26.7
1	11	3	36.7
2	8	3	37.5
3	5		
4	4		
5	5		
6	2		
7	7	5	12.5
8	6		
9	2		
10	1		
>10	8		
	74	15	

rate declines to 12.5%. The relatively high mortality in yearlings and 2-year-olds appears to coincide with the period beginning with self-sufficiency and before reaching maturity. Our movement data further demonstrates that subadults are only slightly less mobile than adult males. Hence this mortality is associated with dispersal of the subadults. Our hypothesis at this time is that this mortality is induced by adult members of the bear population and hence the bear population would be largely self-regulating.

PROPOSED PROGRAM

At this time we suspect that mature males are responsible for the high mortality of the subadult bears. To test our hypothesis we propose to eliminate as many adult males as possible, beginning in 1971 or 1972 at the latest. We will then monitor the population for a further two years to document changes in subadult survival and reproduction. Elimination of the adult males will also imitate the type of exploitation we wish to promote in a trophy-hunting situation. This program will then give us some indication of the proportion of adult males we can harvest without significantly reducing reproduction.

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PANEL 1: THE ECOLOGY, POPULATION CHARACTERISTICS, MOVEMENTS AND NATURAL HISTORY OF BEARS

Population Characteristics of the Northern Interior Grizzly in the Yukon Territory, Canada

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INTRODUCTION

The grizzly bear (*Ursus arctos*) is one of the most important big game species in North America. Although its dominant position in the ecoystem continually places it in conflict with man, mortality from sport hunting and nuisance kills cannot be properly evaluated without some information about the natural population dynamics of the species.

In 1964 the Canadian Wildlife Service began research on the ecology of the Northern Interior grizzly bear. This ecotype of grizzly occurs over the interior mountains of northern British Columbia, the Mackenzie Mountains of the Northwest Territories, the Yukon Territory, interior Alaska, and over the arctic tundra of Canada and Alaska.

A study area in the Kluane Game Sanctuary in southwestern Yukon Territory, where grizzly bears are protected from hunting, was established. These grizzlies do not live under coastal conditions and do not depend on anadromous fish runs for annual sustenance.

This paper presents preliminary information on the population dynamics of the grizzly in the study area. Pearson *et al.* (1968) and Choquette *et al.* (1969) have published other aspects of the study.

STUDY AREA

The area of study was approximately 520 square miles centred around the conflux of the Dezadeash and Kaskawulsh Rivers which joint to form the Alsek River flowing 100 miles south to Dry Bay in the Gulf of Alaska. Fourteen miles of road and four miles of navigable river provided our only access into the area. Travel by helicopter was possible, but too expensive to permit intensive coverage.

The elevation ranges from 1,900 feet to 7,600 feet above sea level. Four biotic zones were differentiated:

1. Gravel flood plains

These areas are gravel and mud crossed by river channels. Vegetation, constantly invading the less active fringes of the flood plains, includes a variety of grasses, pea vine (*Hedysarum alpinum*), raspberries (*Rubus* sp.), gooseberries (*Ribes,* sp.), bearberry (*Arctostaphylos uva-ursi*), and, most important to the grizzlies, soapberry (*Shepherdia canadensis*). The tree cover is spotty and consists mainly of willow (*Salix* sp.). A few balsam poplars (*Populus balsamifera*) and white spruce (*Picea glauca*) also occur.

2. Spruce forest

This zone begins where the valley flats meet the mountain slopes and extends upwards to the 3,000- to 4,000-foot level. Between zones 1 and 2 an intergradation zone varies in size according to the steepness of the mountain slope. The forest is composed mainly of white spruce with some stands of willow, balsam poplar, and white poplar (*Populus tremuloides*). Dense thickets of alder (*Alnus* sp.) grow in the moist spots. Various grasses grow on the steeper, drier slopes.

3. Sub-alpine willow

Dense stands of dwarf willows and birch (*Betula glandulosa*) dominate the 4,000- to 6,000-foot levels. Typically alpine flora is found in the moist area of the plateaus; herbaceous species, in the upper limits.

4. Rock and snow

Above the 6,000-foot level, vegetation is sparse although some lichen communities occur. There are extremely steep rock outcroppings and talus slopes, many permanently covered by snow.

TECHNIQUES

The grizzly bears were captured in traps or shot with a tranquilizing drug from a pursuing helicopter. Precoded, coloured flags were attached to the ears of the animals to allow subsequent identification of observed grizzlies. This provided information on movement, reproduction, and mortality. In 1968 and 1969 radio transmitters were attached to bears by neck collars, and subsequent tracking from the ground and air provided more comprehensive data on movements.

RESULT

Reproduction

The litter size is smaller than that recorded in other areas. Thirteen sows had 22 cubs and yearlings. Yearlings were included in the calculation only if the number of cubs originally in the litter was unknown. There was a mean litter size of 1. 58 compared with 2.36 for the Kodiak National Wildlife Refuge (Troyer & Hensel 1964); 2.2 for Glacier National Park (Mundy 1963); and 2.19 for the Alaska Peninsula (Lentfer 1966). Most litters had one cub; some had two; and only two litters had three cubs.

The young remain with the sow until late May of the third year when the family unit breaks up. The female then breeds in June. If breeding is successful, there is a three-year breeding cycle. A four-year cycle between litters occurred in two cases when breeding was unsuccessful.

The age of sexual maturity of male grizzly bears in the area was not studied. However, there appeared to be a surplus of large males which ensure breeding of all receptive females. Erickson *et al.* (1968) observed that male brown bears from coastal Alaska reached sexual maturity at four years.

The age of three females at or near sexual maturity was judged from annular lines in the cementum of the teeth. One animal killed at 6½ years had two corpora lutea of pregnancy in its ovaries. Two other females were seen in the company of males only in June of their sixth year. It would appear that sows first go into oestrus at 6¼ years and have their first litter at seven. Hensel *et al.* (1969) found that grizzly females on the coast commonly reach sexual maturity during their fourth year.

No previous information has been published on the life expectancy of grizzlies. Annuli of teeth of grizzly specimens collected in the Yukon indicate that only a few females live longer than 16-17 years. It is, however, more difficult to judge the age of older animals, and the estimates may be inaccurate.

Mortality

During the five years of the study two adult males wandered from the game sanctuary and were killed by hunters. Probably most adult male grizzly bears are subject to hunting pressure since they wander over much larger areas than do other grizzlies.

One aged male (20+ years) and one sub-adult male (4½ years) were killed by other bears. Two adult males captured alive had large infected wounds that could have been inflicted only by another grizzly.

Of the 14 cubs observed in the study area, 11 survived as yearlings. Of these one died a natural death. Thus, of 14 cubs born 10 were weaned at 2½ years.

Movements

Radio tracking has shown that under normal conditions grizzly females do not go long distances. The mean range of eight sows during 1969 was 27 square miles. And there is some indication that sows follow a traditional route, perhaps learned from the parent. It was not uncommon to find two or three sows with some common physical characteristic making much the same movement pattern.

The boars cover a much greater area—average range over 114 square miles—and it is, therefore, difficult to track them accurately. New untagged males were caught in the study area each year and it is not known from where or how far they came. Most of the wandering was done in August and September when the animals were feeding along the alluvial valley bottoms. 'Homing' probably occurs among boars since some of them were seen or captured, or both, in the intensive area during all five years of the study. Random movement is not likely to produce such results.

Although they do not normally range over great distances, sows can travel quite far when relocated. One grizzly sow transferred 70 miles from its home site, returned to it in three days.

Population structure

Forty-seven different grizzlies were captured and marked on the intensive study area. In addition nine young of marked bears were observed but not tagged. One untagged sow with two young was seen and identified in 1968 and 1969.

In an area of approximately 500 square miles the annual population increase averaged 4.8 animals. This number could be harvested each year without adversely affecting the population of approximately one grizzly per 10 square miles.

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Use of Foot Trail Travellers in the Great Smoky Mountains National Park to Estimate Black Bear *(Ursus americanus)* Activity[1]

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SUMMARY

The Great Smoky Mountains National Park is a relatively inaccessible area. Only one highway dissects the center of the park, and most areas can be reached only by foot trail. Over 700 miles of trails are maintained in the park; of these, 310 miles are located on the Tennessee side. Beginning in April 1970, 10 routes (19 different trails covering 180 miles) on the Tennessee side were designated as 'Index Trails' and used to determine black bear activity. From April through October 1970, these routes were hiked for a total of 2, 363 miles. The exact location of each bear scat and bear sighting was recorded. Bear survey forms were distributed to backpackers using the trails for extended periods. Over 400 scat-locations and 150 live-bear observations were recorded. Information gathered indicated the distribution, areas of high-bear use, and seasonal onset, peak, and cessation of activity of the black bear in the park. Potential use of the data for estimates of black bear density, food habits and movements, and solutions to some bear-person interactions are discussed.

INTRODUCTION

It is agreed by most wildlife biologists that perhaps the greatest challenge to the profession is that of being able to census with accuracy and precision a population of wild animals. This challenge is especially important at two points in the population dynamics of a species: (1) when the population is so high as to affect its surroundings adversely and (2) when the population is so low as to place the species in danger of extirpation by the untimely influence of various intrinsic and/or extrinsic factors. In many instances black bear populations fit the latter category.

Gilbert (1951) pointed out that apparently no state uses a census method of estimating black bear (*Ursus americanus*) population densities. Spencer (1955) reported that 'No wholly satisfactory method has been devised for censusing the black bear'. It is obvious from the more recent literature that little progress has been made in this direction. It appears that only Spencer *(op cit.)* has utilized bear scat for other than food habits studies. He made random

[1] This study was supported through funds made available from Mclntire-Stennis Project No. 12 and the Agricultural Experiment Station, Institute of Agriculture, University of Tennessee, Knoxville.

cruises of known mileage by foot and canoe in Maine to count scat and other signs as a method for estimating black bear density. It is essential that wildlife biologists continue their quest for better census techniques especially populations of those species that fall into one or both of the categories mentioned above.

As a part of a long-term study of the natural history, ecology and behavior of the black bear in the Great Smoky Mountains National Park (hereafter referred to as GSMNP),an intensive effort is being undertaken to census this species using various techniques. Part of this effort involves recording the incidence (exact date and location) of bear scat (droppings) along established 'Index Trails' within the park boundary. Inaccessibility of most areas of the park by motorized vehicles, and an extensive and well-maintained trails system, provide a good opportunity to undertake such an endeavor. It is hoped that results from using this technique can be related to direct counts or other population estimation techniques and provide a more accurate and precise census of the black bear population in the park.

It was also recognized that these data could be used in delineating other aspects of this animal's life history. This paper includes the preliminary results from traversing these trails and an evaluation of the techniques involved. The usefulness of the data for delineating various parameters of the life history of the black bear is also discussed.

DESCRIPTION OF THE STUDY AREA

The GSMNP covers 800 square miles (512,000 acres) of the Southern Appalachian mountain region. The park is characterized by rugged terrain with 16 peaks rising above 6, 000 feet in elevation (the highest section of mountains in the Appalachian chain). Within the park, altitude varies from 900 feet to over 6,600 feet. With respect to climate and plant life, a trip from the foothills of the park to its highest point is equivalent to a trip from the valley of East Tennessee to southern Canada. Temperature differences from 15 to 25°F are commonly reported between the extremes in altitude within the park. Annual rainfall varies from 45 to 55 inches at low elevations to 85-100 inches at high elevations. High rainfall provides the runoff for over 600 miles of clear mountain streams.

Major vegetation types are: cove hardwood, hemlock, northern hardwood, spruce-fir, closed oak, open oak, pine, and balds (heath and grass). The cove hardwood forest is located in coves and sheltered slope sites to 4, 500 feet elevation. The hemlock forest is typically restricted to sheltered topography along streams up to about 3,000 feet but occurs on more exposed slopes and lead ridges from 3,000 to 4,500 feet. The northern hardwood forest occurs above 4,500 feet and is dominated by beech (*Fagus grandifolia*) and yellow birch (*Betula lutea*). The spruce-fir forest also occurs principally above 4,500 feet. The closed oak forest is found on intermediate to dry slopes and is dominated by oaks (originally by the American chestnut, *Castanea dentata).* The open oak, pine and bald vegetation types are characteristically found on more exposed slopes and ridges. This high diversity of plant life results in a great variety of vertebrate life as well.

One major highway dissects the park. However, many paved roads skirt its perimeter. Over 700 miles of hiking trails are maintained in the park of which 310 miles are located on the Tennessee side (excluding 70 miles on the Appalachian Trail). The Appalachian Trail traverses the Tennessee-North Carolina border along the highest peaks. Twelve permanent stone shelters are located along this trail.

METHODS

On the Tennessee side a total of 19 different trails representing 10 circuitous routes were designated as 'Index Trails'. Most routes started at a low elevation, went to a high elevation, encompassed a section of the Appalachian Trail and an overnight trail shelter, and returned by way of a different trail. 180 miles out of the total of approximately 310 (plus 70 on the Appalachian Trail) on the Tennessee side were included in the Index trails. The length of the routes ranged from 13 to 27 miles. From 4 April to 31 October 1970, most of the 10 routes (19 trails) were hiked biweekly by bear project personnel, graduate students and undergraduate wildlife majors. No route was hiked less than 10 times or more than 15 times during the study. Miles hiked ranged from

TABLE 1. HIKE DATES AND NUMBERS OF BEAR SCAT LOCATED IN THE GSMNP.

Date	Number of Routes Taken	Number of Trails Taken	Miles Covered	Number of Scat Located	Scat/Mile	Miles/Scat
Apr. 4	4	8	75	0	0	0
Apr. 18	3	6	51	4	0.078	12.75
May 2	9	17	160	5	0.031	32.0
May 16	9	18	167	4	0.024	41.8
May 30	10	19	180	23	0.127	7.8
June 13	9	17	163	17	0.104	9.59
June 27	10	19	180	15	0.083	12.0
July 11	7	13	123	27	0.219	4.5
July 25	10	19	180	17	0.094	10.6
Aug. 8	7	14	126	11	0.087	11.45
Aug. 22	10	19	180	41	0.227	4.4
Sept. 5	9	17	166	29	0.174	5.7
Sept. 19	8	15	133	28	0.210	4.7
Oct. 3	10	19	180	40	0.220	4.5
Oct. 17	10	19	180	7	0.038	25.7
Oct. 31	7	14	119	4	0.033	29.8
Total or Average	132	263	2,363	272[1]	0.115	8.69

[1] 155 additional scat were collected at a garbage dump at the half-way point of one index route.

156 miles on the Sugar lands route to 351 miles on the Elkmont-Bent Arm route (Table 2). The exact location of each bear scat was recorded and the scat collected. Pertinent data were recorded on actual bear sightings. Bear survey forms were distributed to backpackers using the trails for extended periods.

RESULTS

A total of 132 separate routes were hiked at two-week intervals in the period 4 April through 31 October 1970 (Table 1). A total of 2, 363 miles were hiked and 272 bear scat located and collected. An additional 155 scat not used in tabulating results were obtained at a garbage dump near one route. An average of 147.6 miles was covered during each biweekly period. On six of the 16 periods all trails were hiked.

The number of scat per mile ranged from zero on 4 April to 0.227 scat on August 22 (Table 1). The number of miles per scat ranged from 41.8 miles on May 16 to 4.4 on August 22. The average miles per scat for all routes was 8.69. A dramatic increase in the incidence of scat was observed between May 16 and May 30. A distinct peak in numbers collected occurred between August 8 and October 3 followed by a rapid decline between October 3 and October 17. The most productive route for scat was Sugarlands with an average of 2.52 miles per scat and the least productive was Gregory Bald with an average of 238 miles per scat (Table 2).

Altitudinal distribution of scat exhibited a remarkably linear relationship. Only four scat (1. 5 percent) were found at less than 2, 500 feet elevation with 155 (56 percent of the total) being found at elevations greater than 4, 500 feet (Table 3).

TABLE 2. INDEX TRAILS AND NUMBERS OF BEAR SCAT LOCATED IN THE GSMNP.

Route	Number of Trips Made	Number of Miles Covered	Number of Scat Located	Scat/ Mile	Miles/ Scat
Mt. Cammerer	13	260	14	0.53	18.57
Snake Den	13	273	19	0.69	14.37
Greenbriar	10	200	8	0.040	25.0
Alum Cave	15	210	19	0.90	11.05
Trillium Gap-Bullhead	13	182	35	0.192	5.2
Sugarlands	12	156	62	0.397	2.52
Elkmont-Bent Arm	13	351	67	0.190	5.24
Tremont	15	255	36	0.141	7.08
Spence Field	14	238	11	0.046	21.64
Gregory Bald	14	238	1	0.004	238.0
Totals	132	2,363	272	0.115	8.69

TABLE 3. THE RELATIONSHIP BETWEEN MONTH, ALTITUDE AND NUMBERS OF BEAR SCAT LOCATED IN THE GSMNP.

	Less than 2, 500 ft.	2, 500- 3, 500 ft.	3, 500- 4, 500 ft.	Greater than 4, 500 ft.	Total
April	1	1	2	0	4
May	1	3	10	21	35
June	0	1	10	23	34
July	0	5	18	24	47
August	1	3	12	39	55
September	1	5	20	32	58
October	0	6	17	16	39
Totals	4 (1.5%)	24 (8.8%)	89 (32.7%)	155 (56.9%)	272

TABLE 4. A SUMMARY OF LIVE BEAR OBSERVATIONS BY INDEX TRAIL HIKERS AND SURVEY BACKPACKERS IN THE GSMNP.

Date	Index Hiker Count	Backpacker Survey Count	Total
April 4	–	–	–
April 18	–	–	–
May 2	1	–	1
May 16	4	–	4
May 30	5	–	5
June 13	5	8	13
June 27	6	17	23
July 11	4	16	20
July 25	7	6	13
Aug. 8	7	14	21
Aug. 22	12	21	33
Sept. 5	1	8	9
Sept. 19	3	0	3
Oct. 3	8	–	8
Oct. 17	6	–	6
Oct. 31	–	5	5
Totals	69	95	164

From a total of 92 survey forms distributed to backpackers, 68 (74 percent) were returned of which 48 (70 percent) reported one or more bear sightings. Table 4 summarizes live bear observations by index trail hikers and backpackers. Index trail hikers recorded a total of 69 live bear observations while backpackers recorded a total of 95 observations.

DISCUSSION

General black bear activity in the GSMNP is not appreciated by the park visitor who does not see this animal until after the first of June. The high influx of visitors to the park at this time and a concomitant movement of some bears to areas where they are readily observed (artificial and easy sources of food along roads, in picnic areas and in campgrounds) gives a false impression regarding the emergence of black bears. This apparent high degree of activity of the bear population continues until after the peak of fall leaf colors and the large reduction in numbers of park visitors. In fact, preliminary attempts at delineating black bear activity and density in the GSMNP and Yellowstone National Park have revealed that total numbers of bears counted on specific dates seem to be directly related to intensity of use of the park by visitors (e.g. easily observed bears were usually counted and these were typically panhandler roadside bears responding to visitor influx). Thus, an important question arises as to the degree to which people influence the general activity and local density of bear populations. It is apparent that direct counts indicate that number of bears are influenced by number of park visitors at any given time or place. However, this technique does not provide evidence as to the status of the total bear population within an area. Direct counts could present a very misleading picture of the activity and density of a bear population.

In the present study onset of black bear activity, as evidenced by the incidence of scat, begins before the first of June and the high visitor influx into the park. Peak activity occurs later than peak visitor-use (July and early August) and coincides with bear's time of intensive feeding and fattening before Fall. Based on the incidence of scat, cessation of bear activity apparently occurs before the peak of leaf colors and major reduction in numbers of park visitors. These data therefore indicate some degree of independence between seasonal black bear activity and intensity of visitor-use of the park.

However, areas of high and low use by bears as revealed by the incidence of scat on index trails support other data being collected on live bear observations. The least productive areas for scat (Gregory Bald, Greenbriar and Mt. Cammerer) are subjected to heavy pressures by poachers and dogs. Few live-bear observations have been made in these areas by park personnel, visitors or bear study personnel.

Some conjectures and observations about data on index trails, incidence of scat and bear populations for Spence Field (an area of low incidence of scat but excellent bear habitat) follow. If the incidence of scat is a true reflection of relative population density and activity of the black bear, then one would postulate that the Spence Field area contains a sparse population of bears compared to other areas in the park. Below Spence Field (at low elevations) is one of the largest campgrounds in the park and a picnic area as well. Here also is found the highest concentration of panhandler bears within the park. The attraction of the picnic and camping areas as a source of food likely causes a large influx of bears from the Spence Field area (and perhaps other areas) to concentrate at these low elevations.

While visitor-use on a park-wide scale seemed to be independent of seasonal bear activity, these data indicate that density of black bears in local areas can likely be affected by people quite dramatically. In fact, visitors and poachers are probably the greatest factors influencing the areas of high and low concentrations of bears within the park.

Further evidence of the role of people in influencing bear populations was obtained from the two most productive index trails for scat (Sugarlands and Bullhead). Both of these trails are located close to Highway 441, the only major highway crossing the park and over which millions of visitors pass each year. The Bullhead trail also traverses Mt. LeConte where a number of bears are attracted by a lodge and its garbage dump. Also, the above two areas (Sugarlands and Bullhead) are relatively well protected from poachers and dogs as compared to other areas within the park. Areas along the Elkmont and Tremont trails are also relatively well protected and revealed a higher incidence of scat.

Several possibilities may account for the higher numbers of scat at high elevations within the park. However, data are inconclusive at this time. Because of the greater rainfall, steeper grades and more exposed trails at higher elevations, one would expect scat to disappear much more quickly than at low elevations. However, preliminary data indicate that bear scat are highly resistant to weathering. Observational data indicate that scat at high or low elevations remains identifiable for at least two weeks.

Through the use of survey forms distributed by index-trail hikers to backpackers, much data can be obtained concerning observations of bears and bear activity. As more and more bears are individually marked in the population, and index-trail hikes are continued, the increasing amount of data will lend itself to various indirect population estimation techniques, analyses of movement of bears in relation to altitude and location, and the influence of people on the bear population.

Thus far, index trails have provided enough scat to analyze the food habits of black bears as influenced by season, altitude and location in the park. Also, preliminary information from the incidence of scat of other mammalian populations (bobcat, fox and European wild boar) indicates that these animals could be evaluated in the same way and in conjunction with bear index trail hikes.

Index trails and scat collections also lend themselves to possible 'feces-tagging' techniques such as radioactive isotopes, dyes, or the use of inert rare earths through Activation Analysis. Thus, captured bears (or other large vertebrates) could be injected with an identifiable 'feces-tag'. Then, when scat is later picked up on index trails, it could reveal movement information as well as population estimates through a ratio of tagged to untagged feces.

Alone, the index trails have provided an invaluable tool for evaluating black bear populations in the GSMNP. In combination with other data (live bear observations) and other techniques (telemetry and/or 'feces tags'), much new knowledge will be revealed about the ecology and natural history of the black bear in the Great Smoky Mountains National Park.

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PANEL 1: THE ECOLOGY, POPULATION CHARACTERISTICS, MOVEMENTS AND NATURAL HISTORY OF BEARS

A Summary of the Black Bear Population Characteristics in Pennsylvania

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SUMMARY

Data available on the age structure of black bear (*Euarctos americanus* Pallas) in Pennsylvania are limited. During the 1967-1968 hunting season, skulls were collected and aged, using the canine tooth sectioning technique. Thirty-seven bears were successfully aged, the oldest being 20.75 years. The mean age of bears harvested during the 1967 season in Pennsylvania was 4.18 years with a standard deviation of 3.39 years. More female bears were killed during the 1967 season than in 1968. The age structure for the sample from the study area indicated a possible overharvest because it was highly skewed toward the younger age classes. An attempt was made to correlate bear age by sex with various skull and canine tooth measurements. This attempt met with limited , success.

INTRODUCTION

Limited information is available concerning the sex and age structures of harvested black bear populations. Many different factors govern the structure of the kill of a particular bear population. Erickson, Nellor,& Petrides (1964) state, 'Sex ratios reported by hunters were found to be biased toward males. The degree of bias was directly proportional to the time elapsed between kills and reports of kills. Kills confirmed as to sex were 52% females.' In another instance Troyer (1962), in work with the brown bear, reports—'Males comprise 65.2% of the kill. Hunters selectively hunt for the larger animals, and since female hides rarely measure over 8¾ feet, more males are taken than females.'

The canine tooth sectioning technique is now used in aging most carnivores. Sauer,Free,& Browne (1966) report that '... the ages of bears can be determined from the annular layering in the cementum ... Deposition of cementum radially from the dentine continues throughout the bear's life, each subsequent wide layer and narrow dark band representing an additional year.' It is felt that captive bears differ too greatly from wild bears in tooth development for data from them to be considered. Rausch (1961) reported striking difference in growth patterns between captive and wild bears. The captive animals were consistently more mature in bone structure and dentition at comparable ages.

In 1967 a study was initiated on the movements, habitat and population characteristics of the black bear in Pennsylvania. This paper deals with the data collected on population characteristics, principally the sex and age structure.

STUDY AREA

Some of the data were collected on the 16,653-acre study area encompassing the Wycoff Run watershed in southeastern Cameron County, Pennsylvania. The area was located entirely within the 50,000-acre Quehanna Wilderness Area of the Moshannon State Forest. This area is approximately 94 miles northwest of Harrisburg and 108 miles northeast of Pittsburgh.

The wilderness area is essentially a 2,200-foot high sandstone plateau deeply dissected by the major stream drainages, one of which is Wycoff Run. Approximately 80% of the entire area is forested consisting mainly of mixed oak association and less frequently northern hardwood associations. A network of state forest roads, logging roads and right-of-way clearings contributes to the accessibility of the area.

METHODS

Two bear check stations were operated on the Wycoff Run study area during the black bear seasons of 1967 and 1968. In 1967 eight legal bears and three illegal cubs were checked. During the 1968 season nine bears were checked. Hunters checking the bears were asked to donate the skulls of their bears for age determination and many complied with this request. The balance of the skulls were supplied by taxidermists interested in the study.

Skulls were measured in a manner similar to the Boone and Crockett Club's official scoring system for North American big game trophies. Seven standard measurements were recorded for each canine tooth. The location of these measurements are shown in Fig. 1 (Sauer 1966). The specimens were aged by canine tooth sectioning.

A total of 30 bears were successfully aged from the 1967 hunting season and seven from the 1968 season. Of the grand total of 37 bears, 12 were harvested on the Wycoff Run study area, six in each year. The oldest animal encountered was a female, number 67-108, killed on the study area during the 1967 season and aged at 20.75 years.

An attempt was made to correlate selected measured characteristics of black bears with their ages. The results of these cross correlations are presented in Tables 1 and 2 for 23 males and 14 females respectively. It was found that the removal of the 20. 75 year old female from the data did not significantly change the correlation presentation in Table 2.

The collection and accuracy of data on the sex of hunter-killed bears from throughout the state placed dependence on the individual hunter's ability to determine the sex of the animal and the taxidermist's cooperation in recording the sex correctly on a tag attached to the skull. The major portion of the statewide kill data were provided by the Pennsylvania Game Commission, Division of Research.

In the case of skulls received from taxidermists which were not identified as to sex, the gender was determined by examination of the skull itself. The presence of the sagittal crest on the skulls is characteristic of male bears and is usually a good criterion for assigning sex. The size of a skull can also often be useful. Whereas the skull width for males and females is essentially the same, the larger skull length of males can often be employed to aid in sex differentiation. Table 3 presents the mean values and standard deviations, by

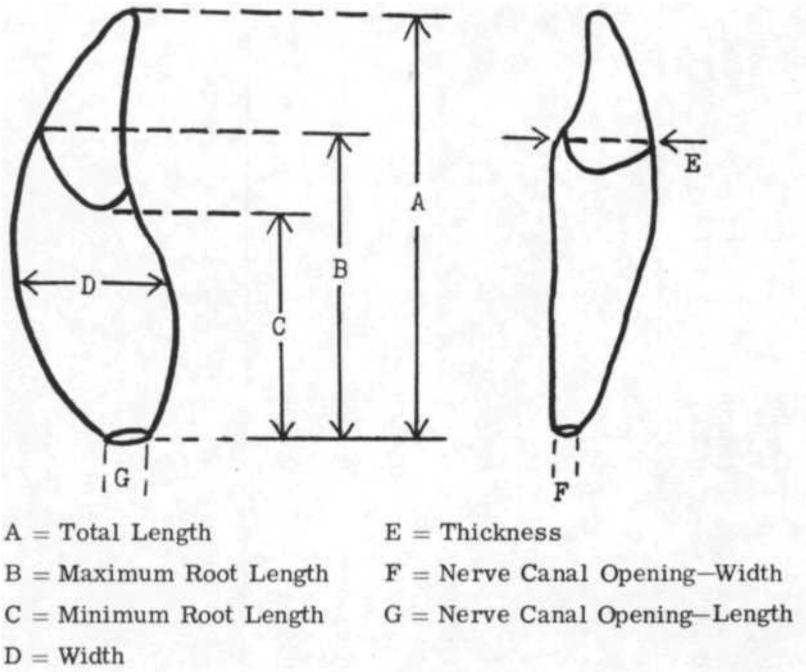

Fig. 1 Location of standard canine tooth measurements.

sex, of the canine tooth measurements, skull measurements, age and field dressed weights of the 37 bears used in the comparison.

RESULTS

The average age of 30 bears harvested during the 1967 bear season was 4.18 years with a standard deviation of 3.39 years. Six of these bears were killed on the Wycoff Run study area and their ages are consistent with the other 24. Fig. 2 illustrates the distribution of the bears by sex in the various age classes. However, the age structure of the 1968 harvest from the study area does not compare at all with that of 1967. Of the six skulls that were received for aging from the study area five were 1.75 years old and the other 2.75 years old. The age structure for this sample from the 1968 harvest indicated that the distribution was not normal but skewed to the younger age classes indicating an over-harvest of the population during the previous year.

The sex structure of the 1967 Pennsylvania bear kill was essentially 96 males to every 100 females with a total reported kill of 278 males and 290 females. The 1968 harvest reflected an opposite trend with a ratio of 100 females to 116 males. The total reported kill included 101 females and 117 males.

Of the total of eight legal adult and three cub bears killed on the study area in 1967 four were males and seven females reflecting the trend of the statewide harvest. The 1968 study area kill again reflected the statewide trend with seven of the nine legal bears killed being males.

TABLE 1. PRODUCT-MOMENT CORRELATION COEFFICIENTS OF MALE BLACK BEAR MEASUREMENTS AND AGE.

	Age (A)	Field Dressed Weight (FDW)	Skull Width (SW)	Skull Length (SL)	Canine Tooth Length (CTL)	Canine Tooth Width (CTW)	Canine Tooth Thick. (CTT)
(A)	1.0000						
(FDW)	0.8249**	1.0000					
(SW)	0.8775**	0.8010**	1.0000				
(SL)	0.8239**	0.8497**	0.9347**	1.0000			
(CTL)	0.6971**		0.8167**	0.8732**	1.0000		
(CTW)	0.5387*	0.7104*	0.6653**	0.7296**	0.8055**	1.0000	
(CTT)	0.3391	0.4647	0.4481	0.5561*	0.6714**		1.0000

* Significant at the 95% level of confidence (d.f. = 22).

** Significant at the 99% level of confidence (d.f. = 22).

TABLE 2. PRODUCT-MOMENT CORRELATION COEFFICIENTS OF FEMALE BLACK BEAR MEASUREMENTS AND AGE.

	Age (A)	Field Dressed Weight (FDW)	Skull Width (SW)	Skull Length (SL)	Canine Tooth Length (CTL)	Canine Tooth Width (CTW)	Canine Tooth Thick. (CTT)
(A)	1.0000						
(FDW)	0.0303	1.0000					
(SW)	0.1320	0.2571	1.0000				
(SL)	0.1585	0.4750	0.2049	1.0000			
(CTL)	0.0766	0.5027	0.1521	0.8097*	1.0000		
(CTW)	–0.0181	–0.0174	–0.0843	–0.3296	–0.1439	1.0000	
(CTT)	–0.2539	–0.4166	–0.2818	–0.3652	–0.2855	0.5291	1.0000

* Significant at the 95% level of confidence (d.f. = 13)

TABLE 3. MEANS AND STANDARD DEVIATIONS OF BLACK BEAR MEASUREMENTS AND AGE BY SEX.

		Age (Years)	Field Dressed Weight (Pounds)	Skull Width (MM)	Skull Length (MM)	Tooth Length (MM)	Tooth Width (MM)	Tooth Thick. (MM)	Sample Size
Male	Mean	2.88	194	160	269	66	19	12	23
	Standard Deviation	1.12	85	20	30	6	2	1	
Female	Mean	5.18	170	158	262	58	17	11	14
	Standard Deviation	4.64	63	15	13	5	1	1	

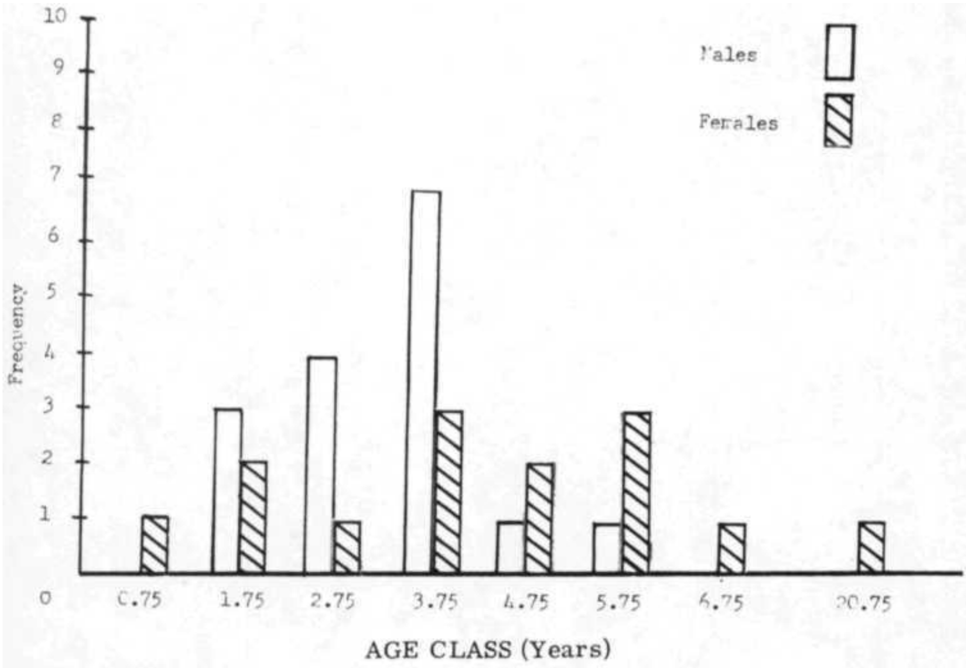

FIG. 2. Age structure of the 1967 bear harvest.

The data show that there was a varying degree of sexual dimorphism among the various skull and canine tooth measurements recorded. Tremendous individual variation, indicated by large standard deviations, accompanying sexual dimorphism, complicates attempts to determine sex through the use of these anatomical measurements. The correlation coefficient of the sex-skull length relationship, —0.1625, best reflects this variation. Of the 14 female skulls the longest measured was 276 mm, whereas nine or 39.1% of the 23 males exceeded this measurement. The largest male skull measured 332 mm long. However, as a general rule of thumb skulls longer than 279 mm usually could be correctly sexed as males.

DISCUSSION

The correlation coefficients are sometimes misleading in that they fail to consider the overlapping measurements and the characteristically higher and lower measurements separately. For example, the correlation coefficient from Table 4 of the sex-canine tooth length relationship, —0. 5246, is strongly negative. However, the length can be of limited use in determining sex. The longest female canine tooth was 64 mm long. Of the 23 male canines 11 or 47.8% exceeded this measurement, the largest was 78 mm long.

The correlation coefficients of sex-skull width —0. 0282, sex-canine tooth width —0.4124 and sex-canine tooth thickness —0. 5108, indicate that these characteristics cannot be used as a characteristic of either sex, although a small degree of sexual dimorphism is exhibited even in these measurements.

TABLE 4. PRODUCT-MOMENT CORRELATION COEFFICIENTS OF MEASUREMENTS AND AGES OF 37 HUNTER KILLED BLACK BEARS FROM THE 1967 AND 1968 HUNTING SEASONS.

	Age (A)	Sex[a] (S)	Field Dressed Weight (FDW)	Skull Width (SW)	Skull Length (SL)	Canine Tooth Length (CTL)	Canine Tooth Width (CTW)	Canine Tooth Thick. (CTT)
(A)	1.0000							
(S)	0.3496	1.0000						
(FDW)	0.1556	–0.1493	1.0000					
(SW)	0.2592	–0.0282	0.6670**	1.0000				
(SL)	0.2012	–0.1625	0.7768**	0.8018**	1.0000			
(CTL)	–0.0137	–0.5246	0.6752**	0.5656**	0.7916**	1.0000		
(CTW)	–0.0208	–0.4124	0.5821**	0.5047**	0.6201**	0.7312**	1.0000	
(CTT)	–0.2151	–0.5108	0.2691	0.2396	0.4036*	0.6136**	0.7502**	1.0000

[a] Males assigned value 1.00 and females 2.00 in computer program.

* Significant at the 95% level of confidence (d.f.= 36).

** Significant at the 99% level of confidence (d.f. = 36).

However, certain relationships were found to be highly significant. Skull width has a highly significant correlation at the 99% level of confidence with skull length (0.8010). The skull length and canine tooth length correlation coefficient (0.7916) is also significant at the 99% level of confidence. The canine tooth length-width and the canine tooth width-thickness relationships are also significant at this level possessing correlation coefficients of 0.7312 and 0.7502 respectively.

When the measurements were separated by sex and the cross correlations computed there were some interesting findings. The males in Table 1 with 22 degrees of freedom exhibited several correlations significant at the 99% level of confidence. These correlations were as follows: age-field dressed weight (0.8249); age-skull width (0.8775); age-skull length (0.8239); field dressed weight-skull length (0.8497); skull length-width (0.9347); skull length-canine tooth length (0.8732); skull width-canine tooth length (0.8167); and, canine tooth length-width (0.8055). The highest correlation outside of the skull width-skull length relationship was the age-skull width correlation (0.8775). The second highest was skull length-canine tooth length (0.8732).

On the other hand, females in Table 2 with only 13 degrees of freedom had only one relationship which was significant at the 95% level of confidence. This was the correlation between skull length and canine tooth length (0.8097). When both sexes were lumped together in Table 4 this was again the highest correlation (0.7916) next to the skull length-width correlation (0.8018).

The 1967 bear kill, in conformance with the cyclic character of bear harvests, should have been a year in which only 300 bears were shot. However, due to the presence of tracking snow, the first in many years during the bear season, and a great many hunters afield, the harvest soared to 568 animals.

It is also believed that the bears killed on the study area in 1968 were immigrants from other sections of the north-central Pennsylvania bear range. The lack of bear sign that had been noted in the study area prior to September cannot be ignored. With the beginning of the mast fall, signs of bear activity began to increase as a result of the animals moving onto the plateau section of the Quehanna area to take advantage of the mast, which was absent from much of the adjacent range. The fact that 84% of the bears checked were males would support the immigration premise since the females would be expected to remain nearer their normal denning areas than the more aggressive males. The sex ratio of the 1967 harvest favored females slightly but the 1968 figures demonstrated an opposite trend. Moreover, the average of the two years results in a near even number of males and females harvested.

A drastic decline in the population was indicated by the size of the 1968 harvest, 218 animals, and observations by personnel in the field. The number of black bears in Pennsylvania was felt to be far below the carrying capacity of the usable range. The age structure data provided definite information as to the condition of the bear population. When the 1968 sample was compared against the 1967 sample it was evident that the population had been overharvested.

As a result either directly or indirectly the 1969 season was reduced in length from the regular six day season to a three day season. Apparently the action was justified for the 1969 harvest was only 250 bears, well below the 29 year average of 384 animals per year. This was followed in 1970 by a complete closure of the bear season.

ACKNOWLEDGMENTS

The study was made possible through the Pennsylvania Cooperative Wildlife Research Unit, the Pennsylvania State University School of Forest Resources, and the U.S. Fish and Wildlife Service. Additional assistance was provided by the Pennsylvania Game Commission and the Wildlife Management Institute.

Many individuals contributed their knowledge and advice to the study. I am particularly grateful to James S. Lindzey, Leader of the Wildlife Research Unit at Penn State, Stuart Free of the New York Conservation Department, and Harvey Roberts of the Pennsylvania Game Commission.

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Grizzly Bear Mortality and Studies in Montana

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SUMMARY

The former and present status of grizzly bear *(Ursus arctos)* mortality in Montana is reviewed. Laws revised in 1967 provide an accurate documentation of the grizzly harvest. Commission regulations permit recovery of specific samples from grizzlies, harvested by hunters, for scientific purposes. Grizzly heads are obtained and examined before being returned to the hunter. Some illegal and marauding grizzly bears are taken each year in Montana. These complete specimens are handled jointly with the Veterinary Research Laboratory. The known man-caused mortality (including hunters) of grizzly bears in Montana during 1967, 1968 and 1969 was 41, 28, and 48, respectively. Hunters harvested 24, 12 and 33 grizzlies for the respective years of 1967, 1968 and 1969. Female grizzlies represented 39 percent of the hunter harvest in 1969, 25 percent in 1968 and 35 percent in 1967. Internal parasites recovered from grizzly carcasses included: porkworm larvae (*Trichinella spiralis*), large roundworms (*Baylisascaris transfuga*), tapeworms (*Taenia* sp. and *Diphyllobothrium* sp.) and hookworms (*Unicaria* sp.). *Trichinella* was the most frequent parasite and occurred in 79 percent of the grizzlies in 1968 and 67 percent in 1969. Routine testing for brucellosis and leptospirosis was negative. Analysis of fat samples from 10 grizzly bears revealed only one had a pesticide residue and that was a trace of DDE and 0.06 ppm of heptachlor epoxide. The regular appearance of grizzlies in the West Yellowstone dump is a potential danger to humans.

INTRODUCTION

Among the western states, Montana has the largest population of grizzly bears (*Ursus arctos*). In the past 30 years or more, Montana has had liberal annual hunting seasons for black (*Ursus americanus*) and grizzly bears. A resident or non-resident with a valid big game license was permitted to kill either one black bear or grizzly bear per license. Black bear seasons commence in the spring (March 15) and continue uninterrupted into the summer and through the hunting seasons. Grizzly bear seasons were confined to the general big game hunting seasons.

An unknown number of bears were killed each year up till 1947, when Department personnel established an estimate of the annual harvest of grizzly bears in Montana. From 1947 through 1966 the estimated annual harvest ranged from 20 to 60 grizzlies, except for 2 years in the early 50's (Table 1). The results of a sharply reduced estimate of 14 grizzlies harvested in 1950 and 10 in 1952 from the previous estimates of 50-55 grizzlies warranted a review of the inventory. Surveys conducted in 1953 and 1954 to corroborate the annual

TABLE 1. ESTIMATED TOTAL HARVEST OF GRIZZLY BEARS

Year	Number	Year	Number	Year	Number	Year	Number
1947	55	1952	10	1957	20	1962	40
1948	55	1953	40	1958	40	1963	35
1949	50	1954	35	1959	60	1964	40
1950	14	1955	35	1960	30	1965	30
1951	25	1956	20	1961	60	1966	45

estimates revealed that 33 grizzlies were harvested in 1953 (Stockstad 1954) and 39 in 1954 (Marshall 1955). Each survey noted that additional grizzlies may have been killed by trappers, ranchers, sheepherders or cattlemen. The estimated annual harvest averaged 40 grizzly bears during 1961-1966.

Since 1967 the annual grizzly bear harvest in Montana has been determined from special hunting licenses along with a program to recover all other grizzlies killed during the year. This report describes the recent hunter harvests and other known instances of man-caused mortality in the grizzly bear populations of Montana.

METHODS

Laws, Regulations and Hunting Seasons

Legislative assistance was necessary to establish a firm basis for determining the status for hunter harvests of grizzly bears in Montana. The State Legislature enacted licenses for grizzly bears which were effective for the 1967 season. The two licenses are specific for the hunters and for the harvest. A special $1.00 grizzly bear license is required for the resident and a similar license for the non-resident is $25.00. When a special grizzly bear licensee kills a grizzly bear he must file an application for a Grizzly Bear Trophy License with a fee of $25. 00, within ten (10) days after date of kill. A specially designed Trophy License, suitable for framing, is returned to the owner, with a personal letter of recognition from the Department Director.

Grizzly bear hunting licenses ($1. 00) are issued by several license agents in the State. During 1967-1969 licenses were available throughout the respective hunting year. In 1970, the sale of grizzly bear hunting licenses was prohibited after the opening date of the first general big game season (September 14, 1970).

Black and grizzly bears were classified as trophy animals and the Law required that only the hide *or* the head must be recovered from a bear after it was killed. Although this law was in effect during 1967 and 1968, some grizzly bear hunters cooperated with the Department's request to recover the heads from their grizzly bears. The 1969 Legislature revised the laws on grizzly bears by requiring grizzly bear hunters to bring out at least the hide *and* the head from these bears. Commission policies established mandatory procedures for identifying hides and heads with numbered, metal seal tags, and to relinquish grizzly bear heads for scientific purposes of examination before being returned to the owner.

Open season for grizzly bears coincides with deer or elk seasons in all districts except in areas specified as closed. In 1969 the general big game season extended from October 19 to November 30, except for a few areas which opended on September 15, 20, or 27. There is no spring hunting season for grizzly bears. The limit is one grizzly bear per person per license year. Cub grizzly bears or female grizzlies with cubs at side may not be taken.

Determining Man-caused Mortality

Special grizzly bear hunting licenses provide a reliable indication of hunter intensities and accurate records of the grizzly bear harvests in Montana. Throughout the year some grizzlies are killed illegally, by accidents or dispatched as marauders. These categories (Table 3) appear to provide a comprehensive coverage of man-caused mortality but occasionally for some reason or circumstance a few instances of grizzly bear mortality may not become known in any year. With the assistance and cooperation of Department, U.S. Fish and Wildlife Service, Park Service and other personnel, an extensive survey can be established for the annual (April through December) mortality. This information will be necessary for management programs of Montana grizzly bear populations.

FINDINGS

Identification of Grizzly Bears and Black Bears

The establishment of grizzly bear trophy licenses required an accurate identification of the bears by Department personnel. Some of the black bears in Montana are quite variable in size and coloration (Jonkel 1967) and have been mistaken for a grizzly bear. In previous years when the head was not required to accompany the pelt, an accurate identification for a grizzly was difficult for some pelts. With the present regulation that a grizzly bear head must be available, an examination of the last upper molar will reveal the species. In the event that it may be difficult to examine these teeth, another reliable feature for identification are the feet.

Some features of the feet are distinguishable between the black and grizzly bears (Greer & Craig 1970). The front claws of grizzlies may be of great length but in several grizzlies these claws are worn down to a length comparable to black bears. However, claw profiles differ between the species. On the front and rear feet, dense hair is present between the foot pad and toe pads of black bears compared to sparse hair in grizzlies.

Skin webbing is at the base of front and rear toe pads in black bears while webbing is about half way up the toe pads in grizzly bears. The base of toe pads are widely separated in the front and rear feet of black bears. Toe pad bases are close together in the front feet of grizzlies; however, some of the toe pads in rear feet of grizzlies are usually fused.

The instep areas of rear feet in black bears frequently have an indented wedge of hair present in the pad but this feature does not appear in the rear feet of grizzly bears.

Hunting Interest and Success

It appears that very few licensees are dedicated and determine for a grizzly trophy hunt. A few hunters, guides or outfitters may frequently locate and observe grizzlies. However, most of the licenses are held by hunters for the authority to kill a grizzly if the opportunity arises while hunting for another species.

Resident grizzly bear hunting licenses increased from 1, 022 in 1967 to 1, 474 in 1969. The 137 to 164 licenses issued to non-residents during 1967-69 represented 10 to 12 percent of the total (Table 2).

TABLE 2. GRIZZLY BEAR LICENSES ISSUED IN MONTANA

	GRIZZLY LICENSE			TROPHY LICENSE		
	1967	1968	1969	1967	1968	1969
Resident	1,022	1,149	1,474	21	9	30
Non-resident	143	137	164	3	3	3
Total	1,165	1,286	1,638	24	12	33

Hunting success is expectantly low and ranges from less than 1 to 2 percent. While non-residents have reportedly taken a few grizzlies in each of the 3 years, the residents eminently harvested 75 to 91 percent of the grizzlies during 1967, 1968, and 1969.

Annual Mortality

Hunters accounted for 24 of 41, 12 of 28 and 33 of 48 of the grizzly bears harvested in Montana during 1967, 1968, and 1969, respectively. Thus from 15 to 17 additional grizzlies were removed from the Montana populations in the same years. These grizzlies were dispatched as marauders, illegals, or by natives of Indian reservations (Table 3).

Distribution

The Montana grizzly bear populations are closely bordered on the north by the Glacier National Park population but separated to some extent on the south from the Yellowstone National Park population. Grizzly bears from these protected Park populations also disperse into Montana. Within the two adjacent Park areas, 2 to 4 grizzlies from Glacier and 6 to 12 from Yellowstone were removed from the Park populations during the respective years of 1967, 1968 and 1969.

The distribution of the 1969 grizzly bear harvest is indicated in Figure 1. About 60 percent (20 of 33) of the grizzly harvest by hunters in 1969 was in the three areas surrounding the Sun River Game Preserve. The same areas accounted for 38 percent of the hunter harvest in 1967 and 66 percent in 1968.

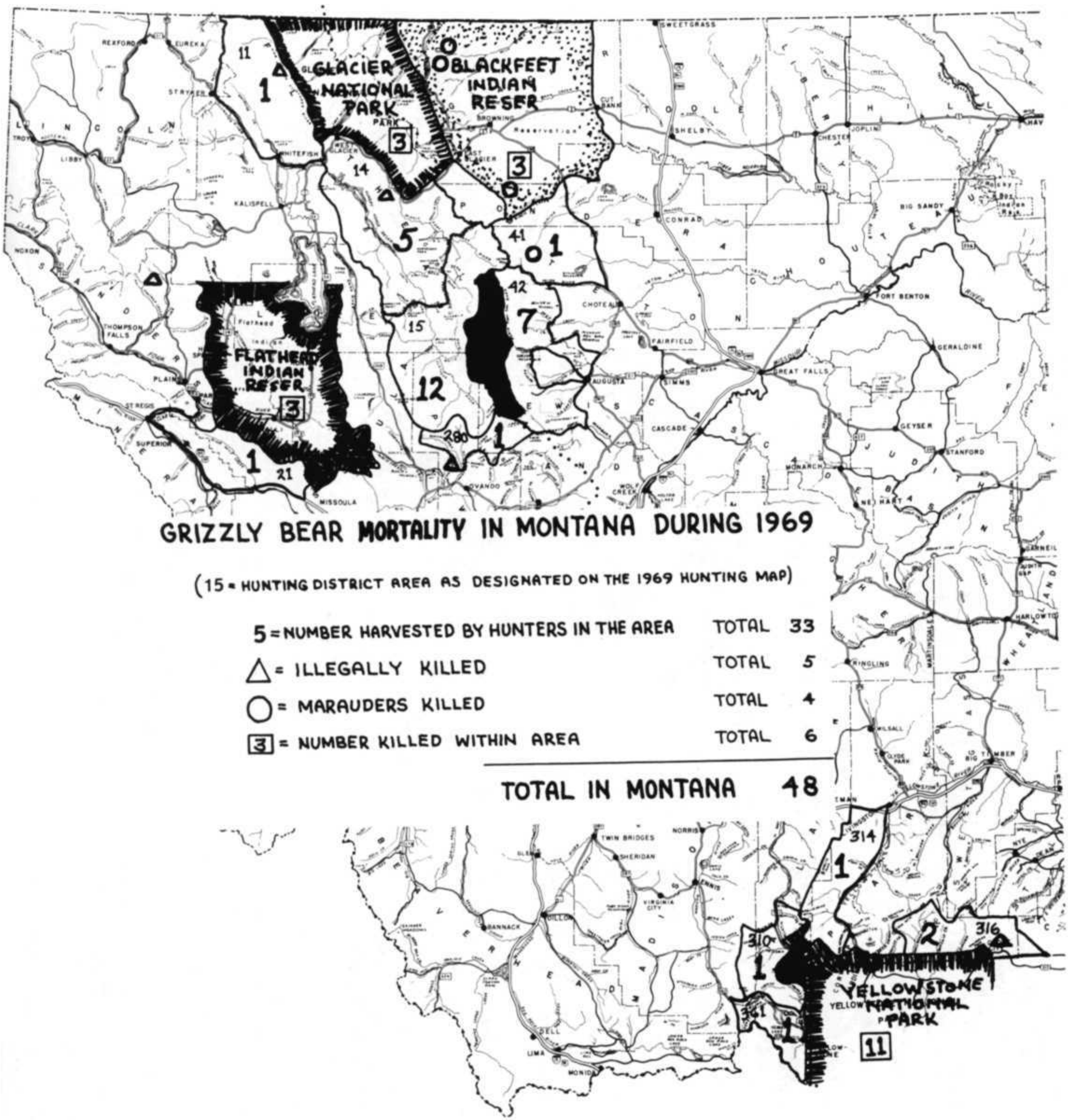

Fig. 1. Distribution of 1969 grizzly bear mortality in Montana.

TABLE 3. ANNUAL HARVEST AND OTHER MAN-CAUSED MORTALITY OF GRIZZLY BEARS IN MONTANA

	1967	1968	1969
Grizzly Bear Hunter Trophy Licenses (Fall Seasons)	24	12	33
Handled by Fish and Game Personnel (Marauders—Illegal)	10 (6-4)	7 (3-4)	4 (0-4)
Marauders Handled by the U.S. Fish and Wildlife Service	2	3	4
Other Illegals	1	0	1
Blackfeet Indian Reservation	4	6	3
Flathead Indian Reservation	–	–	3
Total in Montana	41	28	48
Glacier National Park	4	2	3
Yellowstone National Park	6	12	11
Total in Montana and Parks	51	42	62

In 1969 hunters harvested five grizzlies in the areas immediately adjacent to Yellowstone National Park and two to three were taken in the two previous years (Table 4).

Weather conditions and food sources are quite variable each year and are important factors which influence grizzly distribution and their availability to hunters and people. The annual harvests are therefore expected to fluctuate between known limits and an alarmist action is not usually necessary until extreme harvests are consistent. The documented annual harvest has averaged 39 (28-48) bears for 1967-1969. This average is in complete accordance with the estimated 20 to 60 (average 40) grizzly harvest each year during 1957-1966.

Sex Mortality

Information from the Trophy License application included date of kill, location, sex, claw lengths and foot pad measurements. Skull sizes overlap between sexes and, except for the larger males, are of little value for verification of sex. Hides are presented in a rolled, salted, frozen or packed condition and are inconvenient and difficult to examine. Also, sex determination from pelts is not dependable as the prominent features are always trimmed off. Therefore, the designation of sex is dependent upon the hunter's observation and report on the Trophy License.

TABLE 4. ANNUAL HARVEST OF GRIZZLY BEARS IN HUNTING AREAS OF MONTANA

	NUMBER TAKEN		
Hunting Area	1967	1968	1969
11	2	—	1
14	3	—	5
15	7	7	12
101	1	—	—
131	2	1	—
21	—	—	1
28	1	—	—
280	3	—	1
281	1	—	—
310	—	—	1
314	—	—	1
316	2	3	2
361	—	—	1
41	—	—	1
42	2	1	7
Total	24	12	33

The reproductive performance of female grizzly bears is that of slow maturity to an irregular age for producing a first litter and non-rhythmic recurring pregnancies of some individuals. It has been reported that female grizzlies do not usually conceive a first litter until at least 4½ years of age and some females did not have the first litter until 5, 6, 7, 8, or 9 years of age. The time between succesive litters of some individuals can be 2 or 3 years (Craighead *et al.* 1968). Females of productive age are therefore, a critical segment in grizzly bear populations.

As in the two previous years, male grizzly bears were predominantly harvested by the hunters. The female grizzlies represented 39 percent of the hunter harvest in 1969, 25 percent in 1968, and 35 percent in 1967. At least 15 additional grizzlies were killed during 1969 and the sex was known for only 8 of these; 7 females and 1 male. A total of 48 grizzlies (21 males, 20 females, 7 unknown) is known to have been removed from the Montana populations in 1969.

Age Mortality

The third lower molar (Munday & Fuller 1964) and the fourth lower premolar (Craighead *et al.* 1970) of grizzly bears are criteria for age determinations. An obliteration of skull sutures in grizzlies is obviously correlated with age and sequence of fusions may be similar to that of the black bear (Marks & Erickson 1966). Therefore, every effort is being made to obtain and examine the head of each grizzly mortality.

Skulls are cleaned, examined and photographed. Some teeth are extracted for root segments and the remaining portions are replaced. Grizzly skulls from hunting trophies are returned to the respective owners.

Recovery of grizzly skulls from the annual mortality has increased from 35 to 82 percent in the past 3 years (Table 5). A new regulation requires the hunter to recover the grizzly head and it is expected that all of these and more than 70 percent of the skulls from the other grizzly mortality will be available for examination.

Only 17 skulls were available from the 20 females killed in 1969 and ages were tentatively classified as: 1 cub, 5 sub-adults and 11 adults.

TABLE 5. ANNUAL GRIZZLY MORTALITY AND SKULLS AVAILABLE FOR EXAMINATION

Year	1967	1968	1969
Hunter—Harvest-	24	12	33
Skulls	0	7	27
Other—Mortality-	17	16	15
Skulls	8	8	10
Parks—Mortality-	10	14	14
Skulls	10	13	14
Total—Mortality-	51	42	62
Skulls	18	28	51
Percent—Skulls	35	67	82

Hunter Replies

The grizzly has foraging characteristics which include visiting game kills, offal piles, camps or refuse areas. On occasions bears are observed while traveling on trails, in the timber, in open meadows or even in a resting area. Usually the grizzly tends to be elusive and rather difficult to locate and observe but at times they will command and defend a food supply. Along with these comments, several questions were asked of the 33 hunters taking a grizzly during the 1969 season. 29 responded.

Grizzlies were located by hunters under various circumstances. About half of the grizzlies killed were accidentally encountered in the trail, in a meadow or in the brush or timber while the hunter was pursuing elk. Five were found on an offal pile or on a deer or elk kill; two came into camp; one was in the yard of a home; and six were subjectively hunted.

When shooting their bears, nine hunters reported that at least one other bear was in the vicinity. Only six hunters stalked closer after sighting the bear. All grizzlies were killed at a range of under 200 yards; 12 ranged between 100 and 200 yards while the rest were 75 yards or less. Twenty of the bears were killed with only one shot. Nine hunters killed a big game animal before killing a grizzly. About 12 hunted more than 1 day for a grizzly, 12 sighted more than one grizzly and only one reported to have passed up a bear before shooting the one he did.

Of the 29 respondees 8 were guides or outfitters, 6 were with guides, 14 hunted on their own and 1 did not answer this question.

Other Harvest

Wherever grizzlies occur there is an occasional association with humans or their personal property. Under some circumstances, grizzlies are considered a hazard to the public and when trapping and transplanting is not feasible the animal is dispatched by shooting or lethal injection of drugs. These specimens are usually transferred to the Bozeman laboratories.

A program is continuing for obtaining, examining and processing grizzly bears taken during the year. Agencies cooperating with the Montana Fish and Game Department Wildlife Laboratory include: Veterinary Research Laboratory, Montana Livestock Sanitary Board, Montana Wildlife Cooperative Research Unit, U.S. Fish and Wildlife Service Predator Control, Glacier National Park and Yellowstone National Park (Table 6).

Parasite Studies

The grizzly heads from hunter kills or complete carcasses of 57 bears (37 grizzlies and 20 blacks) were examined for parasites in 1969. When the entire carcass was available, a complete necropsy was performed, including a search for both external and internal parasites. In instances where only the head was submitted, the tongue and masseter were examined for evidence of porkworm larvae (*Trichinella spiralis*). Examinations were conducted by the Veterinary Research Laboratory.

Trichinella was the most frequent parasite, occurring in 67 percent of the grizzlies. The tissues sampled for larvae were the tongue, masseter and, when available, the diaphragm and a portion of the thigh muscle. The heaviest infections were found in the tongue and masseter. In two grizzly bears, concentrations of larvae were present in the muscles which approached or surpassed lethal levels (over 100 larvae per gram) for man. In 1968, larval concentrations ranged from 0. 3 to 142. 7 larvae per gram in 79 percent (11 of 14) of the grizzly tongues examined. Larvae of *Trichinella* were Hot found in any of the black bears during 1969; however, this parasite was present in one of the two black bears examined in 1968.

The most common gastro-intestinal parasite was the large roundworm (*Baylisascaris transfuga*). It occurred in 85 percent (11 of 13) of the grizzlies and 71 percent (five of seven) of the black bears as light infections with less than ten roundworms per bear. In 1968, four of five grizzlies and one of two blacks contained this roundworm.

Two types of tapeworms were recovered; a *Taenia* species in four grizzlies and one black, and a species of *Diphyllobothrium* in four grizzlies.

TABLE 6. LIMITED INFORMATION FROM SOME GRIZZLY BEARS (EXCLUDING HUNTER TROPHIES) TAKEN IN MONTANA, INDIAN RESERVATIONS, AND NATIONAL PARKS DURING 1969.

Date	Location	Sex	Age	Whole Weight[1]	Total Length[1]	Size of Skull[2]
July 12	Cooke City	—F	Ad.	—	—	19 13/16
October 3	South of Woodworth	M	Ad.	—	—	19 14/16
October 4	Thompson River	—F	Ad.	—	—	19 2/16
August 1	Blackfeet Indian Reservation[3]	—F	Ad.	—	—	19 13/16
August 4	Blackfeet Indian Reservation[3]	—F	Cub	—	—	12 9/16
August 16	Blackfeet Indian Reservation[3]	—F	Ad.	—	—	19 7/16
October 20	Dupuyer[3]	—F	Ad.	380	76	20 14/16
August 23	Flathead Indian Reservation	?	Ad.	—	—	BKN
August 23	Flathead Indian Reservation	?	Cub	—	—	12 2/16
August 23	Flathead Indian Reservation		Cub	—	—	BKN
June 27	Glacier National Park	M	2-Yr.	120	56	16 3/16
July 27	Glacier National Park	M	2-Yr.	140	59	17 0/16
August 22	Glacier National Park	—F	3-Yr.	206	62	17 14/16
June 10	Yellowstone National Park	M	Ad.	475	83	23 11/16
June 13	Yellowstone National Park	M	Ad.	480	81	23 1/16
June 16	Yellowstone National Park	—F	Ad.	225	73	21 0/16
June 17	Yellowstone National Park	—F	Ad.	235	71	19 12/16
June 22	Yellowstone National Park	M	Ad.	520	85	23 14/16
July 9	Yellowstone National Park	M	KA 5½	440	83	22 4/16
July 11	Yellowstone National Park	M	Yrlg.	110	48	15 10/16
July 21	Yellowstone National Park	M	4	270	72	20 5/16
July 25	Yellowstone National Park	M	Ad.	610	88	24 4/16
August 16	Yellowstone National Park	—F	KA 7½	265	70	19 9/16
October 13	Yellowstone National Park	—F	KA 10½	310	69	BKN

1 All measurements in pounds and inches.
2 Condylobasal length plus zygomatic width.
3 Marauder taken by U.S. Fish and Wildlife Service, Predator Control.

An undetermined species of hookworm (*Uncinaria* sp.) was found in the small intestine of two young grizzlies from Glacier National Park. This hookworm was present in one black bear during 1968.

Since some bear carcasses were not available until several hours after death, examinations for external parasites were limited to the more recently expired animals, about half of the bears submitted. Woodticks (*Dermacentor andersoni*) were noted on only one black bear.

Diseases

Blood samples from three grizzly bears were negative for brucellosis and leptospirosis.

Fat Samples

Samples of fat are usually obtained from the kidney area of grizzly bears. Of the ten samples analyzed for pesticide residue, only one revealed a trace of DDE with 0.06 ppm of heptachlor epoxide.

Undesirable Distribution

A few grizzly bears occasionally forage in the West Glacier and Poison garbage dumps but the garbage dump at West Yellowstone is continually visited by several grizzlies. The West Yellowstone dump is located on Forest Service land and is about 2 miles north of the town limits of West Yellowstone, a half-mile south of Baker Hole campground and about 100 yards east of U.S. Highway 191.

The forest Service has issued a 'Land Use Permit' to the town of West Yellowstone for the purpose of garbage disposal. In turn, the Town Council of West Yellowstone issued a permit to an individual agent to service the town by removing local refuse and depositing it in the area designated.

In 1969, as in previous years, this dump was operated in an open manner and potentially hazardous conditions prevailed. The service road was accessible to anyone; dumping was on an intermittent basis; garbage was not leveled or covered; the public freely visited the area to observe the bears; bears were exclusively grizzlies; some people were dangerously exposed while in the midst of grizzly bears; at least 17 individual grizzly bears were foraging the area throughout the summer, and up to 15 grizzlies visited the area during hours of darkness in one evening.

In 1969, huckleberry crops were locally well below average, the fall season had extended mild temperatures, winter snowfall was late, and a reduced volume of garbage was intermittently deposited at the dump. These factors probably influenced the frequent appearances of several grizzlies, a minimum of eight during some nights, searching garbage cans in the town limits of West Yellowstone as early as mid-September and continuing through October, 1969.

Meetings of responsible and concerned persons resolved some corrective measures which were implemented before the summer of 1970. The improvements included: a locked gate on the access road; regular dumping to maintain continued interest and use by the bears; spread and cover the garbage daily; and place signs at the gate warning unauthorized persons not be in the area during darkness.

At least 25 individual grizzlies were known to visit the West Yellowstone dump in 1970. From 20 to 22 grizzlies were observed in the dump one or two times a week during July, August and September. In the last few days of September, 17 grizzlies appeared and in early October, 6 were present (Craighead 1970). It was anticipated that at the end of the summer season, some grizzlies would appear in the town limits. By mid-October only a couple of unconfirmed comments were known about the presence of a few grizzlies in the town of West Yellowstone. Reliable reports indicate the appearance of one or two on one or two occasions in West Yellowstone during October, 1970. This is a contrast to the several grizzlies being usually present in the town for a period of 6 weeks in September and October of 1969.

During 1970, growing conditions were perfectly coordinated for an outstanding production of huckleberries throughout the State. It can be considered that grizzly utilization of excessively abundant and widespread huckleberry crops satisfied and exceeded their forage requirements. This factor, along with some early snowfalls in mid-September and early October, may have influenced the distribution of many grizzlies toward a denning area rather than directing their foraging into the dump or city area.

A major action was initiated to establish a new dump site with current standards of sanitary landfill and in this case to also have an enclosed bearproof fence. When the new dump is available and in use, about 2 miles north of the present dump area, the old dump will be eliminated.

This new dump may or may not change the foraging of grizzlies in the city of West Yellowstone. Free-roaming grizzlies in close proximity to people are a potential hazard and contingent policies are to preclude a human-grizzly encounter. Such an encounter is widely publicized and may result in hasty counter measures which are usually detrimental to the species.

It appears that a program of observation, live-trapping and discriminate disposal is necessary for grizzly bears appearing in the town limits of West Yellowstone. If grizzlies are not recognized as repeated visitors they may be transferred and released at a distant site. When live traps are not effective, immobilization techniques or snare traps may be efficiently utilized. It may be necessary to remove some individuals from the population. Each mortality will provide basic data for the current studies. Hides and skeletons will be available for the several requests from museums and educational institutions for specimens.

CONCLUSIONS

Montana has the largest population of grizzly bears in the contiguous states. In the past 30 years, hunting for the species has been and continues to be unlimited to residents and non-residents. A concern for this rare carnivore has always been recognized and the Game Department is responsible for maintaining the status and welfare of the grizzly bears in Montana.

An accurate indication of the hunters' harvest of grizzlies is available from the current licensing structure. The licensing may be refined by increasing the fee for a grizzly bear hunting license, and requiring an interim period for successful hunters before qualifying for another grizzly hunting license.

Publicity and information methods will inform grizzly hunters of the deadline date for obtaining a license, and of the regulation requiring the hunter to be responsible for recovering and possessing a hide and skulls—after killing a grizzly bear.

Providing information to personnel and other agencies about current programs does provide the necessary assistance in obtaining complete specimens, samples and valid reports of grizzly bears killed in Montana.

During some years, grizzly bears freely roam in the town of West Yellowstone and such a close proximity is an extremely potential hazard to people, agencies and the grizzlies. An explicit policy should prevail for this area to preclude such a possible event.

The examination and utilization of complete carcasses provide basic information and specimens for cooperative studies with the Veterinary Research Laboratory, Park Service and other scientific institutions. Regulations provide for the recovery, processing and return of grizzly bear heads from hunter trophies. These hunter trophies permit a close examination for features correlated with an age for each specimen. Reliable age and sex information for the mortality is required. A continuing program is necessary to maintain a documentation of the annual mortality of the grizzly bears to provide a basis for management recommendations of this rare species.

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Life History of the Brown Bear *(Ursus arctos L.)* in North-east Siberia

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SUMMARY

By 'North-East Siberia' we mean the Pacific regions including northern coasts of the Okhotsk sea, Kamtchatka, the Koryak Highlands, the Anadyr drainage, and the Chukotsk Peninsula. The brown bear is abundant here, and in some areas is more numerous than anywhere else in Eurasia. Detailed special ecological studies on the species have not been undertaken in the area and this paper is a summary of our present knowledge, based on the author's own experience as well as on other studies (Portenko 1941, Averin 1948, Portenko *et al.* 1963, Lobatchev 1966, Ostroumov 1966, 1968, Markov 1969, etc.).

DISTRIBUTION AND NUMBERS

Brown bears live throughout the area up to the limits of the arctic tundra (Fig. 1). They inhabit the whole forest zone, the 'beringian' forest-tundra[1] of Koryak lowlands and Anadyr basin, and tundra-like heaths on sea coasts. Brown bears have been observed in the tundra zone, and there are some reasons to believe that there are barren-ground populations, for example, near Chaunskaya Bay (Krivosheyev 1969).

In the greater part of North-East Siberia the brown bear is quite common, and in some regions its numbers are very high. They are perhaps most numerous in Kamtchatka, as well as in some places along the northern coasts of the Okhotsk Sea. Unfortunately, quantitative data on the population density are scanty and are based either on subjective estimations (the number of animals observed by an investigator on a certain territory during a considerable period) or on aerial counts, the interpretation which is very liable to error (Erickson & Siniff 1963); Ostroumov 1968). Thus, the following data may be considered only as approximate.

In mountains bordering the northern coasts of the Okhotsk Sea, we estimated the population density to be close to 1 per 10 sq. km.; in the Upper Kolyma basin the frequency of encounters was 10-20 times lower (Kistchinski 1969). According to aerial counts, the total population density in Kamchatka has been defined 0. 6 per 10 sq. km. (Ostroumov 1968). The distribution of bears in different years may change due to the changes in the distribution of seasonal

[1] A specific type of forest-tundra with *Pinus pumila* as the main 'forest' element; a number of animal species of boreal forest type are associated with this habitat.

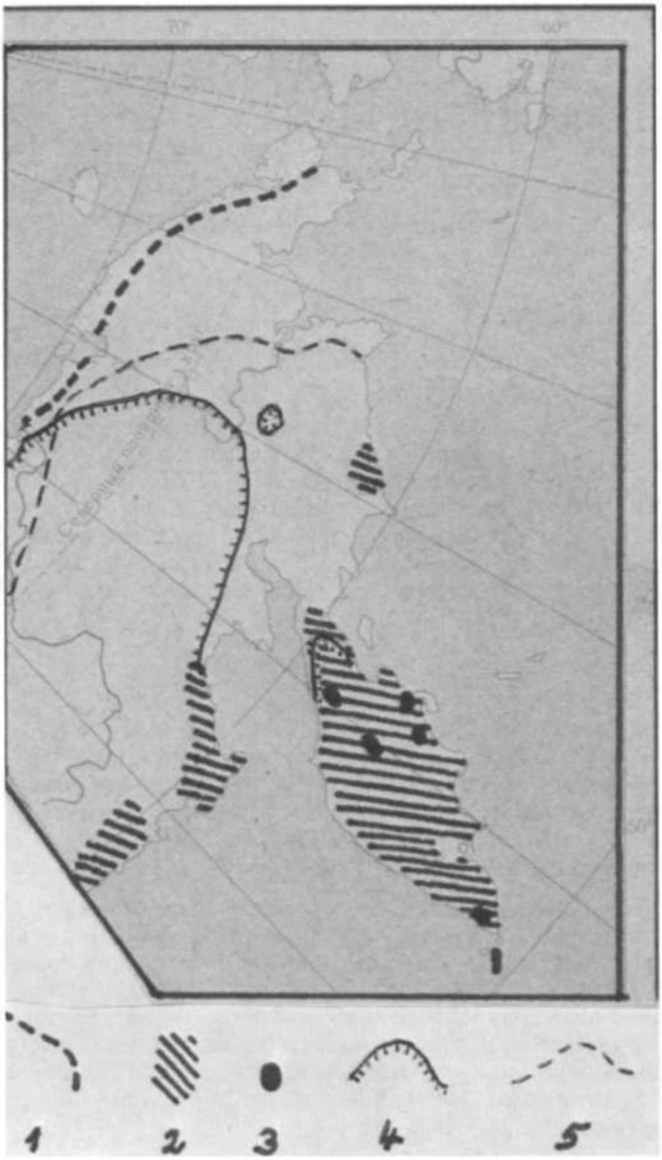

Fig. 1 Distribution and abundance of *Ursus arctos* L. in North-East Siberia.

Designations: 1—northern boundary of the area of the species; 2—areas of high numbers (appr. 0. 5-1 per 10 sq. km); 3—some areas of especially high numbers (appr. 3—20 per 10 sq. km); 4-north-eastern boundary of the forest zone; 5—northern boundary of the distribution of *Pinus pumila*.

food, e.g. spawning salmon. In some areas of southern and eastern Kamchatka the population density by the end of summer is especially high. According to A. G. Ostroumov (1968), in the basin of the Stolbovoye Lake it reaches 3 per 10 sq. km, near the Palanskoye Lake 5 per 10 sq. km, and in the basins of lakes Kurilskoye, Azabachye, and along the river Verkhnyaya Dvukhyurtochnaya 10 per 10 sq. km. Still higher (up to 12-20 per 10 sq. km) densities have been estimated for parts of Paramushir Island (Lavov *et al.* 1963). Such high numbers of bears are found only in areas especially rich in fish; population density here may be compared with the best grounds of southern Alaska (Troyer & Hensel 1964).

The number of bears in North-East Siberia, and especially in Kamchatka, has greatly decreased in recent decades, owing to excessive hunting. For instance, in the Kronotsky State Reserve in the 1940's the number of bears was still estimated at several thousand (Averin, 1948); now it does not exceed several hundred (V. I. Markow & Y. M. Chernikin, according to Ostroumov 1968). Approximate calculations give the total numbers of bears in Kamchatka as about 15-20 thousand (Ostroumov 1968), and in the mountains bordering northern coasts of the Okhotsk Sea as not more than 10 thousand.

TAXONOMY AND VARIABILITY

Bears inhabiting the area under consideration are traditionally included in the subspecies *Ursus arctos piscator* Pucheran 1855, which is close to races inhabiting Pacific coasts of North America (*gyas* and *middendorffii*). Apparently, this form is an extreme variant of the cline of East Siberian bears, in the same way as American forms in analogous biogeographical situations (Rausch 1963). To define the place of Pacific populations in the general system of the species' variability, new studies are needed.

It is known that in old times in Kamchatka there were extremely big bears, but in recent decades animals of medium size (250-150 kg and less) predominate; the biggest bear of 40 kills recorded by Averin (1948) weighed 285 kg. In the 1960's neither the author nor other investigators met with animals of greater sizes.[1] This can probably be explained by an overharvesting and selective kill of big specimens.

The colour variability of brown bears in North-East Siberia is great. On the northern coast of the Okhotsk Sea, very dark (black-brown and dark-chocolate) and light-brown (with darker paws) bears predominate, but sometimes also very light (almost sandy-yellow) animals are encountered. Cubs of the same litter may be of very different colour.

SEASONAL CHANGES OF HABITAT: FEEDING

In North-East Siberia the brown bear is mainly a mountain animal, visiting various habitats during the year. As a rule, the bears leave their dens from the middle of April to early May, beginning with lean single animals and ending with the females with cubs. The dates of leaving dens depend both on spring weather and the abundance of food the previous autumn. In normal years, animals killed just after leaving dens are well-fed. At this period there are

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[1] In recent years, cases of killing very big bears (up to 500-685 kg) are known (Novikov 1969), but extremely rare.

still winter conditions. On emerging from their dens, the bears stay in the mountains and feed on the berries of *Vaccinium vitis-idaea, Empetrum nigrum* and *Rosa spp., that* have lasted through the winter and may be found in sparse thawed patches, and on last year's cones of the dwarf pine *Pinus pumila.* They also eat sprouting green shoots of cereals, *Angelica, Heracleum* and *Filipendula kamtschatica),* last year's 'hay' of *Calamagrostis,* and the remains of salmon on river banks. From time to time they manage to catch other fish (*Salvelinus* spp.), susliks *Citellus parryi,* which have emerged after hibernation, or a stray domestic reindeer. In eastern Kamchatka, where snow is very deep in spring, bears go down to the sea coast to search for anything that may have been washed up (mainly dead seal cubs); sometimes they come to human settlements (Averin 1948).

In years of late spring the mountains remain snow-covered for 1-1. 5 months after the bears have left their dens. They may then make long migrations in the search for food, often crossing steep mountain passes. It is during this period that they use up the fat accumulated in autumn and by June they have become rather lean.

In June, there is a rapid growth of grass in the valleys and on the coast and the bears descend from the mountains. Later, as the grass begins to grow at higher elevations, they gradually retire to the mountains again. Vegetative parts of plants serve as their main food at the beginning of summer (June-July). In addition, in taiga and the thickets of dwarf pine and dwarf alder (*Alnus kamtschatica*), they eat ants and other insects, birds' eggs, last year's cones of *P. pumila,* foxberries (bearberries *Arctostaphylos*) and crowberries. They readily dig up burrows of ground squirrels and, from time to time, succeed in catching a hare or a willow grouse. By July, they often go up to the alpine belt (1500-1800 m above sea level), where there are no mosquitoes and bighorn sheep and wild reindeer graze with their young.

At the end of summer (varying according to region but usually in the second half of July), the rivers of the Pacific basin begin to swarm with the mass migration of spawning salmon. At this time great numbers of bears gather near the spawning rivers and streams to feed on salmon. Sometimes one can see 15 animals along 1-2 km of a river. In the stomach of one bear (Averin 1948) there may be up to 20 kg of fish. The feeding on salmon continues all August, and to a lesser degree still later, in Kamchatka (Averin 1948) till denning and near the Okhotsk Sea coasts till September.

Fishing bears are very picturesque; they have always attracted much attention both in Asia and America, and many brilliant descriptions have been devoted to this period in the bears' life. But although the salmon forms an important food item, its role should not be exaggerated. Bears feed on salmon only 1. 5-3 months a year and intensively for only about 2-4 weeks. Even when salmon are most abundant, not all the bears gather near rivers—some of them stay in the thickets of dwarf pine and dwarf alder, feed on red bilberry bushes in taiga, in the coastal 'tundra', rich in blueberry and crowberry, and on the seashore. Thus, in summer on the tide-line, bears eat green algae and laminaria, shrimps, crabs, mollusks and starfish thrown out by the sea. In 1963, on the Okhotsk Sea, the author observed bears eating green algae; this food was digested so quickly that in fresh droppings containing its remnants one could find many amphipods *Gammaridae* still alive. Sometimes seals (*Phoca vitulina* and *Ph. hispida*) which haul out on the shore serve as an additional food item for the bears; they also eat the refuse of sealing operations.

In August-September bears are also finding abundant ripening pine nuts and berries in the forests, coastal 'tundras' and thickets of dwarf pine, especially blueberries, foxberries, crowberries, berries of *Sorbaria* and also, in Kamchatka, of *Lonicera, Padus* and *Crataegus,* and above all the seeds of *Pinns pumila* cones. In autumn, before hibernation, bears can thus build up a layer of fat 5-6cm and sometimes as much as 15cm thick (Lobatchev 1966, Averin 1948).

Hibernation usually begins in the second half of October and in November. Dens in Kamchatka and the Koryak Highlands are in mountainous terrain. They have been found under the roots of fallen birch trees, among piles of boulders, in caves and in rock crevices. Some areas are particularly abundant in dens, for instance, on the Opalinskaya, Karymskaya and other volcanic peaks of Kamchatka (Lobatchev 1966). The floors of dens are covered with branches, leaves, and grass (Y. V. Averin 1948). Pregnant females in general den earlier than the others and prepare their dens more carefully. In winter active animals are very rare. In southern Kamchatka, at the beginning of winter heavy rain sometimes falls, washing away the snow cover from some dens and forcing the occupants to leave until the termination of the thaw (Novikow 1969).

This sums up the characteristic mode of life (with small differences in phenology) of all populations inhabiting the Pacific territories within the limits of the forest zone and dwarf-pine 'beringian' forest-tundra. In the Kolyma basin, bears do not have such an abundance of summer food in the way of salmon and sea animals. During summer they stay in taiga and the Subalpine belt of the mountains, feeding on greens, dwarf-pine seeds and berries. Sometimes they attack wild reindeer.

Almost nothing is known about the life of brown bear in tundra proper.

THE USE OF TERRITORY

Due to a large set of seasonal habitats, individual movements of bears during a year must be significant. Special studies on this problem have not been undertaken. According to observations and trackings, a single bear or a family may live on a territory 10-15km wide from a week to a month, after which they move elsewhere (Portenko *et al.* 1963). In eastern Kamchatka such temporary 'home ranges' from 8-12 to 60-100 sq. km can be distinguished in June-July (Markov 1969).

At the end of summer bears gather on salmon rivers in great numbers. By this time in convenient places (along tide-lines, river channels and the lower slopes of mountain or foothill valleys) bear pathways used by many individuals are established. In Kamchatka bears sometimes moved a distance of 50-60 km in one day (Ostroumov 1968). Apparently, the greatest movements take place immediately after bears leave their dens.

Bears do not have a clear daily rhythm. Most often they are met with in the evening, as also happens in Alaska (Erickson & Siniff 1963), but we could see them active (moving or fishing) even at midnight.

BREEDING. POPULATION STRUCTURE

The rut of bears occurs in May-June. The litter size is 1-3 (usually 2); litters of 4 or 5 occur very rarely. In mountains bordering the northern shores of the Okhotsk Sea, in 1963, cubs made up 17% (n-35) of the population; in 1964 only 6% (n-16). The spring of 1963 was very late and the bears killed during the rutting time were in an exhausted state (Kistchinski 1969). According to Y. V. Averin (1948), in the 1940's in eastern Kamchatka cubs averaged 23% (n-65) of the population; the mean litter size was 2.1. In 1960-1965, in the same area (Kronotsky State Reserve) V.I.Markov (1969) estimated the percentage of adults in the bear population to be 65% with a sex ratio of 1 male to 1. 30 female. *8%* of the female bears had cubs and 24. 6% yearlings. Cubs comprised 22% of the total population and yearlings 13%. Mean litter size was 2.20 (cubs) and 1. 56 (yearlings) per female. On territories in the vicinity of thermal areas, this author observed a certain increase of mean litter size.

ENEMIES AND PARASITES

Practically, bears have no enemies except man. In Kamchatka rare instances have been known of wolves attacking bears (Averin 1948)

In Kamchatka almost all the bears are infested with ascarids; one animal had 20-30 of them, but as many as 350 have been recorded. In spring ascarids are absent (Averin 1948). In the Koryak Highlands a case has been recorded of an outbreak of trichinellosis caused by the consumption of brown bear meat (Portenko *et al.* 1963).

THE BROWN BEAR AND MAN

The brown bears in near-Pacific regions are very peaceable and present hardly any danger to man. Apparently, their reflex to attack an animal of their own size is not developed. Only single cases of an 'unprovoked' attack are known (mainly by bears active in winter). During the rutting time in uninhabited areas male bears are very unwary and sometimes come up straight to man or a caravan of pack horses.

There are no reliable data on the harm done by bears to reindeer husbandry. Sometimes bears kill horses and cattle in Kamchatka; when in the 1860's cattle were introduced into the Anadyr valley, some of them were eaten by bears (Gondatti 1897).

Hunting of brown bears in North-East Siberia is limited and only allowed from September to May inclusive. In the Kamchatka Region killing of females with cubs is prohibited in spring. The number of animals which may be killed in the hunting season is unlimited and not registered. The hunters include local people, personnel of expeditions and weather stations, and sportsmen hunters. The Koryaks and Chukchis hunt mainly in spring, when the animals may be tracked and the meat brought home by dog teams.

The annual kill in the mountains bordering the Okhotsk Sea, the Koryak Highlands and the Anadyr basin may be estimated in hundreds but probably does not exceed a thousand. It is not considered excessive. In Kamchatka the kill is more intensive (according to A. G. Ostroumov, between 1000 and 2000 per year) and is subject to very little control. The present level of kill is probably too high and should be reduced.

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The Brown Bear *(Ursus arctos)* in Europe: decline, present distribution, biology and ecology

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INTRODUCTION

Due to commitments in Africa I was unable to accept the invitation to attend the Symposium in November 1970 and to contribute a paper on the brown bear (*Ursus arctos*) in Europe. Later, I was again asked to write such a paper for the Symposium Proceedings. In doing so, I have had the privilege of previously reading and commenting on Ian McTaggart Cowan's paper, published in this volume, on the status and conservation of the *Ursidae* of the World, before preparing my own contribution, but even so it has been impossible to avoid some slight overlapping of subject matter.

PAST DISTRIBUTION

In the past the range of the brown bear covered almost the entire coniferous, mixed and deciduous forest zones of Europe. Probably the Subalpine birch forests of Scandinavia, Finland and the Urals were included in its past range as nowadays. Although the brown bear seasonally visits the tundras and arctic heaths above the timberline for feeding purposes, it has never in Europe been a true inhabitant of treeless habitats. This feature seems to distinguish it ecologically from the conspecific North American grizzly (cf. Cowan in this volume).

HISTORY OF DECLINE

The history of local extinctions of the brown bear in Europe is geographically and chronologically as follows:

Denmark: Extinct probably already about 5000 years ago.

Great Britain: Became probably extinct in the 10th century and had certainly vanished by the beginning of the 11th century. It is uncertain whether it has ever existed in Ireland.

Eastern Germany (Silesia): Extinct in 1770.

Western Germany (Bavaria): Extinct in 1836.

Switzerland: Extinct in 1904. Occasional visitor, observed in 1914.

French Alps: Extinct in 1937.

PRESENT DISTRIBUTION

Although the brown bear has thus disappeared from the greater part of its range west of the USSR, it still occurs in most European countries. The destruction of forests and heavy hunting pressure have obliged it to retreat to forest-clad mountains in various parts of Europe, where the populations are isolated. There are at least 13 and probably as many as 19 or 20 insular brown bear populations in Europe. Several of these pockets hold very small populations, the future of which is far from being bright. The main populations live in the USSR, Romania and Yugoslavia.

Information about the size of the European populations varies in accuracy. Therefore, the following data are only indicative.

In Spain the brown bear is to be found as two isolated populations, one in the Cantabrian Mountains, west of the Pyrenees, and the second in the Pyrenees. According to Couturier (1954) there were about 40 animals in the Cantabrians and about 60 in the Spanish Pyrenees. However, the latter population is connected to the French one in the same mountains. There are about 70 brown bears in the French Pyrenees and that is all that remains of the species in France.

In Italy the brown bear still exists in two areas, the Abruzzo National Park in the Apennines and between Adamello and Brenta in the Dolomites. In 1922 there were only 30 or so brown bears in the Abruzzo National Park, which was established the following year. In 193,5 more than 200 animals were reported from the area, a figure repeated by Couturier in 1954 for the whole of Italy. This estimate was probably much too high, for in 1964 the population in the Abruzzo National Park was found to be only about 60 bears (Curry-Lindahl 1964).[1] In 1971, Mr Franco Zunino and Dr. Stephen Herrero worked in this National Park and estimated the population there at 70-100 brown bears (Herrero *in litt.*).

Of the large European carnivores—the bear, the wolf and the lynx—only the bear has survived in the Alps with about 8-10 animals in the Italian Dolomites. (However, the lynx has recently been reintroduced in Switzerland.)

In Yugoslavia, brown bears live in isolated mountains of both the northern and southern parts of the country. Couturier (1954) estimated the population at more than 700, a number that 16 years later seems to have increased considerably: about 2000 (Isakovic 1970). Also in Albania there are 'numerous' brown bears (Hainard 1961), but no figures are available.

In Greece the population was estimated at about 115 individuals in the 1950's (Couturier 1954), but this seems to be too low, because in Macedonia alone there were about 400 bears in 1959 (Hainard 1961) and, in addition, there is also a population in the Pindus Range of northern Greece (Curry-Lindahl 1964). From Bulgaria about 1, 300 brown bears were reported by Couturier (1954). Romania has a fairly sizable population. According to Professor Valeriu Puscariu (verbal comm. 1971) there are more than 3, 000 bears, chiefly living in the Carpathians.

In Hungary there were three to six brown bears in the 1950's (Couturier 1954),

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[1] The IUCN Mission to the Park in the same year accepted a figure of about 100 for the Abruzzi as a whole, based mainly on sightings by forest guards –Ed.

but recent information is lacking. From Czechoslovakia the same author reports 70 to 80 bears and from Poland only about six. These figures were probably too low, because at present there are about 230 bears in the Tatra National Parks alone, located in the northern Carpathians of both Czechoslovakia and Poland (Curry-Lindahl & Harroy in press). In fact, the brown bear is distributed almost throughout the Carpathians.

Hence, the Balkan and Carpathian populations at the present time consist of at least 5, 230 bears if only figures of the 1960's for Yugoslavia, Romania, Czechoslovakia and Poland are included. If data of the 1950's for Greece and Bulgaria are added, there are altogether about 7, 000 animals in the region.

In Scandinavia there are between 25 and 50 brown bears in Norway (Myrberget 1969) and about 300 in Sweden (Curry-Lindahl 1970); some estimates in 1968 reached a total of about 400 (Haglund 1968) but this figure is somewhat uncertain. In Finland the population seems to be larger than in Scandinavia (cf. Pulliainen 1971) judging from the number of bears shot annually in the former country. However, recently (1971) the conservation journal Suomen Luonto stated that the number of bears in Finland has been established at 150.

Obviously it is in the USSR that the bulk of the European brown bear population is to be found. In the Baltic countries the bear now appears only in Esthonia. In southern USSR it occurs as far west and south as White Russia along the Oka River; to Rjazan near Moscow, and farther east in Mordow and Mari to the Urals. Thus it occurs farther south in western USSR than in the east (Curry-Lindahl 1964). Cowan (this volume) summarizes the data from various parts of the USSR territory. The total population in the European part seems to be about 10, 000-11, 000 animals.

The grand total of European brown bear populations therefore seems to be approximately 17, 700-18, 000 animals. This is about 8, 000 animals less than the estimated North American brown bear population (Cowan, this volume).

THE BROWN BEAR IN SWEDEN AS AN EXAMPLE OF RETREAT AND EXPANSION DURING 370 YEARS.

The oldest records of the brown bear in Sweden date back about 8, 000 years.

Fig. 1 shows the decrease of the brown bear in Sweden, indicated by the southern boundaries of its range in each century from 1600 onwards. It is unknown when, before historical times, the species became exterminated in the southernmost provinces but there are subfossil records from deposits contemporary with human presence.

Between 1800 and 1900 the brown bear decreased tremendously, retreating from Southern Sweden to the northern parts of the country. By 1900 it was, except for two minor enclaves in Central Sweden, almost entirely restricted to Swedish Lapland.

During the first decades of the 20th century the brown bear decreased further. The remaining populations were forced upwards into the mountainous regions of Swedish Lapland, where they found refuge in remote valleys. When the species was near extinction in 1925 it became totally protected. As a result of the protection, a certain stabilization of the population seems to have followed locally in the upper Vindel Valley of southern Swedish Lapland and in the mountains of Lule Lappmark of northern Swedish Lapland.

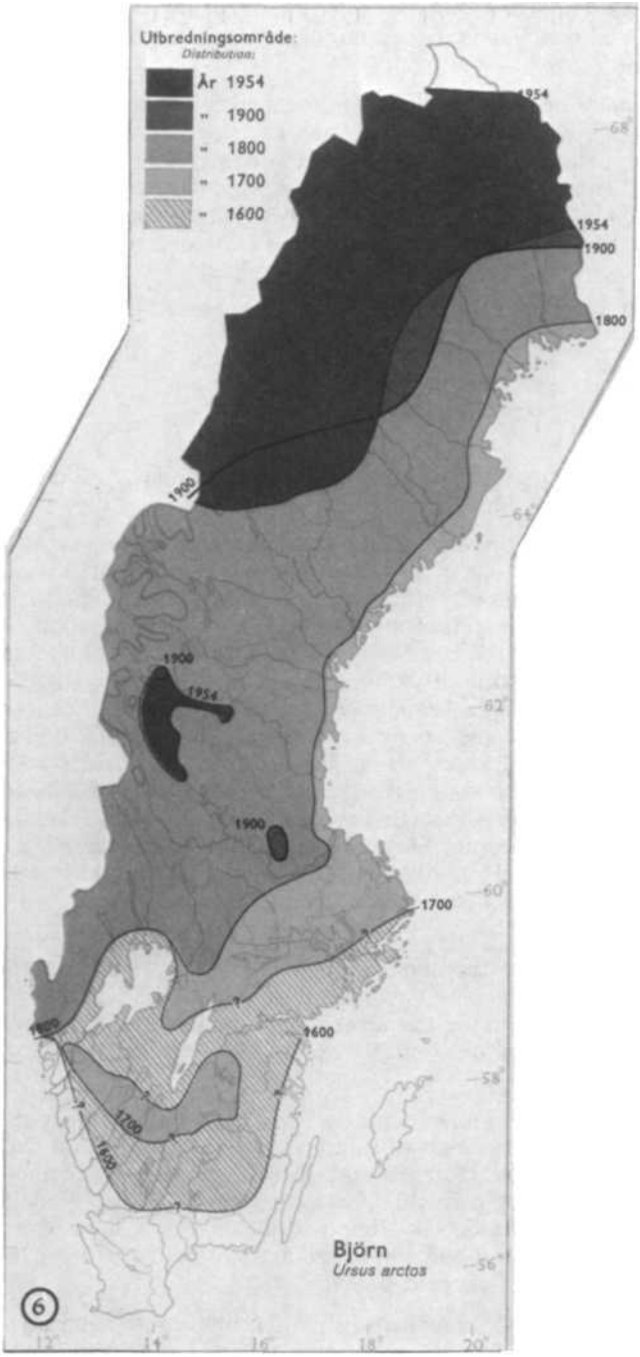

Fig. 1 Breeding distribution of the brown bear (*Ursus arctos* L.) in Sweden 1600-1954. After Curry-Lindahl (1957).

Simultaneously the isolated southern populations in central Sweden increased and spread southwards and eastwards, recolonizing ancient areas as indicated by the map.

In 1943 a two months annual open season was introduced in Sweden. It has continued ever since and in some provinces it has even been extended in time. The hunting pressure on bears living in the upper valleys of Swedish Lapland, where they had been left in peace for 18 years, led to a gradual evacuation of these areas and the reappearance of bears in the lower coniferous forests, where they more easily found shelter and food. Some bears were recorded as far eastwards as Niemisel and Boden near the Baltic coast.

In 1957 a census of the brown bear in Sweden gave a figure of 252 animals.

BIOLOGY AMD ECOLOGY

Only a few features in the biology and ecology of the brown bear in Europe will be commented upon here.

All over its European range the brown bear is an inhabitant of forests, although it makes visits above the timberline in spring to feed on carrion (in northern Europe particularly the carcasses of reindeer *Rangifer tarandus* which have succumbed during the winter) and in late summer and autumn to feed on berries. The optimal habitats of the bear are coniferous, mixed and deciduous forests, with a rich under-vegetation of various vascular plants and whether located in lowlands or in mountains. Scandinavian Subalpine birch forests in some valleys with favourable edaphic conditions and sun exposure, are characterized by a luxurious vegetation, which offers the bear optimal habitats. Also the birchwood steppes close to the southern Ural Mountains in the USSR seem to be appreciated by bears as a biotope. However, in Europe most bears are found in the coniferous forests despite the fact that deciduous woods seem more suitable for them. This is probably due to the fact that man has occupied deciduous forests more intensively than he has coniferous ones.

If left in peace, the brown bear will stay within a certain large territory; if often disturbed, it may roam over tremendous areas. Usually it lives alone, although the females remain with their young up to a year and a half. During the summer it is chiefly active during the afternoons and the evenings. When it has scented or heard something unusual, it takes a bipedal position in order to facilitate vision and scent.

Just before or just after the first snow has fallen in the autumn, the brown bear retreats to a den, which has been prepared in advance. The den is in a natural cave, a dug cavity in the earth of a slope, an anthill (of *Formica rufa*), under a fallen tree, under low overhanging branches, between or under larger roots and under overhanging rocks. The den is lined with branches of spruce, moss, grass, leaves or bark, which form a bed, but there are also dens without lining. The same den can be used during several years.

There is doubtless a small drop of temperature in the brown bear during hibernation, although it does not prevent a winter sleeping bear from becoming immediately active when disturbed. Lobachev (1951) in the USSR found that respiration and heart beat slowed down and that body temperature falls to 29-34°C. Folk (in this volume) gives support to previously recorded minima of 31-37.9°C in the case of the black bear (*ursus americanus*); for the North American brown bear or grizzly (*U. arctos horridilis*) he mentions a drop in heart rate during dormancy similar to that recorded by him for the black bear, namely from 40 to about 10 beats per minute. Changes of this order certainly seem remarkably pronounced in relation to the observed alertness of hibernating European brown bears if disturbed.

The European brown bear is omnivorous, but feeds chiefly on plants. In summer it eats mostly grass, herbs, fruit, berries and roots. In the Scandinavian mountains it is especially fond of the great angelica (*Angelica archangelica*) and alpine lettuce (*Lactuca alpina*). The brown bear also relishes ants, honey, beeswax, insect larvae, small rodents, fish and carrion. Only exceptionally do brown bears acquire a taste for fresh meat and attack larger mammals such as moose *Alces alces,* reindeer, red deer *Cervus elaphus* and livestock.

The reproduction of the brown bear in Europe usually has the following pattern. The species is promiscuous. Copulation takes place in May-June. Up to 16 copulations have been observed during the same day. The rutting period of females is 10-30 days and the gestation period 6-7 months with delayed implantation. The 1-3, seldom 4, cubs are born in the den in December-January. Their eyes open after 4-5 weeks and they are regularly suckled up to June-July, sometimes August, and irregularly as late as up to an age of one and a half years. Usually the female has cubs every second year. Sexual maturity is reached at an age of 2½-4 years, females normally when 2 years old, males when 3 years old. Maximum longevity in captivity is 47 years (Skansen Zoological Garden, Stockholm).

THE BROWN BEAR, LIVESTOCK AND MAN

The European brown bear is not dangerous to man unless it is attacked and wounded or its young are threatened or believed to be so. Hence, it does not share the reputation for aggressiveness of the brown bears of Hokkaido and the grizzlies of North America.

Although the brown bear lives in many areas where there are livestock grazing extensively in the same habitats, it does not normally kill domestic animals. There are observations of brown bears feeding on meadows where cattle were grazing without any reactions from either the bear or the herbivores. A sizable bear population haunts the Caucasus Mountains—often in the middle of the sheep-breeding regions—apparently without coming into conflict with human interests. In one place in the Caucasus shepherds pointed out to me a cave in a mountainside where a bear was resting; neither the sheep grazing all around nor the shepherds seemed unduly concerned. In Swedish Lapland domestic reindeer and bears meet frequently. The former are normally undisturbed when a bear is in the vincinity, but when the reindeer females are giving birth or are accompanied by newborn calves, they are alert to the presence of bears. In Swedish Lapland some bears—apparently the same individuals and perhaps their offspring—regularly every spring visit areas where reindeer females give birth. Many calves are stillborn or succumb just after birth, so this may be the prime reason for the bear's interest during a season when vegetable food on which the bear likes to feed is almost non-existent.

Also elsewhere in Europe bears in some areas in late winter or early spring are forced to feed on carrion or live mammals. In such cases sheep and other domestic animals may fall victim to them, but in general such cases are quite exceptional.

CONSERVATION

The brown bear is not endangered by extinction in Europe, but its range is shrinking due to habitat alterations. Hunting pressure has ceased and the species is at present totally or seasonally protected in most countries. In many areas it is showing a gradual adaptation to cultivated habitats. It is certainly able to live side by side with man without causing serious conflicts.

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PANEL 1: THE ECOLOGY, POPULATION CHARACTERISTICS, MOVEMENTS, AND NATURAL HISTORY OF BEARS.

SUMMARY OF DISCUSSION

F. Craighead. In our population in Yellowstone, we found that the minimum breeding age of females is 4½, that is they produce their first cubs at 5½ years of age and some not even then. These are marked bears which we followed year after year, most of them by radio. Some did not produce their first litters (unless they produced them in the dens and lost them) until they were 6½, 7½ or even as old as 9½.. In over 200 litters that we've followed over the years, about 50% of the females weaned their litters at the age of 1½ and the others at the age of 2½. Mr. Pearson indicated that in the population that he was studying, all the females on which he had data had weaned the young by the time they were 2½ years old and I think he has some ideas as to why this might be.

A. Pearson. Although the sample is small on the area that I was working intensively, I do have information from the hunter kill throughout the Yukon for two complete years. I also have observations—for what they're worth—from outfitters, hunters and guides. I have nothing at all to indicate that there are any grizzlies in the population wandering about on their own that are under 2½ years of age. In other words, the only young animals that occurred in the hunter-kill sample, were killed with the sow. They were killed illegally in this case but they were killed with the sow and I would think that if there was any extensive weaning at 1½ years of age, for sure some of these animals would show up in the harvest that fall because hunters in our country are not selective—at least they claim they're not—for grizzlies. They shoot the first grizzly that is a legal grizzly and size means nothing to them because, without doubt, they all describe the grizzly as being big and there is no such thing as a small grizzly. Now as to why this should be. Our grizzlies are obviously living in a very barren area compared with areas farther south or closer to the coast. The period during which they are actively putting on weight each year is only from about the 1st of August to the middle of September. In other words, their entire growth occurs during a period of maybe 45 to 50 days. The energy input into this system is low, and a young grizzly will only reach about 40 lbs at the age of 6 months. The next year, going into the den with the sow at 1½ years of age, the young will weigh in the neighbourhood of 65 lbs. This is completely different from what is found, I understand, in more southern areas and coastal areas. Perhaps you could tell us some values or weights for your area.

F. Craighead. We have cubs that would be going into hibernation for the first time, that weigh in the neighourhood of 125 lbs in the fall of the year and about 100 lbs more that that at 2½ or up to 250-275 lbs. So there seems to be quite a difference.

V. Berns. We find the same thing in Kodiak. Cubs of the year going into hibernation for their very first winter are weighing between 125 to 150 lbs, occasionally more.

F. Craighead. And what about the weaning? Do you find weaning at 1½ as well as at 2½?

V. Berns. Yes we do. We have examined females with 2½ year old young that were lactating, which indicated that some 2½ year old animals were still nursing, but generally weaning takes place at the age of a year and a half.

F. Craighead. In the Yellowstone population we found that quite a few of the females wean the young and breed again in the same spring. They'll wean them in May, late May or very early June, and then come into oestrus and breed. There is a certain amount of social facilitation that occurs where females that carry the young for 2½ years adopt the yearlings, which are, of course, the same age as their own cubs and look after them through the summer into the fall. At the fall of the year when they go into hibernation they take only their own offspring. These are weaned at 2½ and the female will breed again in the spring at the time she weans the young. We've had some females that develop very close bonds, travelling together throughout the summer and fall, almost inseparable. In three or four instances one of the group of two or more females with offspring, then adopted the yearlings of the other one. But it seems to be this close association of females prior to weaning that is necessary before such adoption takes place.

M. Peltoru Mr. Berns what is the accuracy of your aerial fixes by telemetry?

V. Berns. It was within 25 yards, generally, or a brush patch. We'd fly very low over a bear, getting down within 200 feet of the ground. You could pinpoint their location because there would be a rapid buildup and then almost a cone of silence when you flew over the animal.

M. Pelton. The reason I ask this question is that thus far—as far as I know—, in the southern Appalachian chain, no one has successfully radio-tracked an animal under the conditions that exist there. But we are eventually going to get into a telemetry study and we're trying to work out arrangements for actually tracking the black bears in the Smokies. Every attempt so far has been unsuccessful because of the steep ravines, heavy vegetation, and rock outcroppings.

V. Berns. We have a lot of the same problems at Kodiak with steep ravines. However, in the summer months the bears are generally along the streams so you have an idea where they are. If weather conditions are such that you cannot follow them for perhaps a week, quite often they'll go to another drainage. Then, if they're in a ravine, you may have to be within a half a mile before you can pick up the signal.

G. Burghardt. I'd like to know, first of all, how frequently you can actually see the bears from the plane when you fly over them? Can you ever see them?

V. Berns. In about 9 instances of 247 fixes.

G. Burghardt. What effects did the plane over them have on their behaviour?

V. Berns. Generally they went into an alder patch and stopped.

A. Pearson. I could perhaps make a comment, because we were also tracking by airplane and helicopter. It's obvious from the signal that you receive when you're flying in an airplane, that when you start getting close, the animal is starting to move and you can tell that he is moving and it's one way that you know you're getting close. The other thing, with a helicopter, we've on several occasions been very confident the bear's below us and yet it'd be an alpine situation, with very, very low Salix cover in some of the creek bottoms, and yet we'd fly back and forth and still couldn't see the bear. We were having some doubts as to whether we were having problems but in every case when we persisted, we found the bear was there. When we got in that close, some bears hid in the willows and lay down and we had to go in and persist a great deal in order to scare them out and make sure that they were there. So you get two reactions, the first being running. Then, in some cases, perhaps through learning (because we were also on occasion shooting these animals from the helicopter with a dart gun), they would hide and remain motionless. This made them more difficult to locate.

R. Russell. Dr. Pearson, I was interested in your belief that den sites may be a limiting factor or, at least that there is some competition for den sites in your study area. Aside from the incident in which the male killed the female in the den, what other factors lead you to believe that there may be competition for den sites, and if so, might this be a limiting factor in the population numbers?

A. Pearson. I think it can be, in the area that I'm working in, and I think it could be in other areas such as the North Slope. The reason I say this of my area, is that the den sites are very specific in their location and indeed, once you get used to locating them, you can fly past a mountain in the area and say where there are going to be some den sites and there will be den sites there. And I say sites because there's never one alone, there are always several in any such area, indicating extensive use over generations of that area. I have seen no evidence of actual mortality around den sites other than this one case. I spent some time farther north this summer and saw a grizzly bear. However, I saw nothing that I could recognise as a potential den site and did not see any dens. It was just a casual trip, not a specific trip to look for grizzlies and grizzly den sites, but indeed there does seem to be a lack of appropirate denning areas in the north coast area.

I. McT. Cowan. I would like to ask Dr. Craighead whether he has noticed any difference in the success of young weaned at a year and a half versus young weaned at 2½?

J. Craighead. That's a good question and although we have studied these bears now for a period of 12 years and followed 52 families rather closely, we haven't been able to get sufficient data to determine whether those weaned at 1½ are less successful in surviving that those at 2½. However, our weight data indicate that when bears weaned at 1½ reach 2½, they're not as heavy or as large as those that are carried through and weaned at 2½. So I suspect there probably is a survival factor but we haven't been able to get quantitative data on it.

I. McT. Cowan. Certainly if there is a difference, you'd expect the early weaners in the long run, to dominate the population because the females would be producing more young over a given span of years.

PANEL 2: DENNING—CONTROL MECHANISMS, SITE SELECTION AND PHYSIOLOGY

Data on Grizzly Bear Denning Activities and Behavior obtained by using Wildlife Telemetry

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INTRODUCTION

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

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

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

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

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

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

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

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

METHODS

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

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

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

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

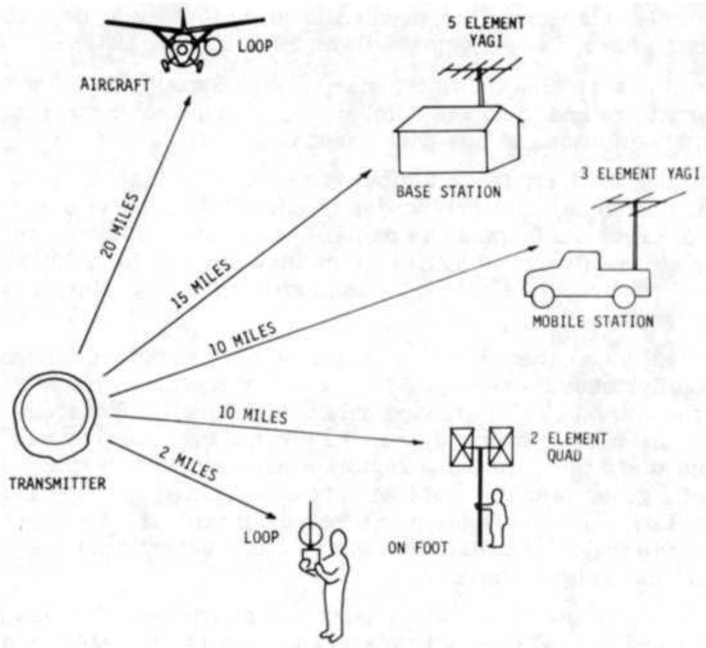

Fig. 1 Radio location system

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

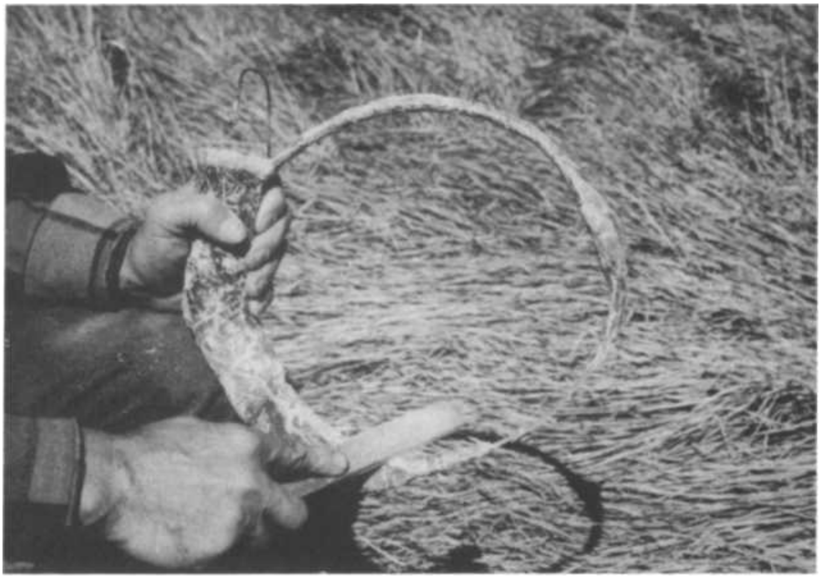

Fig. 3 Putting fiberglass on transmitter-collar assembly to make it waterproof, shockproof and bear-proof

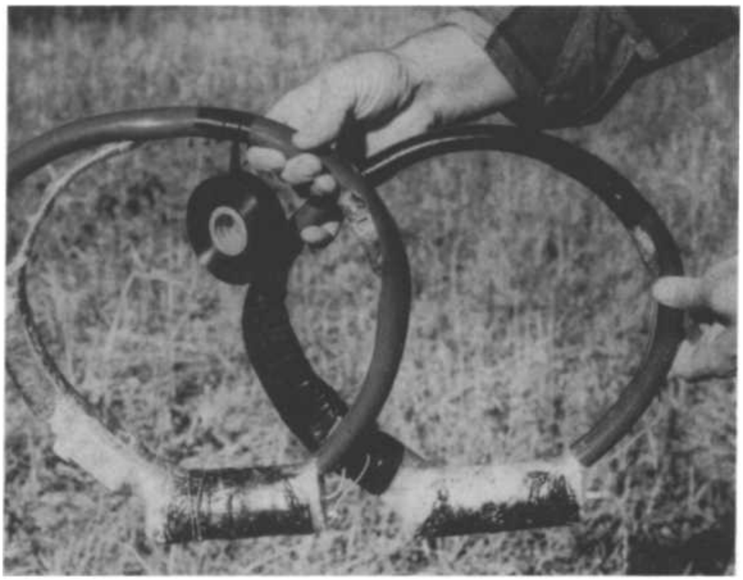

Fig. 4 Plastic hose and rubber padding, wrapped with tape of varying colors, make a comfortable and snug fit.

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

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

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

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

Normal tracking procedure was to record a signal from an instrumented grizzly at the base station using the 5-element yagi antenna. The direction of the signal source was plotted on a topographic map. A second and frequently a third bearing was made with the mobile unit. The intersection of the bearings generally fixed the animal's position to within a ¼ to ⅓ mile area on the map (Fig. 5). We then hiked to within 2 to 4 miles of the fix and activated the portable receiver which was used to move in on the bear until he was sighted or jumped.

TABLE 1. TRANSMITTER CHARACTERISTICS

Frequency	32 MHz
Output power	100 mW pulse
Pulse width	50 ms
Pulse repetition rate	1 per second (nominal)
Antenna type	resonant loop, 11 inch diameter
Antenna impedance	50 ohms
DC input power	280 mW peak, 18 mW average
Battery type	mercury, low temperature 9. 3 volts, 4. 5 Ah
Weight:	
electronics	0.1 lb
battery	0.9 lb
complete collar	2.0 1bs
Operating lifetime	3 months standard, 9 months with additional timer

TABLE 2. RECEIVER CHARACTERISTICS

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

TABLE 3. SYSTEM RANGE WITH VARIOUS RECEIVING ANTENNAS

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

*Typical value—varies widely with terrain

As the instrumented animal was approached, the signal strength increased so that, at about ¼ mile, a null became difficult to obtain. The receiver sensitivity setting was then reduced to get a null; the remaining distance to the instrumented grizzly was covered by following the null. Signal volume and receiver sensitivity provided a good indication of distance between the bear and the observer. We frequently approached grizzlies to within 100 feet before disturbing them. The average distance at which we 'jumped' them from daybeds in dense timber and windfall was 125 feet.

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

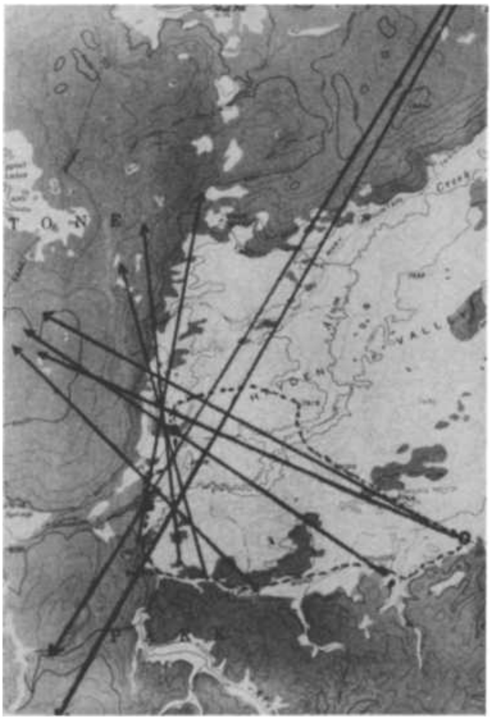

Fig. 5 Bearings of transmitter signal plotted over two consecutive days in order to locate instrumented grizzly. They were taken from a field station (circle) and the base station (upper right, just off map 8 miles to north). Dark spot is position of bear and dotted line is route of trackers using portable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

RESULTS

Den Site Selection

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

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

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

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

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

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

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

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

Den Construction

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

TABLE 4. CHARACTERISTICS OF ACTIVE GRIZZLY BEAR DENS

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

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

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

TABLE 5. CHARACTERISTICS OF INACTIVE GRIZZLY BEAR DENS

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

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

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

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

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

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

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

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

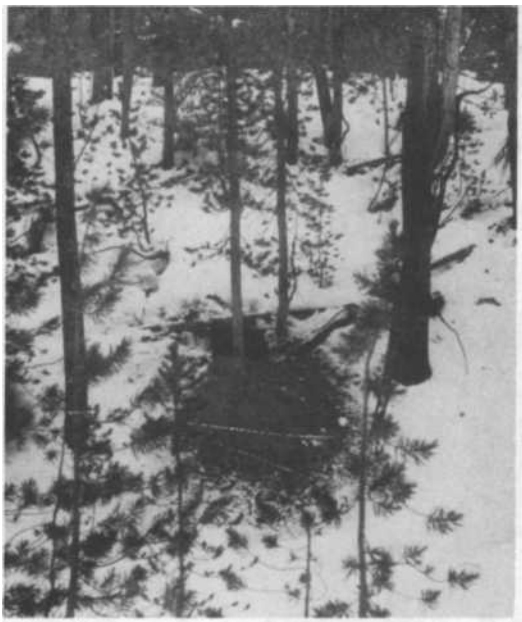

Fig. 8 Den of grizzly sow No. 187, which was abandoned prior to being lined with boughs. This was one of the few dens not dug at the base of a large tree but, instead, sited below a horizontal fallen log.

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

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

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

Den Environment

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

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

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

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

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

Distinctions between Daybeds and Dens

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

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

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

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

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

Re-use of Dens

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

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

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

Prehibernation Movement and Behavior

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

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

Prehibernation Lethargy

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

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

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

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

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

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

Defense of Dens

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

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

The following day we picked up a signal at 52 pulses per minute, coming from the radio collar on the yearling grizzly No. 158. This we knew would lead us to the den of sow No. 39. We hoped to determine whether this yearling as well as his two large littermates would den with their mother (Craighead & Craighead 1969). The signal lured us deeper into the Yellowstone wilderness. Sometimes it was only a weak pulse; other times it came to us intermittently and finally strongly as we approached the den. Occasionally it halted our trek when it died out completely for long periods while the instrumented grizzly remained in the den. In late afternoon still following the signal we entered a thicket of 'doghair' lodgepole pine. Visibility was only a few feet. A sudden increase in signal strength informed us that the instrumented grizzly and probably the entire family were moving toward us. Immediately after we climbed trees, our signal revealed that the bears were running away. Sow No. 39, a grizzly that had a record as a belligerent bear, had not attempted to defend her den.

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

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

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

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

Emergence from Hibernation

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

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

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

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

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

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

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

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

GRIZZLY BEAR MANAGEMENT

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

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

In regard to the meat portion of his diet, the grizzly is principally a scavenger and can detect and will move to 'ripe' carcasses from long distances. Some marked animals have moved airline distances of 18. 5 miles to such sources of food. As many as twenty grizzlies have been observed at one time around a single carcass. Radio-instrumented grizzlies have located dead animals three miles away in three days—about the minimum time needed for a carcass to decompose to the stage where it can be readily detected by scent. In the fall of the year prior to 'hibernation' and in spring soon after emergence from 'hibernation', grizzlies can be readily attracted to carcasses. Where grizzly bear populations are low or declining the use of 'baits' to attract and shoot grizzlies during hunting seasons should be prohibited or permitted only with reservations and with options to prevent the use of 'baits' during some seasons.

ACKNOWLEDGEMENTS

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

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

This study was supported throughout its entirety by the National Geographic Society; it was also supported by Research Grant GB-2672 from the National Science Foundation; continuing grant AT (45-l)-1929 from the Atomic Energy Commission; and funds from the Bureau of Sport Fisheries and Wildlife.

In addition, we gratefully acknowledge financial aid from the Environmental Research Institute and the Philco-Ford Corporation. We received help and cooperation from 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.

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Physiological Condition of Three Species of Bears in Winter Dens[1]

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SUMMARY

The concepts of this paper include:

A. Winter dormancy of the black and grizzly bear is characterized by a slow heart beat or bradycardia more prolonged than that found during the dive of marine mammals.

B. This dormancy of the black and the grizzly bear seems fairly complete with few of these two species active in midwinter. During this period of dormancy, for nearly six months in Alaska, these animals do not urinate, defecate, eat or drink. In a sense their dormancy is more complete than that found in the typical mammalian hibernator which reduces his body temperature and metabolism, but awakens sporadically every four to ten days and may, then, drink, eat, urinate or defecate.

C. Two male polar bears demonstrated that they too have the capacity to reduce physiological functions in midwinter. This was much harder to prove in these animals than in the other two species. Evidence is cited that many polar bears cannot prepare for this period of dormancy by laying down subcutaneous fat. This probably prevents them from taking on this state of dormancy, although it is quite possible that at least for a month at a time even on the Polar Ice Pack, bears may make use of their ability to reduce heart rate and perhaps body temperature and metabolism.

D. The test of the configuration of the EKG pattern has been applied to three species of bears; this pattern appears to be more like that of mammalian hibernators than like that of other types of mammals.

INTRODUCTION

One of the more interesting aspects of the biology of bears in a cold environment is their success in spending the winter in a den. Biologists for some time have debated whether the physiological condition of bears in winter dens is comparable to the typical hibernation found in some mammals such as the woodchuck, hamster and ground squirrel. Typical hibernation includes a lowering of body temperature, heart rate and metabolism, until the body temperature is within about 1 °C of the ambient conditions. Another characteristic of mammalian hibernation is regular awakening in bouts occurring about every four days in the case of the hamster and about every ten days in the case of the ground squirrel (Folk 1966). There is not enough information about the

1 Research supported by the Arctic Institute of North America under contract with the Office of Naval Research.

winter denning of bears to allow an exact comparison with the other mamalian hibernators; however, such information as does exist shows that the black bear and the grizzly bear undergo a condition of dormancy which is more extreme than that found in typical mammalian hibernators. When the other hibernators arouse to normal body temperature (at periods varying from four to ten days), they often urinate, defecate and eat. The bear in typical winter dormancy does none of these. Thus, it seem to have a digestive and excretory system better adapted for winter dormancy than do the more typical hibernators. There has been debate as to how to generalize about the dormany of bears in the winter den, because some of these animals when disturbed in midwinter do become quickly and vigorously active. Because of this and because the female gives birth to her young in midwinter, some biologists have presumed that there is very little decrease in physiological activity. Professor Raymond J. Hock[1] on the other hand believed there was enough reduction to warrant a new term, 'winter lethargy', to be used for bears, instead of hibernation (Hock 1960). It remains to be seen whether this term is justified and will stand the test of time.

The present paper will review our knowledge of the condition of bears as they go into hibernation and their physiological status as they remain there, and will indicate those lines of research which would be most productive for the future. In the facilities of the Naval Arctic Research Laboratory and the Arctic Aeromedical Laboratory, we were able to record by Iowa radio-capsule (Folk 1964) the body temperature, heart rate and the EKG of denning grizzly, black and polar bears. The observations of the first year have previously been reported (Folk 1967). The results from years two, three and four on the same black and grizzly bears, and studies on two polar bears, will be reported here.

DENNING OF BLACK BEARS

Conditions

Black bears in the northern United States are apt to go into dens in early October (Erickson 1964). Most of them appear to remain active until the ground is snow-covered. The location selected varies considerably. Most bears favor dens dug beneath logs, or in holes dug into hillsides. Some of these dens are lined with vegetable matter. Male bears tend to den later than females and young bears. In the sample described by Erickson, the excavated dens and the unprotected ones are the most interesting. Twenty-one per cent dug a hole into a hillside, 46% dug a hole under stumps or logs, and 7% lay down in an unsheltered depression.

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1 Professor Hock was a pioneer worker on the physiology of winter denning of bears and other aspects of hibernation. He built a series of cage-den units at the River Laboratory of the Arctic Aeromedical Laboratory in about 1955 and did a fundamental series of experiments on the metabolism of bears in the winter condition. These cage-den units are still in use for studies on bears. In late summer of 1970, while carrying out a field program in Grand Canyon, Professor Hock was killed by an unusual accident as a portion of a tree fell upon him. It is suitable in this article to call attention to the extensive contributions he made to knowledge of mammalian hibernation.

Some observations of black bear denning in Alaska will be helpful. Most dens which have been described have been under logs, but Dr. Robert Weeden guided us to a den dug in the south side of a hill outside of Fairbanks (Figs. 1, 2). The digging of a den by a black bear has more significance in this area because of the presence of permafrost. Because of the ambient temperatures encountered in Alaska, it is more likely that black bears would seek deep shelter than in the lower 48 states. The radiant contribution of heat from the earth must be much more important in Alaska than in other locations; this contribution to the comfort of the animal in extreme cold seems important enough to include the following physical measurements:

a. In the Weeden den the ground temperature without the animal occupant was repeatedly —9°C when the air temperature was —46°C.

b. In a simulated den made from insulation material, the radiation from the earth warmed the air six inches from the ground to —8°C when the outside air temperature was —47° C

c. When ground temperature was measured under the snow alone and the air temperature was —40°C, the ground temperature remained at —9°C.

This radiant heat from the earth would be as important in a grizzly bear den in Alaska as in a black bear den.

Physiological State

The body temperatures of large animals such as bears can drop only with difficulty if they remain quietly resting in a reasonably warm location in hibernating position (Fig. 3). Even with cellular metabolism reduced to the minimum because of lack of specific dynamic activity and exercise, still the surface mass ratio of a large animal would delay cooling under the conditions of maintained cellular metabolism and a very heavy insulation. It is not surprising that the lowest figures obtained for body temperature of denning bears are as follows: Morrison 37.9°C, Hock 31.0°C, Rausch 33.0°C. By radio-telemetry we confirmed these readings, showing a body temperature drop of the same order of magnitude. Part of the reason that investigators have obtained high body temperatures in midwinter may be the time of day of locating the animals. It could be that a lower body temperature might be found at midnight. We reported earlier the day-night rhythm of body temperature of the black bear during the month of October and during the month of December; there was a high during the day and a low during the evening. As the winter progressed there was only a slight drop in average body temperature but the daily rhythm showed a lower amplitude.

The most striking and important results from the radio-telemetry were the changes in heart rate of the bears as winter dormancy progressed. The summer sleeping heart rate was usually higher than 40 beats/minute. As fall progressed this heart rate in three individual black bears became lower at least during part of the day and eventually during most of the 24 hours. Sequentially over several weeks, heart rates below 30, then 20, then 10, and finally 8 heart beats per minute were recorded. These particular black bears did not urinate or defecate for at least three months. After this time they were artificially aroused. The significance of these physiological observations will be discussed later.

Fig. 1 View of den excavated by black bear, Fairbanks, Alaska, on the Weeden property. The den is on the south slope of a hill in a hardwood forest.

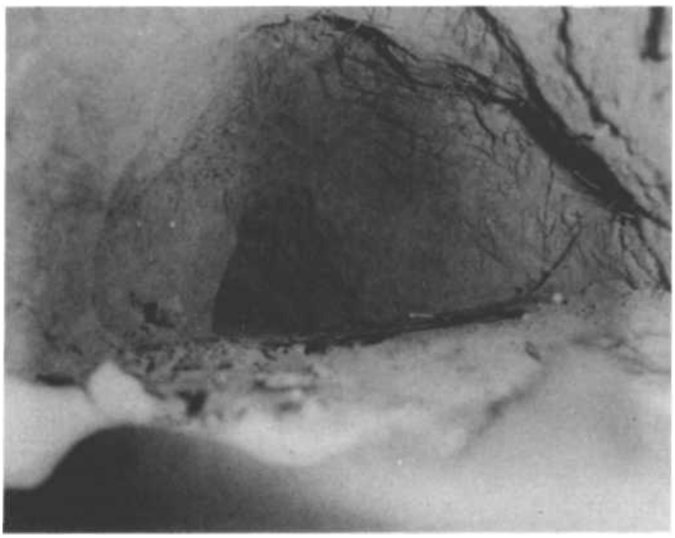

Fig. 2 Interior of the black bear den showing claw marks. Den was two meters deep and one meter in diameter. Tracks in snow provided proof that the bear wintered there.

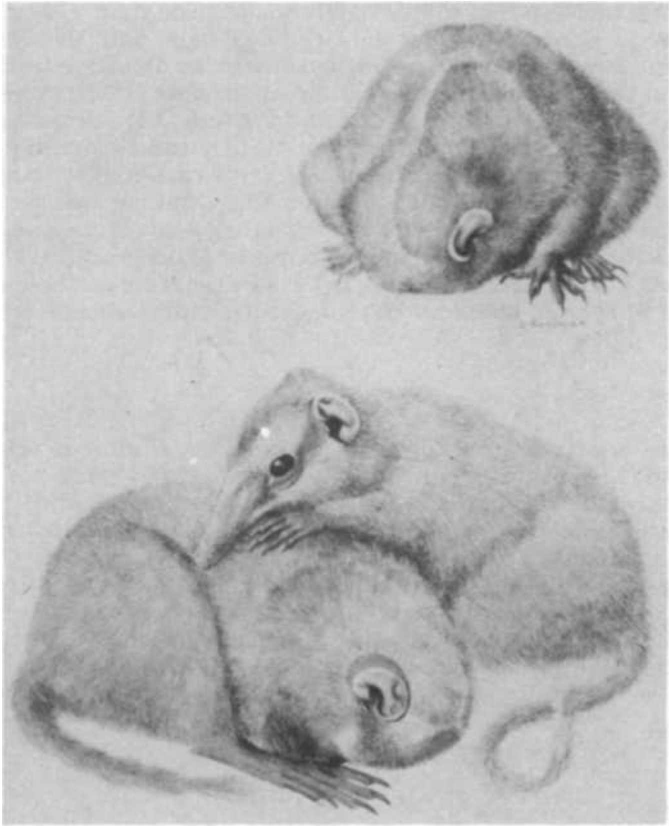

Fig. 3 Sleeping and hibernating position of mammals, illustrated by the Phillipine Tree Shrew (not a hibernator). Note especially the single shrew. We have no photographs, but our 250 lb black bear was observed (unobscured by bedding) in hibernating position all winter. On some occasions he lifted his head.

DENNING OF GRIZZLY BEARS

Conditions

There is remarkably little information about the denning of grizzly bears in Alaska. Many hunters have disturbed these animals in winter dens but have not described in the open literature the dens themselves. The grizzly bears of McKinley Park appear to behave as a marmot or groundhog and dig directly and deeply into a hillside. All dens described and measured by Adolph Murie (1963) were constructed this way. Dens of a similar type have been reported by Lentfer (1967) and Pearson (1968). The bottle-shaped dens are much alike so that we may call their construction an inherited stereotype den-construction pattern like that found in rodents and birds. It appears to be a characteristic of the grizzly bear species. Presumably, the animal benefits a great deal from the earth as a heat sink to the outside environment. The time of denning in northern Alaska may extend from about the first of October until the end of April. Considering the lack of use of the kidney, bladder and digestive tract, this does indeed represent a remarkably long time of dormancy. The three grizzly bears studied both at Point Barrow and at the Arctic Aeromedical Laboratory were allowed to remain in dormancy until they came out of the dens spontaneously. We demonstrated that these grizzly bears for two winters did not urinate or defecate for periods of time extending from four to five months. We do not know exactly how often such animals get out of the so-called hibernation position, but it was certain on some occasions that these bears as well as black bears did not raise their heads when we moved close to the cage noisily. We were even able to take photographs with flashbulbs without the animals raising their heads.

Physiological State

The heart rate change in dormancy of the grizzly bears was similar to that of the black bears. With three of these individuals we were able to study this condition for three consecutive winters. One animal was left undisturbed for each of two winters for as long as five months (Figs. 4 and 5). The heart rate changes and daily rhythms were very similar to those of the black bear. Our usual handicap in this program was the failure of the implanted transmitters as the winter progressed. During one winter an experiment was done to test the complete reliability of the radio-transmitters implanted in these animals. Twice during the winter the grizzly bears which were in dormancy together

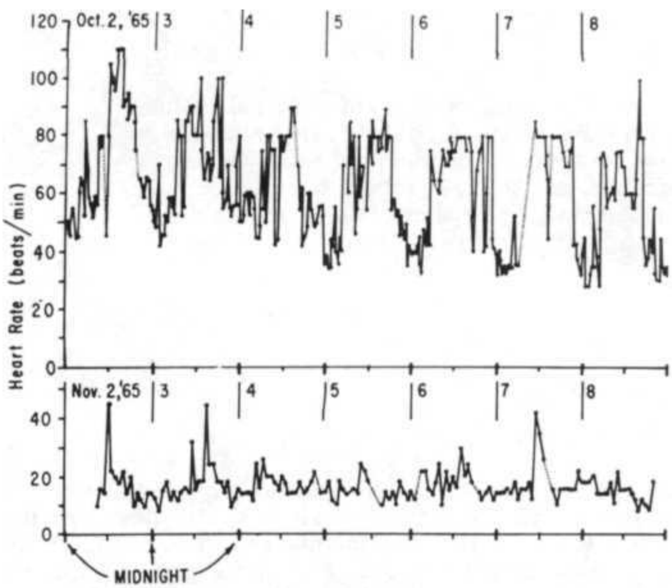

Fig. 4 Heart rates recorded daily every 30 minutes showing the dormancy stages as grizzly bear ('Blondie', 175 lb) went into winter-den condition. Sleeping heart rates began at 40 b/m, became 30 b/m, and by November, were 8- 10 b/m.

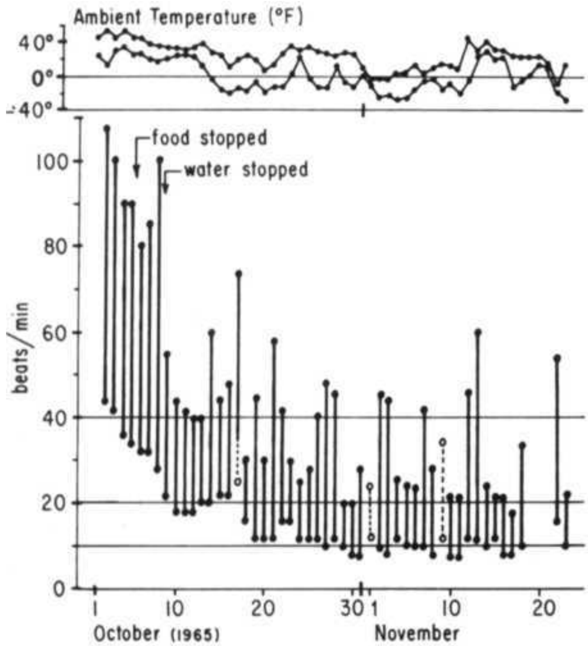

Fig. 5 Example of graphing of maximum and minimum heart rate to represent daily activity of a grizzly bear. Note that the animal went into dormancy in the middle of October. To obtain such records, 48 half-minute records were made each day all winter, on 4 bears.

were awakened and stimulated to test for maximum heart rate recording from these capsules. The capsules provided as high values in winter as in summer.

Fat Storage for the Winter

Part of the preparation for winter dormancy by the black bear and the grizzly bear consists of increasing food consumption and laying down adipose tissue. There have been no careful observations of how much is deposited where it would act as an insulating material and how much is laid down in other areas such as around the kidney. One would presume that this harboring of energy reserves is essential to bears before becoming dormant. In those cases of black bears and grizzly bears being found in midwinter in an active wandering state, they have been thin and without depots of fat. The essential point for the development of this paper is that black bears and grizzly bears usually find the resources to accumulate calories in the form of fat. This does depend upon the availability of food which has certain seasonal and year by year variations. For example, the inland grizzly bear is presumed to make use of berries, roots and grass in the fall to accumulate fat, although berries are the most important. If these are in scarce supply, it would be harder for both of these species to lay dow fat for the winter. This concept of food availability and accumulation of fat is important in the comparison of the biology of the polar bear with these two species.

DENNING OF POLAR BEARS

Conditions

The first question to ask about the polar bear is whether its diet is ever comparable to the other two species. Its range must partly decide diet. There are several reports of polar bears nearly 1,100 miles from Point Barrow in the vicinity of the North Pole (Table 1). It is apparent that some polar bears are found at all times of the year at long distances from land. It is also true that some polar bears wander inland at all seasons, not only just before the season of dormancy. It is reasonable to suppose that the population of bears found well out on the ice do not travel the distance of perhaps 300 to 400 miles to a different habitat when winter approaches. For convenience we may refer to ice polar bears as one group, and shore polar bears as another. According to Perry (1966) many shore polar bears prepare for winter in the same way as black bears and grizzly bears; they wander inland and eat large quantities of vegetable matter. Then they return to remain along the shore all winter. Presumably, this population has accumulated much fat as winter approaches. This is not always successful. Peter Sovalik, of Barrow, describes several incidents of very thin polar bears found in midwinter on the shore so hungry that they would attack and eat dogs regardless of the presence of a hunter. It would appear that they had not accumulated the necessary threshold quantity of fat in order to become dormant, when food was scarce.

The ice bears at some distance from land may be quite successful in stalking seals so that they, too, put on depot fat, but this must be difficult compared to the ease with which black bears and grizzly bears fatten up on vegetable matter. It is possible that most ice bears are male bears and non-breeding females. If this is true, then the cubs listed in Table 1 were over a year old. Perhaps the situation of these ice bears is a vicious circle in which they find it difficult to lay down fat and therefore must keep active most of the winter.

There are more descriptions of polar bear dens than there are of grizzly bear dens. Harington (1968) reports that these dens along the shore are apt to contain two-year-old young males or females, and with or without the mother. Peter Sovalik describes, as many other have, the den of a mother and two cubs, in the Colville Delta, approximately 30 miles from the ocean shore. An Eskimo family had camped very near this den all winter without any clue to the presence of the mother and cubs. Sovalik's description of den size, and lack of fecal matter or urine, coincides with those published by Perry. Two questions now remain. What is the physiological condition of those polar bears which do remain in the den most of the winter, and how many polar bears make use of such a physiological mechanism?

Physiological State

The physiology of polar bears is of particular interest because of their extreme adaptations, uncertain status as a species, and because of questions concerning their relationship to grizzly bears and black bears. As stated above, we had determined that a conspicuous bradycardia (reduction in heart rate) exists in the grizzly bear and black bear when in a condition of dormancy in the winter den. We looked for the same phenomenon in two captive male polar bears maintained together under winter den conditions during the winters of 1967-68 and 1968-69. This study was technically difficult to make because of the value of the specimens and lack of information on how to predict the behavior of the animals. They were deprived of food and water, the standardized procedure for inducing dormancy in these experiments with bears. During

TABLE I. UNUSUAL SIGHTINGS OF POLAR BEARS IN MID ARCTIC OCEAN*

Time	Observer	Ice Island	Position‡	Position	Type of Bear
Spring	Hanson (1963)	Arlis II	86.5	175E	Female
October	Hanson (1963)	Arlis II	88.5	160W	Female, cubs
May	Hanson (1966)	T3	75.5	155W	Female, cubs
September	Hanson (1959)	Alpha II	77.8	171.5W	Adult bear
September	Hanson (1959)	Alpha II	78	171.5W	Female, cub
September	Hanson (1959)	Alpha II	78	171.5W	Seventh bear collected on this station.
—	Perry†(Page 117)	—	88	—	Female, cubs
—	Peary*	—	86	—	Adult
—	—	Alpha I	84	—	Adult
—	Malmson (1970)	—	84	—	Adult
—	Malmson (1970)	—	83	—	Adult
May	Buck (1970)	Arlis V	74	161W	Female (fat)
May	Buck (1970)	Arlis VI	75	168W	Male, adult. Nine other sightings (N = 3) seen here.

* Data provided by Dr. Mzx C. Brewer from the logs of several floating ice islands.

† Perry, 1966

‡ Degrees north

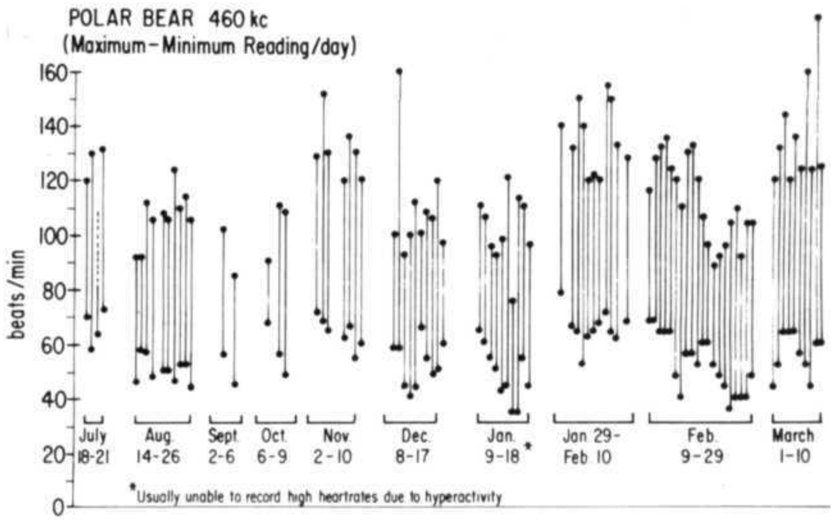

Fig. 6 Polar bear maximum and minimum heart rates during their first experimental winter; they were frequently distrubed by accidental visitors.

the first summer, sleeping heart rates of one specimen were seldom as low as 50 b/m. During the winter, bradycardia was gradually acquired by this specimen until a rate of 35 b/m was achieved (Fig. 6). At this point the experiment was terminated because of uncertainty as to whether one animal might attack the other. During the second summer, the other male polar bear (weight 260 kg, 570 lbs) was instrumented. This specimen showed no sleeping heart rates below 60 b/m during the months of July, August, and September. From October to the end of January the animals were observed by closed circuit television and were provided with minimal food. Their behavior indicated the possibility of dormancy, and during the month of February rigid conditions to simulate denning in the outdoor environment were followed (complete darkness, isolation from camp noise, abundant hay in which to prepare winter dens, and removal of food). The temperature of the enclosure varied from —20°C to —50°C. The instrumented animal once again initially demonstrated sleeping heart rates of 60 b/m which changed slowly week by week until rates of 27 b/m were obtained. The steady downward trend undoubtedly would have continued since both animals remained in the position of dormancy (head under belly near tail). However, on 1 March, one month after the experiment began, the radio-capsule in the abdominal cavity of the animal failed. The results from these two winters are strong evidence that the polar bear has the capability of reducing its circulatory activity in dormancy in the same fashion as the grizzly and black bear.

Discussion of Special Case of Polar Bears

Our physiological observations show that the polar bear is capable of the same dormancy as the other two species (in spite of the deplorable instrumentation hazards which always beset the individual who uses radio-telemetry). It should be emphasized that during the next winter (the third) with reasonable conditions of quiet and isolation and lack of light (although with a warmer temperature than desirable), the same two polar bears did not go into dormancy. A few feet away there was another building with the same noise conditions, about the same temperature conditions, and the same conditions of lighting, in which a 750 lb grizzly bear did become dormant for approximately five months. This observation and similar data lead us to believe that it may not be as usual or as easy physiologically for a polar bear to enter dormancy. If we once again contrast ice polar bears as a population and shore polar bears, one must consider that at least for a month at a time, the ice bears could dig a snow tunnel or cavern that would be suitable for dormancy. As a rule, probably the ice would shift about this den after about a month had passed. A longer time of denning is unlikely because the storage of fat for insulation and reserve energy supply is probably very different in the ice compared with shore populations. This was specifically checked by Ken Bennington, who necropsied seven polar bears which came upon the ice island, Station Charlie. These bears were collected throughout the year, from April to January. What impressed him the most was the complete lack of adipose tissue under the skin. Only one skin needed a small amount of work to flesh off the subcutaneous fat. These observations and others (see Perry) lead us to believe that ice bears are not prepared for winter dormancy and must usually continue hunting. Shore polar bears both male and female, on the other hand, undoubtedly possess the insulation and stored fat to remain many months in the winter den. Although we have shown metabolic and circulatory reduction in both male and female captive bears, the physiology of a female bear which is nursing young is completely unknown. At times our dormant bears of all three species did show a day-night rhythm of variation, although at other times the readings were flat. Probably the female while nursing her young shows the same day-night variation or at least a cycle determined by the nursing periods. Note especially, however, that no nursing polar bear den has contained evidence of feces or urine. It is remotely possible that the mother would eat the feces, but surely not the urine. Apparently the female polar bear in dormant condition — complete lack of use of kidney, bladder and digestive tract from October to April (Harington 1968) — will give birth to young and nurse them.

DISCUSSION OF THE PHYSIOLOGICAL CONDITION OF WINTER DORMANCY IN ALL THREE SPECIES OF BEARS

What is the advantage of a reduction in heart rate during winter denning? We must report a complete lack of success so far in measuring blood pressure, cardiac output and blood flow in a bear in dormancy. Professor Van Citters and his team, of the University of Washington, did the appropriate operations to determine this on two of our grizzly bears, but after receiving the transducers and while wearing the radio packs, the animals did not got into the dormant condition.

First we must accept the situation that the bear is showing a bradycardia which is similar to the diving bradycardia seen in swimming mammals including man. Scholander (1964) has shown that stroke volume does not change during diving bradycardia, that this bradycardia is under the control of the vagus and can be blocked by atropine, and the blood pressure does not rise. In addition, if diving bradycardia is prevented, a seal will quickly die under water in a very few minutes. We reconstruct the situation then that the bradycardia-associated mechanism which permits an Arctic seal to remain under water for 15 minutes, is also helpful to the bear in dormancy. Although the bear's body temperature is not reduced very far, this 'high percentage of reduction in circulation would be reflected in a lower oxygen consumption if the suppositions and experiments of Whalen (1965) are correct. This hypothesis is supported by the direct measurements of Raymond Hock (1960), who demonstrated a 50% reduction in oxygen consumption by his bears in dormancy in spite of the fact that the body temperature reduction was only 4°-7°C.

The present state of development of electronic equipment will not yet permit the measurement of blood flow and cardiac output of bears in dormancy; we intend to pursue the subject by means of body temperature radio-capsules distributed throughout the body. The explanation of this experimental approach is that associated with the bradycardia of diving marine mammals is a compartmentalization of the circulatory system (Folk 1966). Circulation is mostly restricted to the anterior half of the animal's body (Folk 1966); the animal in a sense makes itself into a heart-lung-brain preparation. This is also the case in the mammal when in hibernation and while awakening from hibernation. We presume that this compartmentalization would be of advantage to the bear in dormancy.

SPECIAL CONSIDERATION OF LIPID METABOLISM

One of the more important and profitable areas to be investigated in the winter dormancy of bears concerns fat deposition in the fall, because apparently dormancy depends on it. The scanty data which exist are mostly based upon weighing bears before and after a period of dormancy. The loss of weight during this time could be mostly due to insensible water loss.

Weighing fat masses is also unsatisfactory because over the winter the mass can slowly be replaced in part by water, yet the weight might remain roughly the same. More observations are needed by biologists because we lack information on where lipid stores accumulate. There are numerous patterns of fat distribution in animals preparing for winter: the seal apparently accumulates fat only under the skin; the sea otter apparently does not add any fat at all under the skin; some mammals accumulate large inguinal fat pads (hamster), while other mammals do not (opossum). One must ask also whether the accumulation of fat depots are really intended for utilization during the winter or are primarily important for the animal when it emerges in the spring.

Is fat used during dormancy of the typical mammalian hibernator? At least fat metabolism as a source of energy during periods of stress produced by starvation and cold-exposure has been established. A respiratory quotient of 0.7-0.85 has been reported in bears, bats and marmots during cold-exposure. This figure is indicative of fat catabolism.

The utilization of stored lipid from adipose tissue during hibernation or long periods of dormancy is not well understood. There are discrepancies in the amount of winter body loss, amount of depot fat mass loss, and above all the quality of depot fat loss (weight of fat masses may not be a clue). It appears that animals capable of hibernation or dormancy may not all undergo a period of fall fattening prior to winter. Some rodents which are termed hibernators hoard food, while still others fatten *and* hoard food (Cade 1964). Still other hibernators (bats (Ewing 1970), marmots, black bears, 13-lined ground squirrels) do not hoard food, but increase their weight by fall fattening. Morrison has reported data on one denned bear in which adipose tissue was over 40 per cent of the body weight (Hock 1960). Many more measurements should be made through the skin with a depth gage (Fig. 7).

The increased amount of adipose tissue has been presumed to serve two functions: a) a stored energy source is available and b) the insulation of the animal is effectively increased. It is known that hibernators such as the Arctic ground squirrel lose 30 per cent of their body weight during hibernation, but it is not known what per cent of this loss is water or lipid (Hock 1960; Landau 1960). The black bear may lose 15-20 per cent of its total weight while in its winter den (Hock 1957; 1960). In these animals this loss could be due to mobilization of stored fat for energy, but there are few figures for known loss of just adipose tissue. Beer (1956) states that his bats lost 70 per cent of their fat in mid-November.

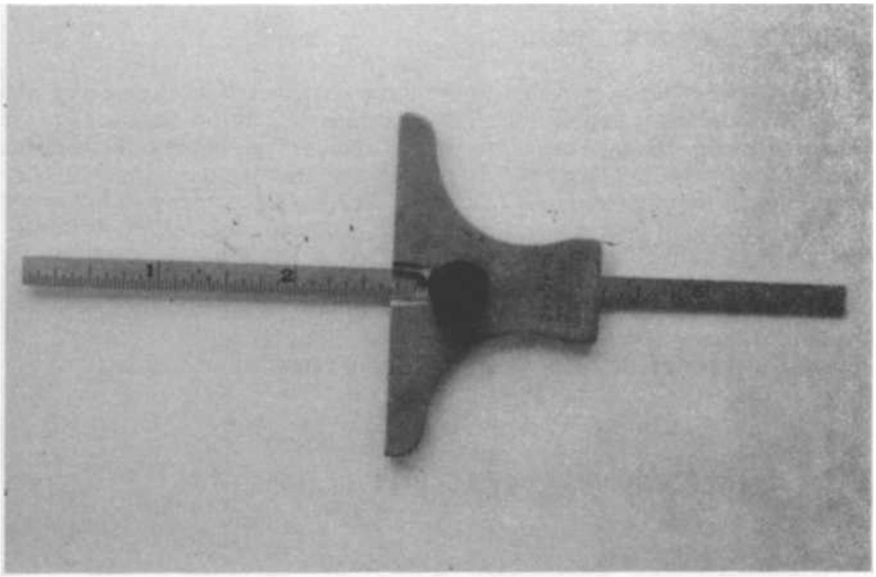

Fig. 7 Machinists depth gage as used for measuring back-fat on live animals. An incision is made through the skin, the ruler is slipped through the fat to the muscle, and the slide is run down to the skin. The procedure was totally satisfactory on seals and polar bears. The standard positions for measurements on live hogs is 2 inches from the midline, at the first and last ribs, and last lumbar vertebra.

An interesting point is the observation by hunters which indicates bears do not become very lean and hungry until after 2-3 weeks following arousal from their dens. This must indicate that fall fattening serves yet a third purpose: that of protection from starvation following arousal before food is secured. This leaves in question the importance which has been attached to fattening in relation to survival of long periods of dormancy.

It is apparent from the literature that a more extensive study of lipid utilization by bears during dormancy is needed. Many of the analytical procedures thin-layer and gas-liquid chromatography) which have been used successfully with other hibernators (hamster, bat, etc.) are readily adaptable to bear adipose tissue (Kodama 1963;Kodama 1964; South 1967; Williams 1967). Both qualitative and quantitative utilization of individual fatty acids could be followed throughout the year on wild caught or killed bears of different species. It is quite possible a study such as this might reveal the true value of fall fattening to a 'hibernating' bear.

In summary several questions can be posed with respect to the value of fat deposition to a hibernator. Is there a preferential utilization of certain adipose depots during different physiological conditions of the animal? Is this preference extended to certain saturations or chain-lengths of fatty acids? Finally can an animal's activity during winter be predicted from his fall metabolic behavior?

HEART RATE AND BODY WEIGHT

When resting heart rates of a new animal are obtained, it is customary to fit them to previous heart rate-weight relationships. Clark attempted to predict the heart rate of animals from their weight and derived the formula presented in Fig. 8 (Kleiber 1961). Even before plotting on his theoretical curve, one suspects there will be curious contradictions. For example, many of the heart rates of our sleeping 500 lb bears were 50 b/m. Many human subjects of approximately 150 lbs who are not athletic have a heart beat of 50 b/m. The summer sleeping beat of our woodchucks is 50 b/m (weight approximately 12 lbs). Another problem is that none of the studies in the literature of heart rate and weight of bears takes into account whether they were thin bears in mid-summer or fall bears which had put on 100 lbs of subcutaneous fat.

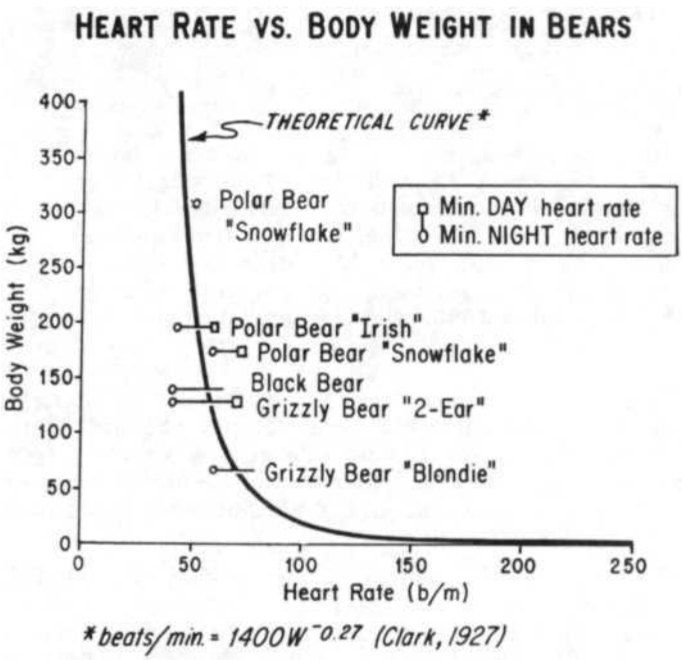

Fig. 8 An expanded end of the curve which shows the relationship between heart rate and body weight.

A further problem in the measurement of basal heart rates is the time of day at which the measurements are made. The sleeping heart rate of the bear is undoubtedly lowest both in the free environment and in captivity from approximately 10 p.m. in the evening until perhaps 6 a.m. However, bears can sleep deeply during the daytime. We believe that there is a physiological setting for most mammals by day and by night so that all physiological readings may be higher at one time of the day than they are 12 hours later. Therefore, it is difficult to accept from the literature sleeping heart rates unless one knows the day-night rhythm of the animal. To be specific, we are certain that at times we observed our grizzly bears to sleep with a heart rate of 50 b/m near midnight but to be in a deep sleep with a heart rate of 70 b/m near noontime. We have, however, made use of what information is at hand by plotting noon and midnight values of some of our bears. There is a reasonably good fit of this data with Clark's theoretical formula. We had mentioned earlier that totally different mammals may have a sleeping heart rate between 40 and 50 b/m, and I presume that it is the smaller animals that are the exception to the rule, and not the larger bears.

IS THE BEAR A HIBERNATOR

One may judge at this point that the extreme reduction in heart rate, digestion and excretion, and a partial reduction in body temperature and in metabolism, indicate that the bear at least semi-hibernates. There is one more bit of evidence to explain the relationship of the three bear species to other mammalian hibernators. It is accepted that hibernators have a very short Q-T segment on the EKG pattern. This means that if we consider that the EKG pattern is made up of three spikes for each heart beat, then the third spike is closer to the second one in mammalian hibernators than it is with the rest of the mammals. There is one exception to this generalization which is that mice and rats also have a short Q-T segment. We have begun to look for evidence in the three species of bears for the presence of a short Q-T segment. Since this segment might change with increased heart rate in the individual, we have attempted to accumulate data only from mammals which are resting or asleep. Most of the species have been tested by radio-telemetry in our own laboratory. Results are expressed as the QT : RR ratio; the line of best fit through the origin represents a constant ratio in spite of variable heart rates (Fig. 9). Points off the line represent a Q-T segment which is shorter than that found in typical mammals. This is apparent in the EKG record of a polar bear (Fig. 10). One hibernator (Arctic Ground Squirrel), the bears and their relatives (the raccoons) depart from the constant ratio. There are two departures from this generalization. The bats are hibernators and although they fall on the line, they may represent the beginning of a hibernator line representing a different ratio from that of ordinary mammals. The other exception is the Arctic fox, a non-hibernator. There is a reasonable explanation for this. The heart beat of the fox, and the daily work of the heart of the fox is entirely different from that of other mammals. This relationship has been discussed in detail in an earlier paper (Folk 1963). The heart of the fox must rest approximately every half hour, then it may change to a heart beat of five times resting value for a brief time and then return to baseline. So far we have found no other 'heart' which shows this behavior; perhaps it explains the occurrence of the fox Q-T segment which is similar to that of hibernators and the bear group rather than that of typical mammals.

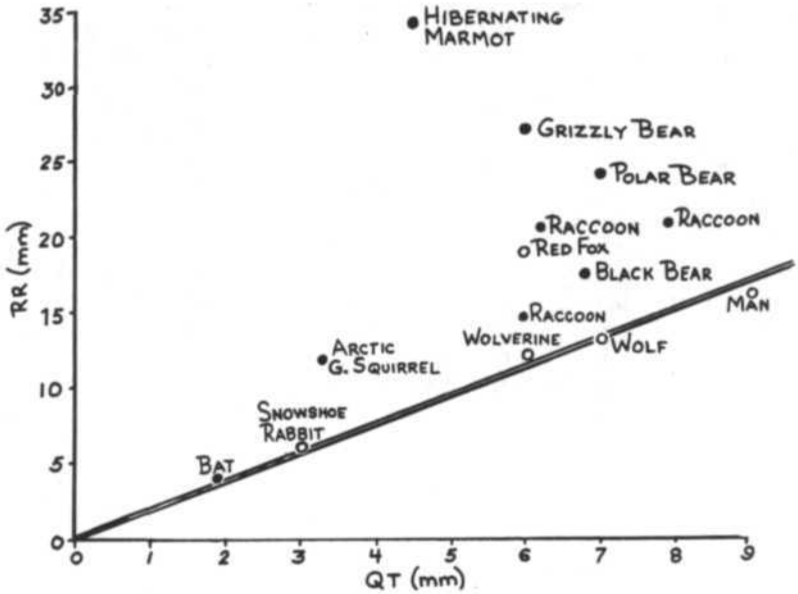

Fig. 9 EKG intervals of mammals. Note departures from the usual constant ratio between heart rate (RR interval) and QT interval. Hibernators have an unusually short QT interval.

Fig. 10 EKG pattern of polar bear weighing about 660 lbs recorded by Iowa radio-capsule (long-life, short range, implanted in peritoneal cavity).

We conclude that this evidence from the Q-T segment supports the position of the bears having an intermediate relationship between hibernators and non-hibernators.

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Remarks on Denning Habits of Alaska Brown Bears

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INTRODUCTION

Brown bear denning studies were conducted intermittently from 1965 through 1969, by the U.S. Fish and Wildlife Service on the Kodiak National Wildlife Refuge and by the Alaska Department of Fish and Game on the Alaska Peninsula. These are two of the most important brown bear areas in Alaska. This paper presents information on denning habits with emphasis on descriptions of dens. Studies were funded by the Refuge Branch of the U.S. Bureau of Sport Fisheries and Wildlife and Alaska Federal Aid in Wildlife Restoration Projects W-15-R-1, 2, and 3, and W-17-1.

STUDY AREAS

The general topography of Kodiak Island is characterized by rugged mountains that ascend to over 4000 feet. The irregular coastline has prominent headlands, cliffs and narrow bays and no point on the island is more than 15 miles from the sea coast. Other prominent features include 11 major watersheds, 15 large lakes and numerous tributaries. Dominant vegetation is alder, willow and grasses, with cottonwood distributed in valley bottoms. The southwest region is characterized by a tundra heathland. Temperatures occasionally go above 70 degrees F. in summer and rarely drop to 0 degrees F. in winter. The annual precipitation averages 60 inches, and the frost-free season averages 171 days. The annual snowfall averages 54 inches, but because of mild temperatures and frequent rain, snow cover readily dissipates from lowland habitat.

The Alaska Peninsula study area is 150 miles in length and extends from Mother Goose Lake on the east to Port Moller on the west. The peninsula averages 50 miles wide in this section. A broad flat tundra belt with many small lakes and meandering drainages extends along Bristol Bay on the north. The steeply-ascending Aleutian Range, with peaks averaging 2800-3200 feet above sea level, lies between the coastal plain to the north and Pacific Ocean to the south. Dominant vegetation is willow and sedge in tundra areas and alder, willow and grasses in mountainous areas. Weather is characterized by high winds, overcast skies, fog, rain in the summer, and snow in the winter. The human population is sparse, and there are no roads.

METHODS

On Kodiak, 82 brown bear dens were located, 79 from fixed wing aircraft and 3 from the ground with the aid of binoculars (Fig. 1). A helicopter was used to reach 11 dens and, in six instances when dens were occupied, to haze bears from the immediate denning area.

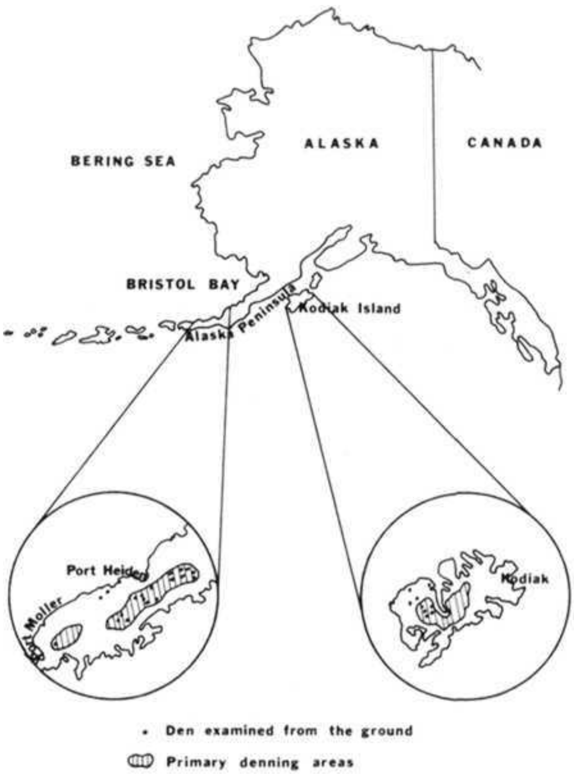

Fig. 1 Study area locations

On the Alaska Peninsula, 52 dens were sighted from fixed wing aircraft. Most searching was done in the mountains, except when a den was reported on the tundra. Professional hunting guides were also asked to report locations of dens, which were then investigated. Of the 52 dens located from the air, 19 were examined by ground crews transported in PA-18 Supercub aircraft equipped with oversize tires. Experienced pilots used short-strip landing procedures to position an investigator close to dens, usually within 4-5 hours walking distance. Twelve dens rechecked late in the fall or in succeeding springs provided information on den re-use.

Most often dens were first sighted in both study areas by the mounds of excavated material that contrasted with vegetation and snow-covered landscapes. Bear tracks could on occasion be traced to a den or indicated that a den was in the immediate area.

For dens observed from the air, location, elevation and exposure were recorded on topographic maps (Scale 1.250, 000). For dens examined from the ground, measurements of excavated material, tunnels and chambers were recorded on standardized field forms. Dens were photographed and diagrammed with emphasis on den compartments and immediate topographic features.

FINDINGS AND DISCUSSION

Den Locations

A frequency distribution of den elevations is given in Table 1. Dens ranged from 100 to 3300 feet above sea level with the greatest proportion at about 1800 feet on Kodiak Island and at about 1300 feet on the Alaska Peninsula. Dens were at higher elevations on Kodiak where the mountains are higher and vegetative zones are higher. Most dens were above 500 feet on slopes with alder, willow and grass. A few were also found in alpine areas. In some cases, snow concealed vegetation so that it was impossible to determine if a den was in or below the alpine zone. The eight dens found below 500 feet were in open tundra with heath cover or a sparse growth of willow.

The areas where dens commonly occurred were characterized by alder-willow thickets and deep snow cover. Alder and willow provide concealment and, in some instances, bedding material. Roots bind the soil and prevent den collapse. Snow drifted in brushy areas may be important as an insulating layer over dens.

North facing slopes were most often chosen for denning on Kodiak, and east facing slopes were most often chosen on the Alaska Peninsula (Table 2). Factors that might influence choice of slope exposure were not apparent.

For 28 dens examined on the ground, slope of the terrain was 0 to 30 degrees for 9 dens, 30 to 45 degrees for 14 dens, and 45 to 60 degrees for 5 dens. Bears may prefer to den on well-drained sites where water seepage into dens would be minimal. Steep slopes may also be selected as an aid in den construction because excavated material is more easily deposited downhill.

Den Structures

All dens examined on the ground had a single entrance and single denning chamber. Twenty-nine were constructed in soil and one was constructed in snow. About half the den entrances opened directly to the chamber and about half had a tunnel leading to the chamber. Three types of dens are diagrammed in Fig. 2.

Den dimensions are given in Table 3. Entrances were typically oval or arch shaped and averaged 3. 0 feet in width and 3. 2 feet in height. The length and diameter of tunnels leading from entrance to chamber of 13 dens averaged 5.8 and 3. 0 feet, respectively. Chambers were typically cone or arch shaped and averaged 5. 3 in width, 7.3 feet in length, and 3.9 feet in height. Dimensions of dens with family groups did not differ significantly from dimensions of dens with single bears.

TABLE 1. FREQUENCY DISTRIBUTION OF BROWN BEAR DEN ELEVATIONS ON KODIAK ISLAND AND THE ALASKA PENINSULA

	Feet Above Sea Level						
	0-499	500-999	1000-1499	1500-1999	2000-2499	2500-2599	3000-3499
Kodiak Island							
Females w/yearlings		1	2				
Singles		2	1				
Unidentified	1	3	16	23	22	3	6
Total	1(1%)	6(7%)	19(24%)	23(29%)	22(28%)	3(4%)	6(7%)
Alaska Peninsula							
Females w/cubs		3	6	1			
Females w/yearlings	1	1	1		2		
Singles	2	1	4	2		1	
Unidentified	4	5	11	2	1		1
Total	7(14%)	10(20%)	22(45%)	5(10%)	3(6%)	1(2%)	1(2%)

TABLE 2. ORIENTATION OF BROWN BEAR DENS ON KODIAK ISLAND AND THE ALASKA PENINSULA.

	N	NE	E	SE	S	SW	W	NW
Kodiak Island								
Females w/yearlings	1			1		1		
Singles	1					1		1
Unidentified	20	12	8	8	10	7	3	6
Total	22	12	8	9	10	9	3	7
Alaska Peninsula								
Females w/cubs	2		3	2			1	
Females w/yearlings	1		1		1		1	1
Singles			2	2		2	1	
Unidentified	1	4	4	3	5	2	3	4
Total	4	4	10	7	6	4	6	5
Grand Total	26	16	18	16	16	13	9	12

Snow was melting when dens were examined, and the ground at most den sites had several inches to 15 feet of snow. In most cases, bears tunneled through snow when emerging from dens. One atypical den formed entirely in snow by a single bear on the Alaska Peninsula had an S-shaped tunnel 19 feet long, a small alcove, and a cone-shaped chamber 9 feet high and 6 feet wide (Fig. 2A).

Two dens, each occupied by a female with cubs, contained alder and willow branches. Den floors were evidently lined with branches during the final phase of construction in the fall.

Three family groups and an unidentified bear had beds outside their dens. Some beds were in snow and some in soil. Figure 2C shows the orientation of beds used by a female with two yearlings. It appears bears constructed and used these beds after they first emerged and until they abandoned the den site.

Other Denning Activities

Investigators revisited 12 dens during succeeding fall and spring periods to determine if bears had used them again. There was only one instance of possible re-use. Most bears probably construct new dens each fall because thawing, seepage and erosion cause dens to collapse during the spring and summer. A few cases of denning in natural rock caves have been reported on Kodiak and the Alaska Peninsula, but none were found during this study. Denning could be expected in such rock caves during successive years.

The one instance of co-occupancy, other than in dens used by females with young, was by two bears judged to be two-year-olds. These animals were probably litter mates that denned for the first time without their mother.

No evidence of mortality associated with denning or parturition was discovered.

TABLE 3. DIMENSIONS IN FEET OF 26 BROWN BEAR DENS EXAMINED ON KODIAK ISLAND AND THE ALASKA PENINSULA.

Den Type and No.[1]	Excavated Material		Entrance		Tunnel		Chamber		
	Width	Length	Width	Height	Length	Average Diameter	Width	Length	Height
Females w/cubs									
A-1-65	[2]	[2]	3.1	3.8	0	—	5.0	8.0	4.8
A-5-67	6	15	3.6	3.0	6.0	2.3	ca. 3	ca. 4	ca. 4
A-1-68	8	12	2.5	2.0	0	—	4.8	5.4	3.3
A-2-68	6	25	3.7	2.2	0	—	4.3	11.9	3.9
A-3-68	8	20	2.9	3.6	0	—	5.0	9.2	3.8
A-5-68	7	15	2.6	4.7	9.2	3.2	5.0	5.0	4.3
Mean	7	17	3.1	3.2	7.6[3]	2.7	4.5	7.2	4.0
Females w/yrlings									
K-l-70	[2]	[2]	1.8	1.8	6.3	3.0	4.6	6.3	4.2
K-2-70	[2]	[2]	2.4	4.6	3.3	4.5	6.0	8.5	3.0
K-8-70	6	15	3.2	2.2	0	—	4.1	9.0	2.5
Mean	6	15	2.5	2.9	4.8	3.7	4.9	7.9	3.2

Singles									
K-9-69	[2]	[2]	2.9	3.0	1.5	2.1	5.5	6.6	3.5
K-4-70	[2]	[2]	2.0	3.5	[2]	1.9	5.3	8.5	2.8
K-6-70	5	10	2.5	2.5	2.2	3.1	4.1	6.2	3.7
A-1-66	7		[2]	[2]	[2]	[2]	[2]	[2]	[2]
A-1-67	7	16	2.8	2.5	7.0	2.0	6.9	6.1	4.6
A-4-67	2		4.8	4.2	0	—	7.0	10.0	6.8
A-7-67	10	15	3.1	2.8	10.0	3.0	7.0	5.0	4.2
Mean	7	12	3.0	3.1	5.2	2.4	6.0	7.1	4.3
Unidentified									
K-3-70	[2]	[2]	[2]	[2]	[2]	[2]	8.0	11.0	2.6
K-5-7	10	14	3.0	3.0	6.5	3.5	6.8	6.8	4.5
K-10-70	5	9	4.2	2.6	6.5	3.1	5.2	5.2	2.6
A-2-66	5	7	2.5	[2]	4.8	2.5	ca. 5	ca. 5	ca. 4. 5
A-3-67	12	15	3.3	3.6	0	—	3.3	9.0	4.3
A-6-67	8	12	2.2	4.3	0	—	6.5	6.2	3.8
A-8-67	8	15	4.3	4.3	6.0	4.3	5.0	4.7	4.6
A-4-68	5	15	3.0	[2]	0	—	4.9	6.7	4.6
A-6-68	8	8	3.1	3.9	0	—	4.2	9.6	3.3
A-7-68	10	15	[2]	[2]	0	—	6.3	9.2	4.2
Mean	8	12	3.2	3.6	5.9	3.3	5.5	7.3	3.9
Mean for all dens	7	14	3.0	3.2	5.8	3.0	5.3	7.3	3.9

[1] K refers to Kodiak, A refers to Alaska Peninsula, and last 2 digits refer to year.
[2] Not measured because of snow cover or partial den collapse.
[3] Dens without tunnels not included in mean dimensions of tunnels.

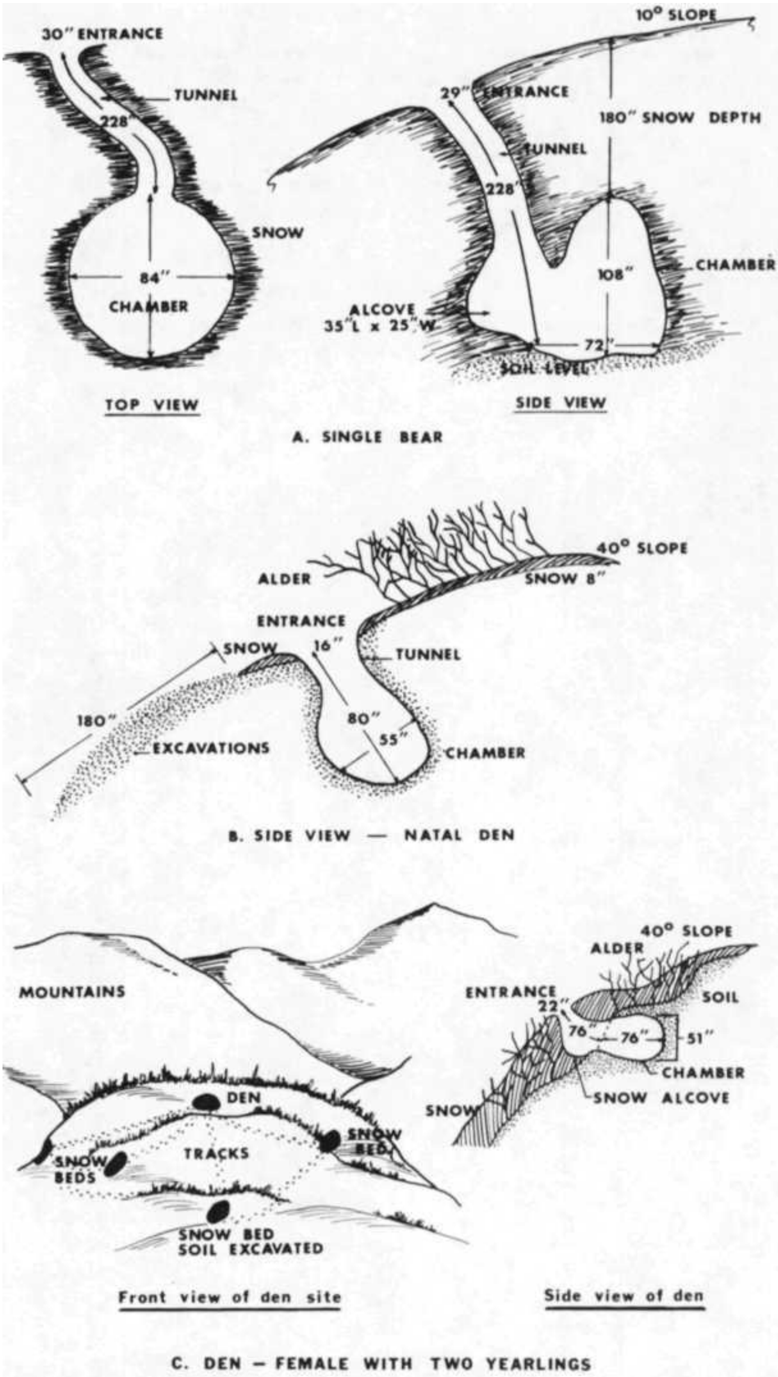

Fig. 2 Three den types: (A) atypical snow den used by a mature bear; (B) natal den used by a female and three cubs; (C) den and beds used by a female and two yearlings.

PANEL 2: DENNING-CONTROL MECHANISMS, SITE SELECTION AND PHYSIOLOGY.

SUMMARY OF DISCUSSION

M.Barrett. Dr. Craighead, you mention that denning was probably instinctive and that during a given storm, many bears appear to head towards their denning areas. Now I'm curious about the time sequence here. Were you able to document that some of the bears started to prepare their dens well in advance of the time that they probably would need them or was it an immediate thing.

F. Craighead. We feel it's instinctive for the grizzly bear to dig a den. We have found in the case of several of them, very good natural shelters within a 100 yards or so of areas where they have had difficulty digging a den in a rocky soil and yet they didn't use the natural shelter. The timing is varied with individuals. I think I mentioned that the earliest den digging that we recorded was September 3, another September 8. The latest den preparation was in the middle of November, just prior to entering the den for the winter. These were bears which had been disturbed at a former den and had abandoned the den and then dug another one. Grizzly No. 202 that I mentioned took off and left his regular fall haunt, went down into the Yellowstone Canyon and immediately started preparing a den. This was at the end of October—early November. Then it did not enter the den until about the middle of November. The time that they start digging the dens seems to vary quite a bit but there usually is a triggering snow storm as far as we've been able to determine that finally puts all of the bears, at more or less a given elevation, into their dens at the same time. We feel that a combination of storm, snow on the ground, snow accumulating, gradually lowering temperatures with a final storm followed by cold weather, puts the animals in for the winter sleep. We've had them return to their dens with a storm maybe putting down 6-8 inches of snow. If this is followed by a warming trend, temperatures up in the 40's, maybe even 50's at midday, then grizzlies don't enter their dens, they wait for the next storm. It seems quite definite that environmental factors influence the final movement to and entering the den. As I mentioned, this is varied by as much as a month over a 9 or 10 year period.

J. Lentfer. I can comment on observations on the Alaska peninsula. We feel that the females with young go in first and the males stay out longer and we have not been able to relate it to a definite climatic event. They probably do go in after there is snow on the ground and the weather is fairly cold, but in flying over the area we'd gradually see fewer and fewer bears and we assumed from this that they had gone into their dens.

A. Pearson. My question is directly related to this because of my experience with the grizzlies in south-western Yukon. Through tracking and radio transmitting, we know that the sows with young enter before the males. In our country we have, as I said, 1900 foot valley bottoms and peaks up to 7600 feet. I have not found a grizzly den yet that was not between 3800 and 4000 feet in a sub-alpine zone—a dug den again. We do find that when there's snow at that altitude on a north exposure, there are many other areas without snow and the snow doesn't seem to be quite as important there. For example, last year, 1969, we had, during the fall, two sows with radio collars—one with 3 yearlings and one with 1 yearling, each in separate dens. The entrances were open, no snow whatsoever, and we could go each day and look inside the dens, hovering over them with a helicopter. The temperatures were warm during the day, up to 40°F; nice clear high pressure conditions. We tried our best to find out if those bears came out of the den once they had gone in and I'm quite confident that once they went in, they did not come out again, even though they were active. We could see them moving in the den by shining a powerful light in there. One bear would peek out and then another one. It doesn't seem that there is this trigger mechanism that Drs. Craighead seem to have in Yellowstone.

I. McT. Cowan. I wonder if a significant variable for timing hibernation could be the input of the length of time and intensity of human predation on bears in different parts of their range? In the Yellowstone area, the bears were living in contact with Indian groups, which used bear claws as symbols of success as hunters. A bear enclosed in a den, without snow cover, is a very vulnerable creature. Consider areas where human predation on grizzlies was a significant selective force. In this situation a bear that retired during a snowstorm could not be tracked to its den because its tracks would be obscured by snow. This behaviour pattern would not be of selective advantage where human predators were not tracking bears to their dens.

F. Craighead. I feel it does have definite survival value and it certainly occurs in the Yellowstone area. The black bear in the same region does not do it.

L. Miller. There is one other thing I'd like to bring up about when bears go into hibernation. In the Alaska Peninsula there are several streams that have salmon very late into December and it's quite common to see numbers of bears on these streams in December. In other areas, not too far away, the bears have obviously denned up. So food may be an important factor.

J. Craighead. Mr. Hensel, you had a total of about 126 dens that you observed and that you located from the air. Could you tell me in what proportion or what number of those, you actually observed bears in the den or right at the den site?

R. Hensel. Seventeen in the Alaska Peninsula and 6 on Kodiak Island.

J. Craighead. The reason I asked the question was because in the case of the grizzly bear, we started attempting to locate dens without actually tracking the bears to the den and we located what we called, day beds, which appear to be similar to the dens. Some of them are excavated 4 to 6 feet back into the soil; they're on slopes. The bears apparently use them during very warm weather and we found literally hundreds of these and I was just wondering if you have any way really of separating what might be highly developed day beds from winter dens.

Also we found that when the bears emerge—some of them will come out early in the season, in March—they'll make bough beds on the snow; we'll get a storm which will cover them with as much as 2 feet of snow, resulting in what looks like snow dens. When the snow leaves they do sometimes dig fairly elaborate day beds in the vicinity of the winter den.

R. Hensel. Yes, we found actually 2 different types of day beds, and one was pretty much associated with summer feeding habits along salmon streams, where they're feeding maybe in the early morning or the early portions of the day and towards evening. The remainder of their time, they're resting and excavating shallow beds. These are quite a bit different from the type of beds that we found in den sites and the main criterion that we go by, of course, is just the difference in the habitat. The daytime beds associated with feeding involve lowland habitat or tundra types of situations, whereas the daytime beds associated with denning are at higher elevations.

E. Folk. The consensus seems to be that often the winter den is quite far from the feeding area. Is that your impression?

J. Craighead. Most dens have been located distantly from fall and summer feeding areas and one characteristic of all the den sites we've located in Yellowstone Park is that they are very definitely isolated. They're isolated from human habitation particularly and this seems to be an important factor in den selection. They seek isolation, often in distant-timbered areas or, in the case of that one bear, on the slopes of the Yellowstone Canyon. This den was actually between 2 avalanche runs in a small stand of timber on about a 45 degree angle. In this island of timber, the majority of the trees were scarred by falling rocks. It was an area that after just a few inches of snow had fallen, was a really hazardous place to try to get to and it took: us 2 days, even in the spring, to get down to the bottom of the canyon and climb back up again to the base of the cliff to get to this particular den. I just mention this because it was isolated, it was difficult to get to, and this is a characteristic of most of the dens that we have located.

J. Lentfer. Most of the feeding areas are away from the denning areas on the Alaska Peninsula.

S. Herrera. I'd like to comment on some black bear denning observations which were made during several hundred hours of observations spread over a two month period. These were repeated observations on a single black bear, a sow which had one cub of the year. The sow first came out in late February during an unseasonable melt, during the warm chinook winds that we get here. As soon as she came outside, she brought the cub out, and constructed 3 day beds within 30 feet of the den. The observation of bears re-entering the den during periods of inclement weather was exactly what I observed with her. During continued chinook conditions she was out on the day beds both day and night. Then as soon as the weather became inclement again, she would re-enter the den with the cub and stay until conditions improved. She remained at or near the den site for almost 2 months during which I was able to observe her. Then in early April the weather got good again and she left the denning area and entered the forest where I was able to track her in spring snow. I found her several hundred yards away. This time she had built a tremendous day bed. It was a structure, which I've described elsewhere, fully 18 inches thick, done out of duff from the ground. The next day a foot of snow fell but she remained on the new nest and never returned to the den. She, remained on this nest for 3 or 4 days, and then the weather ameliorated completely and she started using a larger area.

E. Folk. Was this a dug den ?

S. Herrero. It was an artificial culvert, under a road, so it was simply utilized. There was, however, a lot of boughs and typical denning material which had been taken inside.

A. Pearson. One thing that interests me is the re-use of dens. I found considerable evidence of re-use of dens. I could not verify whether the bear that dug the den re-used it or whether the bear used a den dug a previous year by another bear. I know of one den that was present on the study area when we arrived and was not used for 2 years. Then all of a sudden that fall a sow with a couple of young came along and reactivated the den. There was very little reactivation to do. In our country dens last a long time. There's not a great deal of slumping and falling. Now I would think that might be the case in Yellowstone also. I'm wondering whether there are a number of old den sites around that you could equate to a population like you have, having denned for hundreds or even thousands of years?

F. Graighead. We have indirect evidence of re-use of dens but none of the dens to which we've tracked bears by radio have been re-used. In most cases dens have either partially or completely collapsed by fall so that they couldn't very well be re-used or even re-excavated.

E. Folk. One interesting physiological event is plugging the digestive tract in the black bear and the grizzly bear. This is associated in some way with the process of not eating and not drinking for 4 months but, to my knowledge, there's been no proof of the plug in the digestive tract in the polar bear. I'd appreciate some comments on this. The plug is associated with denning and apparently this plug is passed several days after leaving the den.

F. Craighead. Well, we have found, of course, these lower digestive area plugs when we have worked with the bears in obtaining body temperatures and so on. We've disturbed them—some of them to the point where they have excreted these plugs and then gone on in their winter sleep, apparently without any noticeable effect.

One other thing that we've noticed, and maybe some others studying the bears have, and that is that just prior to hibernation they will have a very dark watery stool and this seems, in some cases, to be a scouring of the digestive tract in preparation for hibernation.

E. Folk. Mr. Hensel, have you observed this in Alaska bears?

R. Hensel. Yes, we found one complete plug and remnants of a second at two widely separated den sites. One den involved a mature male. We photographed the plug which, as I recall, must have been in the neighbourhood of 32 inches in length and about 2 to 3 inches in diameter. But this broke when it was discharged; it was in segments and the terminal segment was about 10 or 11 inches in length.

E. Folk. This was passed by the animal?

R. Hensel. Yes.

E. Folk. Has anyone here dissected one? I know that Morrison has.

R. Hensel. In the case of observations in Kodiak, segments of the plug were collected and preserved, but to my knowledge they haven't been analysed. They're of a very, very dark carbonaceous substance and it appeared as if there was quite a bit of vegetative matter in the plug.

E. Folk. Dr. Craighead, did you analyse any of the ones you found?

F. Craighead. We haven't definitely analysed these but they have contained quite a bit of vegetation. It seems, in just a quick examination, as though they may be a combination of vegetation and other food that the bear fed on just prior to going into hibernation.

R. Russell. The reason I am interested is that I have just been finishing a food habit study on polar bears in the Hudson Bay and James Bay region and, when collecting faeces, I did find three scats, which may have been plugs. They were in fairly close proximity and they may have been from one bear. They were found in front of a den, I'm not sure whether it was a summer den or a winter den, and when I analysed them, I found them to be around 75% sand. They were quite compact and heavy and the vegetation was mixed in. Things like birch *(Betula)*, *Lycopodium* and some moss and leaves of *Salix* and *Betula* again. Now I wondered at the time if this was a plug. I discussed this with Dr. Jonkel, and he suggested that it may have resulted from the bear licking itself off after digging the den. This material may have adhered to the hair and during a grooming process been ingested. I was just wondering if you'd found inorganic material mixed in with plugs ? Thank you.

E. Folk. This material you're talking about is somewhat unique in the animal kingdom, as far as I can see. I don't know if we're using the right word. The literature speaks of plug but there is a question whether this shouldn't be dropped as a term because we haven't any evidence that it's anything but accidental vegetation that went in 4 months before.

F. Craighead. I'll just make a remark on 2 observations that we made in regard to this. One was a radio bear that we startled close to its den and it defecated. This was just a glob of clay, as near as we could determine it, mixed with a lot of mucus. In one black bear den we found 2 stools or plugs about 6 inches long, composed of clay and the chewed up remains of white bark pine cones. The plug was very, very dense, very stiff and rigid.

C. Jonkel. In regard to black bears I have analysed several of these plugs. They were composed of materials that you would find in the den. There were chips of bark, and a lot of black bear hair, things like that, and I felt certain these were a result of grooming over the winter. During numerous observations of black bears in dens, they did move around and scratch and groom themselves and one another, if there was a family in a den. Over winter I should think they would accumulate quite a lot of material. I recall one of the polar bear scats that Dick Russel analysed that was most certainly dropped early in the spring, about the time the bear would have come out of the den. It was composed almost entirely of polar bear hair. Again, as if the bear had been picking this up over the winter.

K. Mundy. I had the good fortune when I was working on bears in 1961 and 1962 to obtain a female grizzly shot in the Swan Hills, I believe it was on the 28th of January. It was an adult bear, she had 2 young bears in the den with her. The details are a little foggy, whether they were cubs of the year or 2½ year olds, but I had the good fortune to go through the entire alimentary tract for parasites. The gut was clean, it was essentially a starved bear, with an enlarged bile duct. The first metre, I believe, of the duodenum was stained with bile. The rest of the gut was empty except for the last metre which had a long, sort of viscous plug. It was about a metre long and it was composed almost entirely of hair.

PANEL 3: POLAR BEAR STUDIES

Infra-red Scanning for Polar Bear

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SUMMARY

An airborne imaging infra-red scanner was tested for its ability to detect and record the presence of polar bears on the Chukchi Sea ice pack. The equipment and its manner of use is described. A monitoring oscilloscope failed to reveal bears, although scan data recorded on magnetic tape and subsequently transferred to film did reveal the presence of polar bears and their fresh trails. Additional testing under a wide range of weather and snow conditions appears warranted.

INTRODUCTION

The low visual contrast between polar bears and a background of snow and ice precludes aerial surveying or censusing over large areas, in the manner commonly employed for other wildlife. A consistent ability to detect polar bears within a reasonable distance of an overflying aircraft demands a detection method superior to vision, and infra-red sensing offers an alternative possibility. Infra-red scanning equipment is available that has the potential of detecting large mammals under certain conditions. This paper describes limited tests of such equipment to evaluate its usefulness for detecting polar bears on the polar ice pack. The assistance of Theron A. Smith who piloted the aircraft carrying the equipment during the tests and Charles P.Allen who flew the second aircraft and helped in locating bears is gratefully acknowledged.

EQUIPMENT AND METHODS

Croon *et al.* (1968) explain the principles of infra-red sensing and imaging line scanners in connection with game censusing. A resume of actual or potential applications for infra-red scanning is given by Thackrey (1968), and a basic account of theory is offered by Wolfe (1965). To review briefly, infra-red sensing is based on the phenomenon that all solids and liquids above absolute zero emit electromagnetic radiations. Infra-red radiation lies in the band of wavelengths between 0.75 and 1, 000 microns and is invisible. The amount and spectral range of emitted energy vary with the temperature and surface characteristics (among other things) of the emitting object. Thus, it can be expected that two objects as dissimilar as a mammal and snow covered ice would differ in energy emitted within a particular infra-red band. It is this difference that we seek to detect. Maximum radiation from mammals seems to occur between 8 and 14 microns so this is the wavelength region of most promise for detecting them. Fortunately, emissions in this region suffer relatively little atmospheric absorption and there are detector elements that are most sensitive to these wavelengths.

The airborne infra-red scanning equipment tested is basically composed of three elements: a detector, an optical-mechanical scanning mechanism, and a signal processing and recording system. The detector receives infra-red energy and converts it to electric signals which are processed for recording on magnetic tape (or they may be monitored on an oscilloscope in flight.) Because the detector has an instantaneous field of view of only 2. 5 milliradians, a means of moving it laterally to scan a line is required. This function is performed by the optical-mechanical mechanism that provides 120 scans/ second within a field of 120°. The forward movement of the aircraft furnishes two dimensional coverage. The tape recorded signals are subsequently transferred to 70mm film strips in the laboratory.

Daedalus Enterprises, Inc., of Ann Arbor, Michigan, furnished the test equipment on a lease basis. The equipment was mounted in a U.S. Fish and Wildlife Service de Havilland Beaver aircraft having a camera hatch to accommodate the detector and scanning unit. The cabin also provided ample room for the tape recorder, oscilloscope and control panel. A second aircraft (Cessna 185) was employed to assist in locating or verifying polar bears and as a safety precaution in the event of a forced landing. Operations were based at Cape Lisburne on the northwest coast of Alaska and flights were made over the frozen Chukchi Sea.

To facilitate obtaining imagery that could be evaluated in relation to polar bears, it was decided to initially locate a bear by the usual method of tracking, and then make scanning passes over the animal. A flight on April 4, 1970, failed to yield imagery because the tape recorder malfunctioned. On April 5 testing was continued with all equipment operating normally; Ice cover on the Chukchi Sea area investigated was complete, 1. 5 inches of new snow covered the ice with scattered packed snow drifts associated with pressure ridges. The temperature was —5° F.,the wind was north at 5 knots and the sky was clear. The tests were flown at midday.

The aircraft made several passes at an altitude of 500 feet over a polar bear using a trimetal detector (Hg:Cd:Te) which is most sensitive in the 8-14 micron range. This detector was then replaced by another type (In:Sb) having best sensitivity between 1. 5 and 5 microns, and several additional passes were flown over the bear. Upon returning to the base, the magnetic-taped data were transferred to 70mm film which allowed visual study and photographic enlargement of selected sections.

RESULTS

In-flight imagery displayed on the oscilloscope did not reveal polar bears, though the pattern of smooth versus rough ice was visible. At flight altitude (500 feet) the strip scanned measures 1700 feet wide so a target as small as a polar bear becomes invisibly small, if it appears at all, on the small oscilloscope screen. Furthermore, an image remains on the screen only a few seconds which makes it impossible to focus long on a single 'hot spot' within the varied background pattern.

The imagery obtained with the indium-antimonide detector was of poor quality when viewed on the photographic film strip. According to Dr. Carl Miller, of Daedalus Enterprises, Inc., the aircraft exhaust probably interfered with the reception of infra-red energy from the surface.

The trimetal (Hg:Sb:Te) detector yielded much better results. On film, the infra-red imagery showed good resolution and contrast. When enlarged by projection on a screen or on photographic paper, an object the size of a polar bear would register but not in a way discernibly different from the background pattern. However, it was immediately noticed that any movement of a polar bear left a warm trail that would be recorded. The trail persisted for several minutes after the animal moved over a given spot. This distinctive trail would lead to the bear and permit its recognition if it were within the field being scanned (see Fig. l). Because observations indicate that polar bears (unless denned, which is uncommon on the ice pack) invariably move upon the approach of a low flying aircraft, it is probable that most or all bears in the area being scanned would be detected under conditions that existed during these tests.

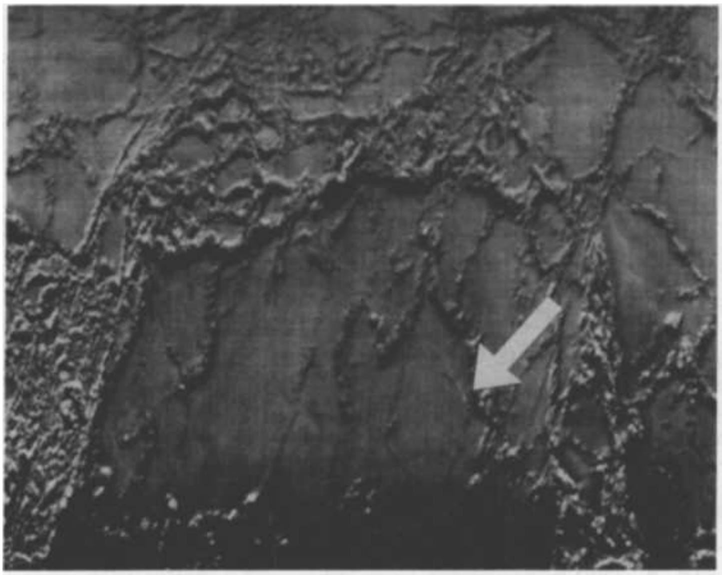

Fig. 1. Photographic reproduction of a recording obtained from an imaging infra-red line scanner. A bear trail is visible with the animal located at the point of the arrow.

DISCUSSION

Imagery on the oscilloscope monitor did not reveal polar bears or their trails, although it served as a quick reference to assure that the scanning equipment was functioning properly.

The tests utilizing a trimetal detector (Hg:Sb:Te) in combination with the tape recorder yielded imagery on film that would permit identification of polar bears. Unfortunately, opportunity did not allow testing under the variety of conditions that would surely be encountered in extensive surveys. It is not known how long the bear trails might be detected if wind velocities were higher, though it is expected that they would dissipate more quickly. Differing states of cloud cover and thickness would probably influence background contrasts, perhaps enhancing the imagery as far as bears and their trails are concerned. The depth of snow on the ice may influence the character of the bear trails and the ability of the equipment to record them. Additional testing will be required before the technical practicality of the method under a wide range of conditions can be judged.

The costs of buying or leasing imaging infra-red scanners and the expense of operating aircraft are substantial. Nevertheless, the initial testing indicates that this method is probably superior to any other and could have application in line transect sampling systems aimed at yielding estimates of bear numbers over fairly large regions.

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Further Notes on Polar Bear Denning Habits

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SUMMARY

Polar bears construct maternity dens in the snow throughout their range. The Owl River maternity denning area on the Manitoba coast of Hudson Bay, Canada, had a measured productivity of 100-150 cubs in 1970 and 1971. Maternity denning is now confirmed for the Twin Islands in James Bay, but estimates of productivity for James Bay and the Ontario coast of Hudson Bay should still be made. Female polar bears build a variety of dens in the vicinity of their winter dens and along their route as they move to the sea ice. This makes the censusing of maternity dens and estimating of productivity difficult. The winter dens in Hudson and James bays differ from high arctic dens in that earth chambers are used, with snow dens added as winter progresses. Summer denning occurs along the Manitoba and Ontario coasts of Hudson Bay, and on the islands in James Bay. Surface pits, shallow dens and deep burrows are the three basic types of earth dens built. All three types appear to be constructed for temperature regulation by the bears, but each type is sometimes used later for shelter, protection from insects, protection from other bears or for winter dens. These behavioural adaptations appear significant in delineating a discrete polar bear population for James Bay and southern Hudson Bay.

INTRODUCTION

Polar bears (*Ursus maritimus* Phipps) den throughout their circum-polar range. Winter maternity dens constructed in drifted snow by pregnant females are the most common type and have been described by many arctic writers, especially Uspenski & Chernyavski (1965) & Harington (1968). Such dens are typically prepared by the female digging into a new drift, but sometimes she lies on or digs into a drift remnant from the previous year, allowing the snow to cover her. The maternity den is later expanded, perhaps by body heat, consumption of snow, scratching or digging. Maternity dens dug into deeply drifted areas show considerable evidence of design and construction (Uspenski & Chernyavski *op. cit.;* Harington *op. cit.*).

Certain polar bears other than pregnant females construct winter dens in the snow, especially in maternity denning areas (Van de Velde 1957, 1971; Harington, *op. cit.)*. Uspenski & Chernyavski (*op. cit.*) found no such evidence on Wrangel Island and the ecological and behavioural causes for this type of denning remain unknown. Another form of winter den, referred to as 'temporary' or 'natural' by Harington (*op. cit.*), is used only for short periods as shelter during severe storms.

In the Hudson and James bay areas of Canada, polar bears construct earth dens during summer and autumn. Unique to the Southern portions of polar bear range, such dens were first mentioned by Kolenosky & Standfield (1966) from aerial observation along the Ontario coast, and by Doutt (1967) from the Twin Islands of James Bay. The structure and function of earth dens are very different from those of typical winter dens.

The present study of winter denning, denning areas and the types and distribution of summer earth dens of polar bears was begun by the Canadian Wildlife Service in 1969, in response to a request by the IUCN Polar Bear Study Group based at Morges, Switzerland.

While there is increasing evidence from the recapture of tagged animals that female polar bears return to ancestral denning areas to produce their young, Uspenski & Chernyavski (*op. cit.*) thought it probable that females breed each time in a different area of the Arctic. If maternity areas are indeed ancestral, it is important to investigate why certain geographical areas are favoured; what ecological, genetical and behavioural forces are involved; what the total productivity is for specific denning areas; and where as yet undiscovered denning areas are located. New denning areas in Canada are suspected on Devon, Elsemere, Somerset, Prince of Wales and Akpatok islands, and along Prince of Wales Sound, but adequate field studies on the extent of these localities have not been made. The urgency of undertaking such studies is growing, as mineral exploration teams and, particularly, their seismic activities could be having profound effects on polar bear behaviour and reproductive success.

METHODS

Suspected winter denning areas were visited by us during March and early April of 1970 and 1971 using skidoo, fixed-wing plane and helicopter; during July through September of 1969, 1970 and 1971 using helicopter and on foot; and during November-December 1970 by helicopter.

March-April studies included recording the numbers of females with young moving to the sea, back-tracking families to locate specific winter den sites, taking measurements of and marking winter dens, and collecting data on litter sizes.

July through September field work involved making observations of bear distribution and bear behaviour in the summer denning areas and of bears in the summer dens, checking winter den locations, and capturing and marking individual bears found in dens. We measured and permanently marked specific dens with tape, for further study. Permafrost measurements were made inside the dens and in surrounding areas with the aid of a case-hardened serrated steel probe 1. 5 cm in diameter (Brown 1968). We investigated the extent of summer denning areas and the purpose of summer denning by systematic searches and extensive behavioural observations.

November-December studies consisted of locating specific occupied dens for winter studies, marking pregnant females in dens, recording the behaviour of females during their selection and preparation of winter dens, and observing the behaviour of bears in dens.

RESULTS

A major polar bear winter denning area discovered in the Owl River drainage of Cape Churchill during 1969 (Jonkel 1970) has provided additional data on polar bear productivity rates and behavioural adaptations. This denning area is located between the Nelson and Churchill rivers in a partially treeless zone underlain with discontinuous permafrost (Fig. 1). It is centered about 10 to 20 km inland from Hudson Bay, but its outer boundaries include patches of tundra within a heavily forested zone 15 km north of the Nelson River. The area extends northward 100 km to the almost treeless coastal tundra between Cape Churchill and the mouth of the Churchill River.

Fig. 1 Geographic location of the Cape Churchill (Owl River) and Cape Tatnum, Manitoba, winter denning areas.

Emergence and Productivity.

During 1970 and 1971 females with young started to leave the denning area and move to the sea in late February (Fig. 2). We saw additional females with young moving eastward all through March and as late as 12 April. Not all of the area was searched in 1970, because we had not yet found its northern projection but, on the basis of four winter trips, we concluded that approximately 60 females had produced young in the area. During late February and early March the temperature averaged 20 °F below zero, but by early April there was mid-day thawing.

In 1971 we observed a similar pattern of movement although the weather was milder. Many bears left their dens earlier, building alternate dens in the vicinity or, as during a warm period in early March, lounging on the snow near

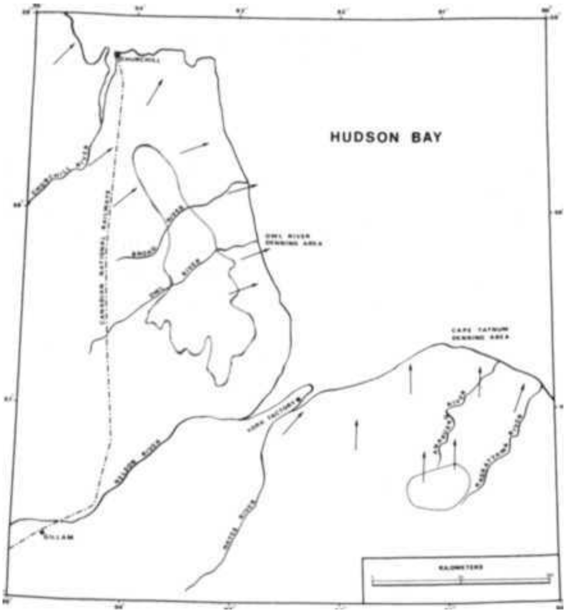

Fig. 2 Detailed map of the Owl River and Cape Tatnum maternity denning areas in Manitoba, showing the general direction of family movements to the sea during March and April.

den entrances. Again in 1971 at least 60 females produced young in the Owl River denning area. We noted additional females with young travelling to the sea from outside the main denning area, of which, three were observed north of the Churchill River and 16 came from distant inland areas and crossed the Churchill rail line (Fig. 2). Some of the 16 females from inland may have been inadvertently included with the 60 from the Owl River denning area because of poor tracking conditions on certain days.

Preliminary summer and winter studies show that a similar but smaller maternity denning area occurs inland from Cape Tatnum south of the Nelson River (Fig. 2). In 1971 a partial survey of this area indicated that at least 16 females produced young here. The average litter size for the Owl River denning area in 1970 was 1.9 for 52 families; in 1971 it was 1.8 for 93 families in both areas.

Maternity denning also occurs in scattered areas along the Ontario coast south to James Bay (Jonkel *op. cit.*). Detailed studies of the productivity of bears in this area are planned for 1972 and 1973.

We also suspected that there were maternity dens on the Twin Islands in James Bay (lower arrow Fig. 1). During March and April 1968 and 1969, we tracked bears but failed to find any maternity dens, though females with young were in the area. Summer studies in those two years revealed only one den that had clearly been used as a winter den. In March 1970. however, we found three females with young denned on the Twin Islands. At least eight females with young, seen in the vicinity of the Twin Islands that year, apparently had maternity dens on James Bay islands.

A small number of denned adults with no cubs were noted in the denning areas: one was on North Twin Island in 1968, and two were seen leaving the Owl River denning area in 1971.

Winter Dens

Winter dens in the Owl River district occur most often in treeless or almost treeless areas (Fig. 3) wherever steep banks occur, such as along lakeshores, meandering tundra streams or the sides of palsas and hummocks created by permafrost. Bears avoid other likely sites such as the high mineral soil banks of rivers, eskers and stream banks in heavily forested areas, as well as shores of lakes with low banks. Banks which drift deeply with snow provide particular attraction, especially if sloping to the south or southeast. Willow (*Salix* spp.) and black spruce (*Picea mariana*) are usually present along such banks and result in additional drifting.

Fig. 3 An aerial view of the summer-winter polar bear denning area south of Cape Churchill, Manitoba.

These winter dens in the snow closely resemble high arctic dens as described by Harington (*op. cit.*), but whereas the latter include extensive snow chambers and alcoves, many maternity dens in our area consist of an earthen chamber in peat banks, with a large snow chamber either added to the entrance (Fig. 4) or constructed nearby (Fig. 5). Dens which did not have a snow chamber attached, opened by a long tunnel through 1-2 m of snow directly to the outside.

Females leaving winter dens followed a uniform pattern of behaviour. After breaking though the ceiling of the snow chamber (Fig. 6), they spent up to a month in the vicinity of the den (Fig. 7), apparently leaving and re-entering the den repeatedly, as reported in the High Arctic by Harington (*op. cit.*). The cubs played on banks of the snow and in nearby willow bushes, while the females

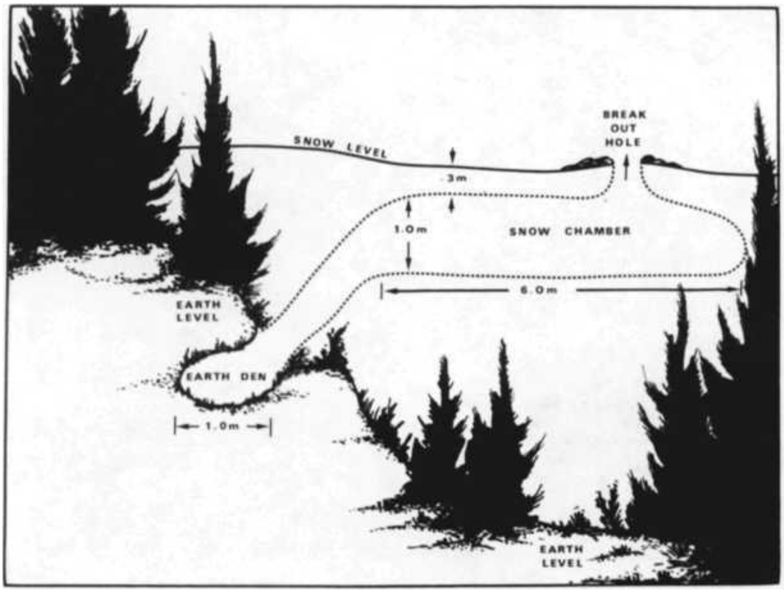

Fig. 4 Diagram of a typical Owl River or James Bay winter den showing an earth den with the snow chamber added during winter.

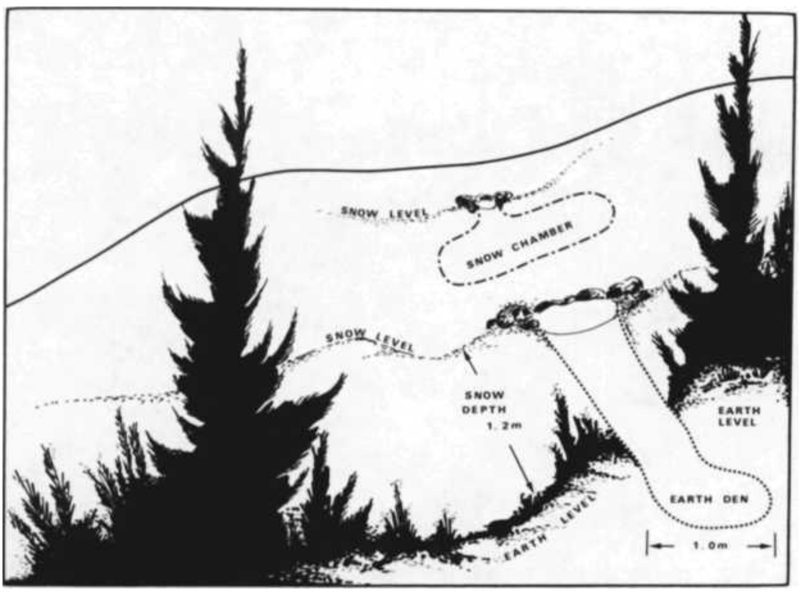

Fig. 5 Diagram of a maternity den located in an earth den, but with a snow chamber added nearby.

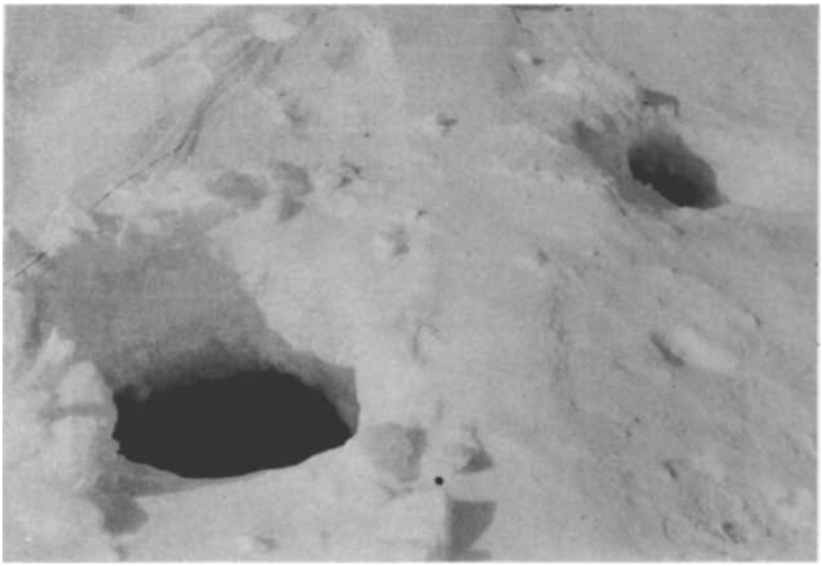

Fig. 6 A winter den of a female and cub, showing the break-out hole used on 3 March, and a hold dug for re-entry to the maternity den in a peat-moss bank, used during the animals' stay in the vicinity.

Fig. 7 The tracks of polar bear cubs indicate considerable 'playing' in the willow bush. Centre of photo shows where female polar bear dug down in stream bottom to obtain herbaceous foods.

dug additional dens or dug down to stream bottoms to consume grasses (*Calamagrostis* spp.) and mosses (*Sphagnum* spp.).

Upon leaving the vicinity of the winter den, the family usually moved to heavier cover, especially along a meandering stream, and constructed temporary dens. These comprised either a series of single dens a few kilometers apart, or groups of dens in a particular area, especially an area with summer dens, banks and variable snow conditions. The bears usually dug down to existing summer dens in the earth, made surface pits and shallow dens in the snow, or dug deep L-shaped dens with a rounded bed at the end. Debris from inside the summer dens was often thrown out onto the snow in the process, and at least one earth den was found which was dug entirely in the winter. Unless bears are carefully tracked, many of these temporary dens could be mistaken for winter dens.

By late March or early April the families move directly towards the sea. They travel perhaps 0. 3 to 0. 5 km at a time initially; at each stop the females construct a rounded bed 20 to 40 cm deep in the snow and feed and warm the cubs. When the temperature is low, the cubs spend these rest stops sitting or standing on top of the female and sometimes curling up in her fur. In this halting manner the family moves in a relatively straight line to the sea, across the floe edge and out onto the drifting pan ice (Fig. 8). In rare cases a cub will even ride on the female, especially if frightened as well as cold. In James Bay we saw a female giving the smallest of three cubs a ride for a considerable distance.

Fig. 8 The floe edge of Hudson Bay. Females and young move onto the drifting pan ice (left) to hunt seals and seal pups during early spring.

Summer Dens

Summer denning in the earth occurs most commonly within the winter denning areas already discussed, but also occurs on coastal beaches and offshore islands of southern Hudson Bay and James Bay. We also found a few small excavations on Southampton and Coats islands. Denning in the earth by polar bears has never been reported outside of these areas, but could be expected in higher latitudes wherever the ground thaws sufficiently. Earth dens are constructed during late July through October by bears of various sexes and ages (Table 1), and sometimes the dens are modified by pregnant females during November or later for winter denning.

TABLE 1. SEX AND AGE OF BEARS OBSERVED IN SUMMER DENNING AREAS DURING 1969 AND 1970. CLASSIFICATIONS WERE BASED ON BODY SIZE AND FORM.

Year	Date	Ad. XX with young		Ad. XX without young	Ad. WW	Sub-adults
		XX	young			
1969	Aug.13	3	6	—	4	7
1970	Aug. 31-Sept. 2	7	12	3	31	10
	Nov.9-13	1	2	7	3	—
Totals		11	20	10	38	17

There are three basic types of summer-autumn earth dens built by polar bears. These include (1) a shallow surface pit or bed similar to a canid day bed or the snow beds discussed above; (2) a bed in the form of a shallow den dug into the side of various types of banks; and (3) a deep burrow also dug into the side of a bank.

Surface pits are common along the coastal areas and islands of southern Hudson Bay and James Bay. They are usually 1.0 m in diameter, 20.0 cm to 0. 5 m deep, and are constructed on level ground (Fig. 9). Sites most often selected are the tops of (1) low coastal beaches (berms) and 'ice pushes' (ridges of sand) just above the high-tide line, (2) old inland beaches and eskers, (3) sand dunes, and (4) ice-pushes around inland lakes. In permafrost zones they are found (5) on the tops of peat-covered palsas and hummocks, or (6) on the crests of high banks of lakes. In rare cases they are constructed (7) on steep slopes by making a shallow excavation into a bank and locating the pit on the excavated soil, or (8) on the tailings of a deep den. The most popular sites are coastal beaches or the banks of inland lakes in open or thinly treed permafrost zones.

Shallow dens are similar to the temporary winter dens of polar bears described by Harington (*op. cit.*), to brown bear (*U. arctos* L.) winter dens described by Craighead & Craighead (1966), and to certain black bear (*U. americanus* Pallas) winter dens found by Jonkel & Cowan (1971).

Shallow dens are occasionally located close to the sea on high sand or gravel beaches which are vegetated sufficiently to provide support, but most commonly they are dug into the steep banks of eskers on the James Bay islands, and the peat banks of palsas, hummocks, lake-shores and streams in permafrost zones inland from the Manitoba-Ontario coast. They are deep enough only for a bed, and average 1.0-2.0 m wide and 1.0-2.0 m deep, with entrances 1.0 m or less high (Table 2). In peat soils they often terminate at permafrost. In sand or

Fig. 9 Photo of a typical Polar Bear surface pit or bed.

TABLE 2. THE MEASUREMENTS OF SHALLOW DENS BUILT IN THE SUMMER AND AUTUMN BY POLAR BEARS, NORTH TWIN ISLAND, N.W.T.

Den No.	Approx. Slope (Degrees)	Measurements (meters)			Remarks
		Length	Width	Height	
1	40	2.4	2.4	1.2	Sod and sand
2	40	3.6	1.6	1.1	Birch clump
3a	30	1.1	0.9	0.9	Three beds in one den,
3b	30	1.1	1.1	0.6	nest materials
3c	30	2.0	0.8	1.0	added.
4	40	2.4	2.4	1.0	Sod and sand
5	40	2.4	2.0	1.0	Sod and sand
6	35	2.4	2.4	1.2	Sod and sand
7	30	2.6	2.4	1.0	Willow and birch, sand
8	45	1.0	1.0	1.0	Sod and sand
9	45	2.3	2.8	1.1	Willow and gravel
10	20	1.6	1.6	1.0	Willow and sand
11	20	2.3	2.8	1.1	Willow and sand
12	10	1.6	2.9	1.1	Birch and willow, sand

gravel areas shallow dens are dug laterally into banks which slope approximately 45° from the horizontal, whereas in areas of peat substrate the banks used are often vertical (Fig. 10). The soil type and vegetation are important, with bears usually choosing sites where caving of the walls or ceiling is unlikely. Sand or peat substrates are sought most often. The dens face any direction, especially those in the perimeter of palsas and hummocks, but dens on lakeshores dens often face south or east because the land slopes towards the sea and the banks on inland shores are higher than on seaward shores, especially on large lakes. The extent of permafrost action in the tundra surrounding the lake also affects the height of banks and the location of the dens.

Fig. 10 Photo of a typical shallow den in peat bank.

Deep burrows, which are found only in high banks with peat substrates, are not frequent. They are similar in construction to shallow dens, but may extend for 4 to 6 m into the earth, terminating at permafrost.

The lair at the end of one such den occupied by a 562 kg adult male was 2.0 m long and wide and 1.2 m high. The den turned to the left and down, so that the floor of the lair was located about 2.0 m below the entrance of the den (Fig. 11) and was very dark and cold.

Permafrost measurements were made in and around recently occupied summer dens (Table 3). In one case an adult male had dug a shallow den so that the rear wall was permafrost and was lying against the ice. In most cases the permafrost was 0.1 to 0.2 m from the surface of the bed. The depth from the surface of the ground to permafrost behind the dens and on the surrounding stream and lake banks was usually uniform. Lake or stream shores in front of the dens or below the banks generally had no permafrost or had permafrost too deep for us to measure. Mineral soil was at the surface or very close to the surface at the lakeshores, whereas the banks or the level ground above the banks normally had 1 to 1. 5 m of peat overlying the mineral soil.

TABLE 3. PERMAFROST MEASUREMENTS FROM RECENTLY OCCUPIED POLAR BEAR DENNING SITES, AUGUST AND SEPTEMBER, 1970.

			Depth to Permafrost (Cm)				
			Interior of Den		Surrounding Area		
Area	Direction Facing	Den No.	Back Wall	Floor of Den	Top of Bank	Foot of Bank	Remarks
Broad River	NE	1	12.5	22.5	35.0 75.0*	45.0	Shallow bank
Beale Creek	NW	2	5.0-10.0	10.0	37.5	45.0	Adult male # 704; lake bank
Rupert Creek	E	3	—	50.0-52.5	50.0-52.5	200.0†	Winter den site: stream bank
Rupert Creek	SE	4	11.0	12.5	50.0	—	Adult male; lake bank
Anabusko River	NE	5	20.0	20.0	45.0	250.0	Hummock

* Depth to permafrost from surface of a shallow lake
† Could not reach permafrost.

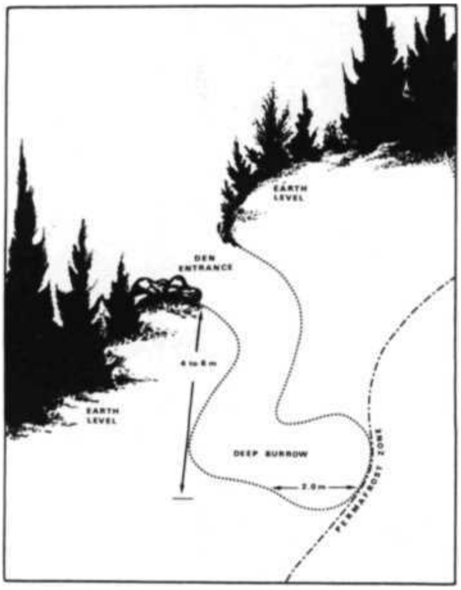

Fig. 11 Diagram of a typical deep burrow.

Several dens were found containing lichens and mosses from the surrounding surface. In one case, in a peat and permafrost area, a bear had raked the vegetation from an irregular area measuring approximately 10 m wide and 40 m long (Fig. 12). Some of this material was in a surface pit, apparently used as a winter den, but much of the material was missing. In another case, mosses and herbaceous plants had been raked into a shallow den which had been dug into a raised beach on North Twin Island. Beds within the den indicated that it had been used during winter by a female and two cubs.

During August and September 1969, we counted 286 bears along the Hudson and James Bay coasts between Churchill and Moosonee,at the southern end of James Bay. Bears were found along the coastal beaches and in the inland denning areas. A similar aerial survey during September 1970 gave a total of 260 bears. A majority of the bears were resting either in surface pits, shallow dens (Fig. 13), deep burrows or moist grassy areas, when first observed. A flight over the Twin Islands in September 1967 revealed that bear behaviour there was similar. During all three surveys certain bears showed a marked reluctance to leave their beds.

Similar observations conducted during October and early November 1970, revealed many bears (we assumed pregnant females) in dens in the maternity denning area, but few bears in dens or pits along the coast. In fact, large numbers of bears were walking along the shore, sitting or lying on frozen lakes near the coast, or lying very near the edge of the sea. Bears that were in dens, were in the deeper of the shallow dens rather than in surface pits, and they were even more reluctant to leave the dens than in summer. A few of these bears appeared by their body form to be young animals. Most were medium-sized adults, which one can usually assume to be females. One bear which we chased from a den and drugged was an adult female. Several others remained in their dens and were identified as females in March when their tracks and the tracks of their cubs were observed leading away from their dens.

Fig. 12 The area from which mosses and lichens had been raked into a shallow bed and apparently used as a winter den by a polar bear.

Fig. 13 A polar bear emerging from a shallow den dug into a sand ridge along the Ontario coast.

DISCUSSION

The winter polar bear denning area found in northern Manitoba has particular biological significance because data on the productivity of denning areas is basic to the management of the species. Although Kolenosky & Standfield (*op. cit.*) and Doutt (*op. cit.*) had reported that polar bears den along the coast from Cape Churchill to the Twin Islands, the great concentration of dens north of the Nelson River was not previously known.

Judging from their large size, from caving and the degree to which they are re-vegetated, many summer dens appear to be ancient. Some bears use the summer dens for winter dens, and if summer dens are a valid indication of past use of the area as a winter denning area, we could assume that it has been an important centre of productivity for many decades. It seems likely, however, that considerably more bears have used the area in recent years. Coastal aerial surveys do not show a marked increase (Jonkel & Standfield 1969), but many persons long familiar with the area believe that the number of bears has increased rapidly since the York Factory settlement was closed and the military personnel left Fort Churchill. The number of bears present on Cape Churchill each autumn since 1968 does appear greater than in earlier years (Jonkel *op. cit.*).

On the other hand, the area is still seldom visited. If biologists had not made a special effort to visit Cape Churchill in late autumn and the denning area during late summer and March the past several years, the large autumn concentrations of bears on Cape Churchill, as well as the existence of the western Hudson Bay denning area, would be unknown today. Inadequate research in the past and the almost complete lack of travel into particular geographical areas during inhospitable times of the year lead one to question how many denning areas in the Arctic are still unknown. For example, the eight females which we believe denned on the Twin Islands in 1970 comprise only a small fraction of the total bear population in the south end of Hudson Bay and James Bay. Scattered records of dens from earlier publications (Kolenosky & Standfield *op. cit.*, Jonkel *op. cit.*), and accounts by Indian trappers suggest that the entire Ontario coast of Hudson Bay and northern James Bay should be investigated.

The purpose of summer dens seems to be unrelated to winter denning. They appear to be hastily constructed and their two basic functions are as a resting and cooling place. The beds on ridges are located where they receive the most cooling winds from the sea or large lakes. Once constructed, the pits apparently can be re-used indefinitely. Many times during July and August adult polar bears were observed using old pits which were completely overgrown with lichens and mosses. They are, by personal experience, delightfully comfortable. In very sandy areas, pits are difficult to distinguish from holes made by wind and seem easily converted into large useless holes or sand dunes. Surface pits are found in most of the same areas as the other types of dens, but not on coastal beaches.

The shallow dens and deep burrows are more detailed in construction than the pits described above and provide more sheltered beds. The sheltering results from the location of the dens below the crests of ridges and from a partial or complete overhang of earth and shrubbery.

Doutt (*op. cit.*) surmised that the earth dens of the Twin Islands were used by bears during the winter. Our winter studies showed little evidence of this and use of only a small portion of the more suitable peat dens in Manitoba. A vast majority of the earth dens are unsuitable for use as winter dens because of their size or location. We believe, therefore, that bears dig most summer and autumn earth and peat dens in order to reach the cool substrate, and to escape the direct rays of the sun, high ambient temperatures and, in some cases, insects. These earth dens are sometimes used later for shelter in the autumn and as maternity dens in winter merely because they exist.

In the autumn the dens offer shelter from severe winds, storms or snow. Two young bears on North Twin Island appeared to use shallow dens for protection from the weather as well as a sanctuary from large males in the area. We have observed polar bears using trees, shrubs and ice blocks as cover when pursued by a helicopter. In taking cover, four bears ran into shallow dens, and at least 12 bears found in dens stayed in the dens for cover. Again, we believe that the summer dens were used for cover as a secondary function.

The selection of the den sites seems directly influenced by the slope of the terrain. The height of the ridge or slope does not seem important; some are as little as 2 m high but the higher the ridge the more space there is for additional dens. Most were located in high peat banks of the mainland or in the 45 m high sand and gravel ridges on the Twin Islands. There were no dens at the crest of the ridge where the slope ceased, but bears often made dens in areas where the shrubs (birch *Betula nana* and willow S. *arctica*) were particularly dense and also dens about 1 m high, even if the slope was slight. No earth dens were found dug into level ground.

Certain areas along the high banks of the Twin Islands consist of gravel and sand which is attractive to bears. In one part of this area there was a concentration of dens near where a sand ridge meets the main ridge of mixed gravel and sand. This perhaps indicates that sand substrate may be the most stable for den construction, or that a sandy bottom may somehow serve the function of the den more properly.

On slopes rising to 45 m above the shore on the Twin Islands, a curious pattern of den formation was noted. The original dens apparently were built at midpoint or lower on the slope, but then were extended higher each year, or each several years, as the overhang collapsed and the den had to be rebuilt. The collapsed den evidently is a preferred location to dig new dens, and this has resulted in long shallow trenches which extend as far as 40 m up the slope. These trenches sometimes branch in ascending the slope and often terminate in a new den just below the crest of the ridge. Other trenches which continued to the top of the ridge terminated in unused and overgrown dens on almost level ground at the abrupt ecotone of the shrub-dominated vegetation and a tundra vegetation (dominated at the ecotone by white mountain saxifrage *Saxifraga groenlandica).* The amount of re-vegetation indicates that the progress of these dens up the slope must be very slow, but we found no way to determine their age. The reconstruction of most dens after one year would involve the removal of approximately 0. 5 to 1.0 cubic meters of earth and debris.

Despite the unique denning behaviour discussed here, bears of southern Hudson Bay and James Bay hunt seals, make annual migrations and seek sanctuary in the sea as do polar bears everywhere. Apparently certain bears in the area, besides pregnant females, den in the winter as do bears observed by Van de Velde (*op.cit.*) in the High Arctic. But the types of dens constructed differ in many ways from the dens that the more northern bears dig into snow banks during the summer. These earth dens have existed for generations on the Twin Islands and along the southern Hudson Bay coast. Similar earth dens of polar bears have not been found elsewhere in the circumpolar range of the species, including the nearby southern summer sanctuary for polar bears on Akpatok Island in Ungava Bay.

Even the winter dens differ from the usual type of winter den in having both earth and snow chambers. Some of these differences in denning can be attributed to topographical conditions—especially the hummocks caused by discontinuous permafrost upheavals and the thawed earth, but, more probably, some of the differences may be related to learned behavioural traits. These adaptations in the behaviour of polar bears therefore may be significant in delineating a discrete population of the species in James Bay and southern Hudson Bay.

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Norwegian Polar Bear Hunt, Management and Research

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SUMMARY

More than 8,000 polar bears have been killed in Svalbard (Spitsbergen) since 1945. New hunting regulations were enforced on 1 September 1970. Long term ecological and physiological polar bear investigations started in 1964. Of 103 bears marked, there have been reported 33 kills and 2 resightings. Various observations suggest a common Norwegian-Russian polar bear population in the Barents sea. An evaluation of various estimates suggest a total world population of polar bears close to 20,000 animals.

NORWEGIAN POLAR BEAR HARVEST

The Norwegian catching of sea mammals has traditions dating from 1795. Catching grounds range from the Kara sea in the east to the Newfoundland region in the west. The polar bear (*Ursus maritimus*) has been hunted in Greenland, Svalbard (Spitsbergen) and Jan Mayen, as well as in the pack ice of the Greenland sea and the Barents sea. Hunting is performed by the following main categories: 1. winter trappers, 2. weather station crews, 3. sealing vessels, 4. summer sport hunters (Arctic safaris), 5. expeditions, miners and others.

The polar bear harvest was of little economic importance prior to 1900. The total catch has varied from year to year, depending upon the number of vessels and hunters involved, weather and ice conditions, and skin and blubber prices. Between 1945 and 1969 the total Norwegian polar bear catch was 7807 animals, with an annual average of 312 bears. The average for the last 5 year period was 299 bears. The catch for the 1969-1970 season is estimated close to 500 animals, which is the highest take since 1950. Prior to the late 'fifties, the sealing fleet accounted for the majority of the take, and in particular the ships operating in the Barents sea and around Svalbard. The sealing in those waters has decreased, but better prices for polar bear hides have simultaneously encouraged the commercial polar bear winter harvest by trappers and by weather station crews, who together now account for about 75% of the take.

This commercial hunt deserves some attention. Some areas in Svalbard, such as Hopen and Halvmåneöya islands and Hornsund and Tjuvfjorden fjords are particularly famous polar bear hunting grounds. The typical trapping team consisted of two men, operating from a small trappers' station with between a dozen and half a hundred set guns. Some bears have also been taken free-roaming or with the aid of a 'signal', which is a primitive alarm system connected to the cabin. There have been about one to three trappers teams operating in Svalbard each winter for the last two decades, except in the winter 1969/70, when there were 6 teams trapping bears.

Until 1970, the following major laws regulated the Norwegian polar bear harvest:

the use of poison and steel traps was prohibited;

Kong Karls Land and adjacent waters were a polar bear sanctuary;

the catching of live bears was generally prohibited, but permits could be given on applications from approved zoos or for scientific purposes;

trophy hunters operating from vessels (Arctic safaris) were limited to one bear per hunter, and could not kill cubs or yearlings or females with cubs or yearlings;

bears could not be taken with the aid of motorized vehicles or aircraft.

As better protection of the polar bear was required, new hunting regulations were introduced on 1 September 1970, summarized below:

polar bear hunting in Svalbard and Jan Mayen and by Norwegians in any territory requires a permit, issued on the basis of a quota system;

Kong Karls Land and adjacent waters are a polar bear sanctuary;

trapping devices as set guns, snares, steel traps and the use of poison are prohibited;

rifles must be at least 6. 5 mm calibre, with a minimum energy of 200 kgm at a distance of 100 m;

cubs and yearlings and females with cubs and yearlings are protected;

polar bears must not be caught alive;

the use of motorized vehicles and boats is prohibited, except when necessary , in the performance of legal hunting; the use of aircraft is prohibited. (This means that bears can be pursued and hunted with the aid of vehicles and boats by hunters who hold a permit).

Dispensations from these regulations can be granted for scientific and other purposes. Licence fees, stamping of hides and skulls, submission of reports by hunters and other requirements may be introduced if found necessary.

In essence, the new regulations control the polar bear harvest through an annual quota, which for the 1970-1971 season has been set at 300 bears. It has been allocated as follows: 1. winter trappers: 100 bears; 2. weather station crews: 40 bears; 3. sealing vessels; 60 bears; 4. summer sport hunters (Arctic safaris): 40 bears; 5. expeditions, miners and others: 60 bears. The Governor (Sysselmann) of Svalbard, who is in charge of issuing the permits for categories 1, 2 and 5, has issued a licence for one bear per man on the weather stations, except on Hopen, where the four men of the station have been allowed four bears each. The winter trappers were allowed ten bears each, except for one trapper wintering alone in Hornsund, who got twenty, and another on Halvmåneöya, who got sixteen. Most likely, weather station crews and other professional bear hunters will take about 100 bears this season. Hunting success by the other categories is expected to be high, because motorized vehicles now are permitted.

One cannot expect a selective polar bear harvest in Svalbard, for example directed towards old males. Only the trophy hunters, operating from icegoing vessels in summer, are in the position to sail in pack ice areas where bears are abundant enough for some degree of selection during the normal ten day cruise.

NORWEGIAN BEAR RESEARCH

The Directorate of Fisheries has collected polar bear harvest statistics from 1924 onwards. But prior to 1964, Norwegian polar bear research was only occasional.

Dr. Odd Lönö, who wintered for the fourth time in Svalbard in 1964-1965, collected specimens and made observations from his bear hunts in Tjuvfjorden Edgeöya. He has published polar bear harvest statistics which are accurate between 1885 and 1906, and from 1924 onwards. He has also presented new information on polar bear breeding biology, age and sex structures, denning habits, mortality and food habits, as well as on other topics (7).

In 1964, a long term polar bear project in Svalbard was launched as a cooperative enterprise between the University of Oslo and the Norsk Polarinstitutt. The program consists of a physiological part, headed by cand. real. Nils Are Öritsland, Zoophysiological Institute, University of Oslo, and an ecological part, headed by the present author. Field work in Svalbard started in 1966, with monthly aerial surveys over the eastern pack ice between March and October for the purpose of bear counts and ice observations. The same summer, an attempt was made to catch and mark polar bears from icegoing vessels, and 4 were captured and marked in a 5 days effective survey (3). The aerial survey programme was repeated in 1967, and bears were captured from a chartered sealer in the eastern pack ice in July and August. During 20 effective days, 105 bears were spotted, of which 51 were captured and 2 more were killed during capture. Another marking expedition in 1968 spotted 48 bears during 12 effective days in August. 32 were captured and marked. None were killed (5). The 1968 summer expedition was followed by a one year long expedition to Tjuvfjorden, from September 1968 to August 1969. Participants were Mr. Öritsland and the author, plus two assistants. Polar .bears were trapped in foot snares, or taken free-roaming. Den surveys received a high priority in the spring of 1969, when Edgeöya and Barentsöya were carefully searched for dens or signs of denning (4). Physiological studies, with special reference to polar bears temperature regulation, were made by Mr. Öritsland on bears kept in captivity in the station.

PRELIMINARY APPRAISAL OF THE INVESTIGATIONS INTO POLAR BEAR ECOLOGY

Many scientists have claimed that polar bears all belong to one single population, and some even describe migration patterns of such a population (9). But polar bear marking programs carried out by the U.S.A., Canada and Norway, show that polar bears do not migrate very far (2, 5, 6). Of the 33 recoveries and 2 resightings made of bears marked in Svalbard (up to November 1970) only one was killed in Nanortalik, SW Greenland, less than 2 years after it had been marked. All the others were taken in the Svalbard area.

Track observations made from aircraft in 1966 and 1967 and on the ground during the 1968-1969 winter expedition, revealed a southwestward migration of bears from the Barents sea to Hopen, Edgeöya, Barentsöya and the west coast of Spitsbergen in late fall and winter. Bears tend to follow the shorelines and the winter ice edge, and are less frequent inland or on the frozen fjords. In late winter and early spring, the bears migrate back into the Barents sea. This migration pattern is confirmed by recoveries of bears marked in Svalbard (5). Parovshchikov (8) describes an analogous migration pattern in the eastern Barents sea and the Franz Josef Land and Novaya Zemlya areas.

He states that there is a connection between the polar bears in Svalbard and those in the western Soviet Arctic. Vibe (13) has shown that polar bear abundance is correlated with seal occurrence and ice conditions. He states that ocean currents and pack ice drift are important factors in determining polar bear abundance and migration. The southwestern ice drift in the Barents sea favors a migration of bears from Russian territories to Svalbard. It is reasonable to regard Svalbard, Franz Josef Land, Novaya Zemlya and the pack ice between those archipelagos as one geographical unit, and the range of a single polar bear population.

The eastern regions of Svalbard have been assumed to be important denning areas for polar bears. The Norwegian delegation to the Fairbanks polar bear conference in 1965 thus estimated about 500 polar bears to den on the archipelago each winter. Dr. Lönö has also described eastern Svalbard as an important denning area. But over a 20-year period, he reports less than two dozen dens, with a maximum of 6 in 1948 (7). Only a few dens were registered on Kong Karls Land during the aerial survey programme. It must be remembered, however, that polar bear dens may be difficult to locate from the air. The low number of dens found in 1969 is also noticeable (4). It is therefore questionable if Svalbard is an important denning area after all.

The 33 recoveries of 103 marked bears made so far (2 in 1967, 9 in 1968, 6 in 1969 and 16 in 1970) may indicate a heavy harvest pressure on the polar bear population in the Svalbard area in recent years. A selective catch among those marked is however possible, due to a high hunting effort along some important migration routes. One bear marked on Kap Lee on Edgeöya and 3 marked in Tjuvfjorden were recovered in the same localities one year after they had been marked (5). It is possible that individual bears follow the same migration pattern from one year to another.

Hopen is the only place in Svalbard where the hunting effort may be assumed to have been about the same for the last two decades. The 4 men on the weather station have taken the majority of their bears with set guns, until the latter were outlawed in 1970. The crews' experience has been about the same from year to year. Short time fluctuations in the harvest can be correlated with varying amounts of ice around the island (7). But the ice conditions cannot explain an increasing catch from 1957 to 1965—from 18 to 93 bears per season. The USSR prohibited polar bear hunting in the Soviet Arctic in 1956. If there is a common Norwegian-Russian polar bear population as previously suggested, Hopen may have had more bears to catch on in the subsequent 1957-65 period. The harvest increase can also be explained by a possible higher hunting effort due to increasing hide prices (from 450 n.kr. in 1957 to 750 n.kr. in 1965). But the harvest has stabilized with an average of 80 bears per season since 1965, while skin prices have increased by over four times in the same period. The prices should have encouraged an increased hunting effort, in particular when the weather station crews for several years have been aware of the proposed set gun ban now enforced, which has restricted their commercial bear hunt.

Various attempts have been made to estimate the world's total polar bear population, and numbers estimated range from 19,000 (10) to 5,000 (11). More recent world estimates have been presented by Harington (l),who suggests 10,000 animals, and by Uspenski and Shilnikov (12) who present a figure of between 10,000 and 15,000 bears. The variation between the many estimates, and the lack of evaluation of the various methods and their bias, limits the value of those estimates. Probably the best figure is obtained by summarizing the estimates made within limited regions of the Arctic. They are as follow: Alaska, 1959: 2,500 (10); Canada, 1968: 6,000 (1);USSR, 1968: 5,000-7,000 (12). So far, reliable data have not been presented from Greenland or Svalbard. But from 1966 onwards, bears have been counted from aircraft and ships in Svalbard, and attempts have been made to evaluate some of the limiting factors. Data revealed an expected difference between air and ship counts, with a higher success from ships. Counting success depends very much upon light, weather and ice conditions, observers' experience and the distance from the bears. Observers' color sense is an important factor in polar bear counts. When spotting bears from aircraft, observation probability decreases sharply with increasing speed and altitude. A careful and preliminary estimate suggest about 3,000 bears in the Svalbard area. The harvest data from Greenland suggest a population of at least 1,000 bears in that region. Totalling all the figures, we arrive at an estimated overall world population of between 17, 500 and 19, 500 polar bears. It may be argued that some bears cross national borders, and hence may be counted twice. On the other hand, the majority of the estimates have been made from the air and, since air counts are very inaccurate, the figures should be regarded as minimum estimates only. It is reasonable therefore to suggest that the world population of polar bears is close to 20, 000 animals.

FUTURE RESEARCH NEEDS

At present, collected serum, hemoglobin and milk are being analyzed by electrophoresis, in an effort to state the discreteness of the Svalbard polar bear population. The results will be compared with craniometric studies. Polar bear skulls collected in Svalbard since 1964 are aged by tooth sectioning and skull characteristics in an attempt to get more information about the hunting pressure over the last few years.

Additional den surveys on Edgeöya, Barentsöya, Kong Karls Land and Nordaustlandet are necessary, in order to evaluate the importance of Svalbard as a denning area for polar bears. If there is a common Norwegian-Russian polar bear stock as suggested, it is possible that the majority of the females den in Russian territory.

We cannot expect polar bears marked in Svalbard to be recovered in the Soviet arctic, because of their polar bear hunting prohibition. Marking and sampling in the western Soviet Arctic is necessary in order to solve many of the questions mentioned in this paper.

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Polar Bear—Sea Ice Relationships

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INTRODUCTION

The population status of polar bears (*Ursus maritimus* Phipps) throughout their circumpolar range is unknown. Scientists and informed laymen differ in their estimates of relative abundance, expressing opinions ranging from the possibility of extirpation because of over hunting to the assumption of near normal abundance. Unfortunately, little effort has been directed at determining the influence of climatic change on potential polar bear habitat and in turn the bear population. Climatic change is directly manifested by sea ice conditions. I intend in this discussion to relate polar bear occurrence and patterns of movement to occurrence and movements of the various types of sea ice, with emphasis on observations made off the west and north coast of Alaska.

Preparation of this report was supported by Alaska Federal Aid in Wildlife Restoration Project W-17-3 and the Naval Arctic Research Laboratory, Barrow, Alaska.

CHARACTERISTICS AND MOVEMENTS OF SEA ICE

Arctic sea ice can be classified into three types-land fast ice, drifting pack ice, and polar pack ice.

Land fast or fast ice is ice which is anchored to the shore. In protected bays, fast ice generally forms in place along the shore in the fall. Along open shorelines, ice which eventually becomes land fast ice generally forms at sea and is brought to the coast by currents and winds. In some areas, fast ice is mainly newly frozen ice that forms with a smooth surface. Along other shorelines, including the north coast of Alaska, old ice is interspersed with the newly formed ice causing the surface in some areas to be quite rough. The fast ice belt is narrow along coasts with deep water and offshore winds and currents, and extends offshore the farthest where shallow water permits ice to freeze to the bottom, and where winds and currents do not tend to move ice offshore. Along the Alaska coast, the first fast ice forms during the fall in the area to the east of Point Barrow and then from Point Barrow southwestward toward Cape Lisburne. Most fast ice melts during the summer or breaks loose from shore and joins the drifting pack ice.

Drifting pack ice extends as a belt of ice in motion between shore fast ice and the heavier ice of the polar pack in the central polar basin. There is more open water in the drifting pack ice zone, especially in early winter, than in the polar pack zone. This open space allows winds and currents to move ice masses relative to one another. Openings in the ice, known as leads, and pressure ridges are formed as the ice is moved within the confines of the more immovable polar pack ice and the stationary fast ice. During winter, leads freeze over as they are formed.

Polar pack ice covers the central part of the polar basin. It is a year or more old, and pressure ridges have been eroded so the surface is fairly smooth. Thickness is fairly uniform with freezing on the bottom in winter generally in equilibrium with destruction of the upper ice surface in summer. Polar pack ice is packed together so there is not much movement of ice masses relative to one another, and leads and pressure ridges are not formed to the extent that they are in drifting pack ice. North of the Alaska coast there does not appear to be a sharp delineation between drifting pack ice and polar pack ice. Some areas of heavy unbroken flat ice occur within the drifting pack ice zone; the extent varies from year to year.

Off the coast of Alaska, ice cover is at its maximum in February and March and at its minimum in August and September (Wittman & MacDowell 1964) (Fig. 1). Ocean currents and winds cause both the drifting pack ice and the polar pack ice to move in fairly well defined patterns. The earliest comprehensive reports on ice movement are from the drift of the Norwegian ship 'FRAM' as reported by Nansen (1902) and the drift of the Russian ship 'SEDOV as reported by Zubov (1943). More recent information has come from Soviet and United States drifting ice stations. Fig. 2 shows the most widely accepted pattern of surface current movement.

Changes in ocean currents and climate affect sea ice. Vibe (1967) states that the relative strengths of the Canadian, the East Greenland arid the Irminger Currents in Davis Strait off the southwest coast of Greenland determine sea ice distribution which in turn influences climatic conditions and the composition, distribution and stability of plant and animal communities on and adjacent to Greenland. He distinguishes three different climatic periods, each about 50 years long, between 1810 and 1960, reflecting three stages of penetration of East Greenland ice into Davis Strait. He believes that conditions of 1810-1860 are now repeating themselves. He designates this as a drift ice stagnation stage where the Canadian current has a dominating influence, and east Greenland ice does not penetrate far north into Davis Strait. The climate is cold, dry, and stable.

Several authors have presented data indicating that sections of the Arctic have experienced warming trends prior to about 1950 and have experienced cooling trends since that time. Zubov's (1943) data show a warming of the Arctic for approximately 100 years prior to publication in 1943. He shows that Arctic glaciers have receded and the southern boundary of Siberian permafrost has moved northward. Zubov also present comparative data obtained during the drift of the 'FRAM' and the drift of the 'SEDOV, 43 years later, over similar tracks in the Eurasian sector of the Arctic Ocean. The mean ice thickness was one-third less and the mean air temperature 4°C higher in 1937-40 than in 1893-96. Dorf (1960) quotes Willett (1950) who states that in Spitsbergen mean winter temperatures have risen about 8 between 1910 and 1950. Dorf (1960) also quotes Ahlmann (1953) who reports ice free ports in Spitsbergen to be open to navigation about 7 months of the year as compared with only 3 months 50 years earlier. Mitchell (1965) states that world climate during the past century has been characterized by a warming trend from the 1880's to the 1940's. Thereafter, the warming trend appears to have given way to a cooling trend that has continued to at least 1960 with some evidence that it was continuing in 1965. Budyko (1966) says that polar ice cover is so sensitive to temperature that a summer anomaly of plus 4°C would cause the entire ice pack to melt in 4 years; an anomaly of plus 2°C would produce the same effect in a few decades. Once the ice pack had disappeared, negative temperature anomalies could re-establish it.

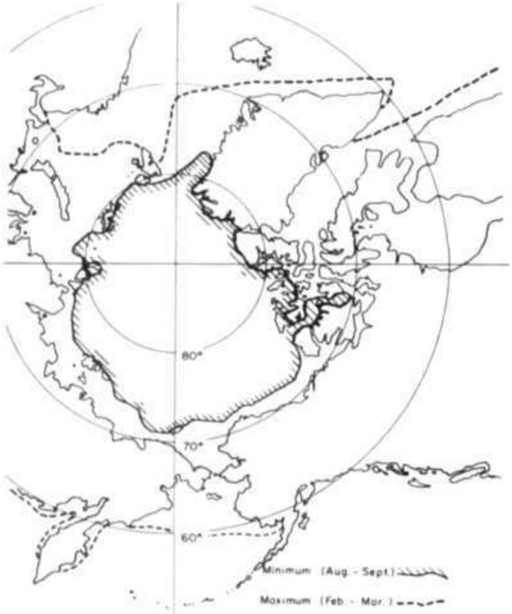

Fig. 1 Ice cover, North Polar Basin

Fig. 2 General surface circulation, North Polar Basin (adapted from Oceanographic Atlas of the Polar Seas, 1958. U.S. Navy Hydrographic Office, Washington, D.C.).

POLAR BEAR DISTRIBUTION IN RELATION TO TYPE OF ICE

Polar bears generally first appear along Alaska's north coast in October, when shore fast ice enables them to travel from drifting pack ice to the beach.

The first bear sightings are reported to the east of Point Barrow and then to the southwest in the same sequence that fast ice forms. Eskimos indicate that polar bears travel from north to south in the fall, along the coast between Point Barrow and Cape Lisburne. Considering the two most productive bear hunting areas along this section of coast, bears are first taken by Eskimos in the northernmost Point Franklin area and then in the Icy Cape area to the south. Eskimos also report that, traditionally, bears are more numerous along the coast in years when winds from the north and west bring old ice to the coast than in years when newly frozen ice drifts in. Bailey & Hendee (1926) verify this and report that in the fall of 1921, old ice failed to come in and new ice formed for miles out from the shore. Consequently, few polar bears were killed between Barrow and Point Hope. In the fall of 1967, Alaska Department of Fish and Game personnel observed that winds brought more heavy ice further south than usual, and there were more bears along the coast than usual. This situation appears to be repeating itself in 1970.

Several things attract polar bears to shore fast ice. One is beach carrion which includes carcasses of walrus *Odobenus rosmarus,* bowhead whales *Balaena mysticetus,* beluga whales *Delphinapterus leucas,* ringed seals *Pusa hispida* and bearded seals *Erignathus barbatus.* Ringed seal pupping dens in fast ice attract bears in the spring. Bears also travel on fast ice to find suitable denning sites. Polar bear dens have been reported along river banks in northeast Alaska and on fast ice close to the islands east of the mouth of the Colville River. Quantitative data on the number of dens along the north coast of Alaska have not been obtained, but dens are less concentrated than in many denning areas elsewhere in the polar basin.

During the winter, drifting pack ice off the Alaska coast probably supports greater concentrations of polar bears than either shore fast or polar pack ice. This is probably because juvenile ringed seals and bearded seals, the bears' main food, are more numerous in drifting pack ice than in fast or polar pack ice. Seals probably prefer drifting pack ice because of open water and the relative ease of keeping breathing holes open where leads have recently frozen over. Intensive studies have not been conducted off the Alaska coast in the summer, but it is assumed that seals and therefore bears are more numerous in drifting pack ice than in the more stable polar pack ice. Bears may be more concentrated in drifting pack ice in the summer than in the winter because there is less ice on which to disperse during the summer. T. Larsen of the Norwegian Polar Institute (pers. comm.) found bears quite concentrated in the drifting pack ice east of Spitsbergen in the summer.

There is not much information on polar bear abundance and distribution on polar pack ice. Bears have been sighted close to the North Pole, and at several locations on polar pack ice between Alaska and the North Pole, by personnel of United States drifting ice stations and the British Transarctic Expedition (data on file at Naval Arctic Research Laboratory, Barrow, Alaska). The number of sightings, however, suggests that bears are sparsely distributed The area where drifting pack ice occurs north of Point Barrow sometimes has extensive heavy ice without open leads or thin ice, and observations here might give some insight into bear abundance on polar pack ice. Some bears travel through these areas, but they apparently do not spend appreciable amounts of time in them.

HARVEST

It appears that the pattern of ice formation and movement in any year can affect the Alaskan harvest of polar bears for that year. More bears occur and are taken by Eskimo hunters along the coast in years when winds bring drifting pack ice close to the beach and shore fast ice forms early in the fall. Nearly all Eskimo hunting is on the beach or on fast ice. The mode of travel is snow machine or dog team. Nearly all bear hunting for trophies is accomplished with the aid of aircraft on drifting pack ice. Hunter selectivity of bears, in years when there is much rough ice and relatively few areas suitable for landing an airplane, is low. The differing degrees of selectivity can affect the total kill and contribute to variations in sex and age structure of the harvest from year to year. In Greenland Vibe (1967) relates changes in distribution of the polar bear harvest to changes in ice conditions.

DENNING RELATED TO ICE MOVEMENTS AND CLIMATE

In polar bears, the pregnant females appear to be the only animals that routinely go into dens in the fall for extended periods. Young are born in the den. Most known areas that have high concentrations of denning animals around the polar basin are on large offshore islands. There are little data on fluctuations in the numbers of denning females from year to year in these areas, but there are reports that numbers of bears visiting islands where denning occurs vary from year to year, depending on ice conditions (Harington 1968; Kistchinski 1969; Lønø 1970). In years when relatively few pregnant females reach denning areas on land, some may be forced to den on sea ice. It is quite possible that ice provides a less stable platform for denning than does land. This could cause the segment of the population denning on the ice to be less successful in raising cubs and therefore to have a lower reproductive rate than the segment denning on land.

A general warming of the Arctic could adversely affect denning. Changing ice conditions because of a warming climate could result in fewer bears reaching some of the more favorable denning areas. Also, Vibe (1967) has pointed out that bears and ringed seals, their principal food, require a relatively stable Arctic or sub-Arctic climate without periods of thawing and melting of snow during winter, in order to successfully den and produce offspring. Warming of the Arctic would reduce the extent of such favorable areas. Disappearance of the ice cover because of air temperature anomalies, a possibility described by Budyko (1966), would have a severe impact on denning and, in fact, the food chain supporting the polar bear. Periods of cooling trends, during which the ice cover increased, should make more land areas, especially further south, accessible for denning.

DISCRETENESS OF POLAR BEAR POPULATIONS

Discreteness of bear populations is of primary concern from the standpoint of polar bear management. Effects of sea ice movements on distribution of bears must be considered in an analysis of tag returns and related data to determine if there are sub-populations of bears. Possible effects of ice movements are considered here primarily as they relate to bears off the Alaska coast. Fig. 2 shows that moving ice could transport bears in various ways. Bears could reach Bering Strait, normally the southern limit of their range off Alaska, by drifting on ice carried by the current moving to the southeast from the vicinity of Wrangel Island. Bears could then be carried north and then northwest toward Wrangel Island, or north and northeast past Point Hope and Cape Lisburne and then along the Alaska coast toward Point Barrow. Bears north of Point Barrow could drift west toward Wrangel Island, or north and then in a clockwise movement to the east and then to the south past the west side of the Canadian archipelago, and then northwest from the vicinity of Banks Island back toward Point Barrow.

Drifting ice could thus transport bears so as to prevent formation of isolated groups of animals off the coast of Alaska. Bears from the vicinity of Wrangel Island could be carried to Bering Strait and then past Cape Lisburne to Point Barrow and the Canadian archipelago. Bears from the northwestern section of Canada could drift past northeastern Alaska on their way toward Wrangel Island.

On the other hand, currents could tend to isolate sub-populations west and north of Alaska. Bears west of Alaska could drift back and forth between Wrangel Island and Bering Strait. Bears north of Alaska could be part of a population that remains in the area north of Alaska east to the Canadian islands.

Active movements of the bears themselves will have to be considered as well as their passive movements on drifting ice. Polar bears travel in their search for feeding areas, denning sites, mates, and more solid ice at time of spring breakup. Bears travel on their own, independently of ice movement, northward from the southern Chukchi Sea in March prior to ice breakup. Along the north coast of Alaska, there is a pronounced movement of bears to the east during the spring. This appears to be from an area where ice is breaking up, to an area where the ice is still quite solid.

It is interesting that bears tend to travel against the direction of prevailing ice drift along the north coast of Alaska in the spring and thereby tend to remain in a fixed position relative to the land. Recovery data have been obtained by re capture and hunter harvest for 26 of 202 bears marked off the Alaska coast prior to 1970. Most animals have been recovered 1, 2 or 3 years after tagging in the same general area where tagged. However, there have also been some recoveries a considerable distance from the tagging site. If bears can selectively navigate on changing sea ice with no constant reference points, the mechanisms for doing so would be most interesting to study.

INFLUENCE OF HUMAN ACTIVITY

With the expanding human population and attendant exploitation of natural resources, man will have a greater impact in the Arctic. The most immediate concern with regard to sea ice and polar bears is oil exploration, offshore drilling and the transport of oil by ships through ice covered seas.

Consideration should be given to limiting oil extracting activities in known polar bear denning areas throughout the polar basin. Human activity, including the use of large vehicles and explosive seismic charges, could keep bears away from denning areas. The effects of such activities when bears are in dens or emerging is unknown. Seismic exploration and drilling activities on fast ice could also affect seals, especially ringed seals when they are denning and pupping in the spring.

Oil spills would probably result if wells were drilled offshore and oil were transported by ship. From documentation of oil activity in Cook inlet in south-central Alaska (Evans 1970), it appears that spills would be inevitable. Moving ice would pose a threat to offshore drilling platforms, pumping facilities and transport ships. In the case of a leaking transport ship, ice would hamper or prevent repairs at sea and might delay travel to a docking area. Ice would hinder or prevent a mopping-up or containing of a spill, and currents could spread a large spill over a considerable area. Oil spills would affect polar bears by reducing the insulating value of their fur and adversely affecting species in the food chain below them.

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Immobilization and Tagging of Polar Bears in Maternity Dens

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SUMMARY

In the spring of 1969 and 1970, 12 female bears were immobilized in maternity dens (Wrangel Island) with the help of powder syringe guns and the drug Sernylan. The procedure was as follows. On finding a den we covered the exit with snow and dug a 'well' 20-30 cm in diameter over the place where the entrance branches from the room of the den. Through this well the female bear was shot by the syringe into the muscles of the head or neck. The best dosage of Sernylan was 1.2-1.8 mg per 1 kg of body weight; the total dosage for a female of usual size was 250 mg. A mixture of 2. 5 cc of a 10% water solution of Sernylan with 2. 5 cc of ethyl alcohol is most convenient for low temperatures. Duration of a latent period is usually 8-10 min.; immobilization lasts 5-8 hours. The reaction of an animal to the drug is described. Female bears were tagged with ear tags (metal and coloured plastic), and red figures were painted on their flanks or backs. All the experiments on immobilizing by Sernylan were a success. Having recovered, female bears left their dens at once or stayed near the den for about a day. An attempt to immobilize a female bear with myorelaxin was unsuccessful.

INTRODUCTION

The problem of polar bear migrations and the rate of the differentiation of the species is very important for establishing rational management and conservation, but the problem is far from being resolved. Craniometric (Chernyavski 1969) and some other studies have not so far helped to define the presence or absence of certain geographical races or populations of the polar bear. A direct answer may be obtained only through tagging of a considerable number of animals. In recent years, countries with Arctic regions have begun tagging of polar bears with the help of immobilizing techniques. Bears have been immobilized by a 'syringe-gun' and drugs of different types—myorelaxants, narcotics and other chemicals affecting the central nervous system, among them the most successful being phencyclidine hydrochloride (Sernylan). Investigators in Canada, USA and Norway have worked with non-breeding bears that were found on the move on sea-ice or on land (Flyger *et al.* 1967; Jonkel 1967; Larsen 1967, 1968, 1969; Lentfer 1968, 1969, etc.).

In the course of field studies on Wrangel Island in March—April, 1969 and 1970, the authors managed to immobilize and tag female polar bears in their maternity dens. As on this island female bears breed in great numbers, it is the best place to master the method.

TECHNIQUES

For immobilization we used a 'Cap-Chur' powder syringe-gun and analogous equipment made in the USSR, with the drugs Sernylan (USA) and Myorelaxin (DDR).

The technique for immobilizing female polar bears in dens was the following. On some occasions after approaching an open den by vehicle we managed to make the female bear put her head out of the entrance, by teasing her, so that it was possible to fire the syringe from the door of the vehicle or standing beside it. Rarely, we found dens with broken ceilings[1], which also makes the animal easy to shoot.

But, as a rule, the female bear keeps hidden with her cubs in the den, and it is impossible to lure her out while one stays in the vehicle. In such cases, having found an inhabited den, we determined (by the direction of the entrance, under-snow sounds etc.) the probable location of the maternity room; we then covered the exit of den with snow and dug a 'well' 20-30 cm in diameter, aiming for the point where the exit corridor branches from the chamber. The female could not get out through the 'well', provided the snow roof of the den was thicker than 30-40 cm, but she would protrude her head through it. (Fig. 1). Choosing the right moment we then fired the syringe into the masseter or neck muscles, taking care not to hit the thick skull bones or make a sliding impact, which would only result in a ricochet and wastage of the drug.

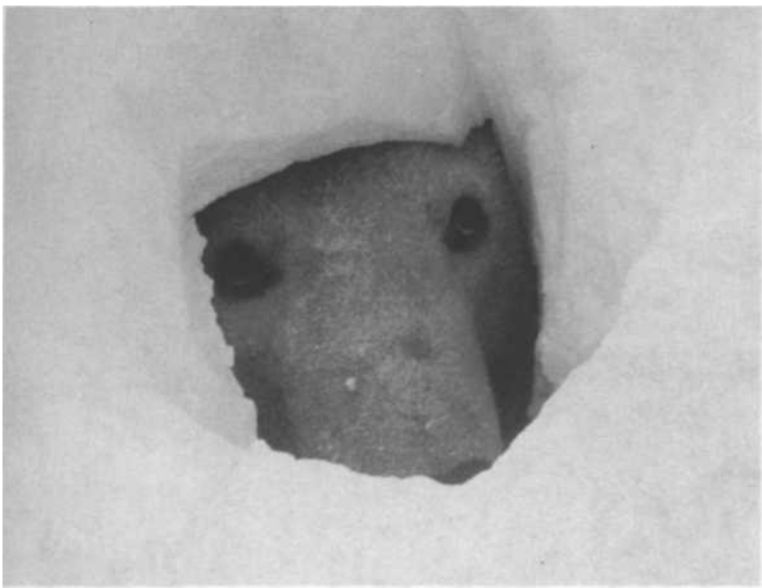

Fig. 1 Female bear looking out of the vertical hole dug down to the den chamber, just before the syringe is injected.

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[1] Details of den structure and the ecology and the behavior of bears in dens are given by the authors in the next paper.

After firing we kept watch over the female through the hole until she ceased to move and then dug out the den (Fig. 2) to carry out the tagging. The whole cycle from finding of den up to the complete immobilization usually did not take more than an hour. During this time, one person usually stood on guard with a rifle. However, in our experiments bears never got aggressive and as long as the thickness of the roof over a den is more than 30-40 cm, the execution of the immobilization procedure on foot is quite safe.

The only other method used, on a single occasion, was when a female bear and cubs left their den, were overtaken by a light track vehicle, and the mother was immobilized by a shot at a distance of 20 m.

The immobilized animals were tagged (Figs. 3 and 4) in one or both ears with stainless steel ear tags and round plastic colour tags. A cub captured in 1969 and kept in the Moscow Zoo, has not lost these tags up to now. In 1969, we also sometimes applied small (13 × 3 cm) 'flags' of red polyvinyl chloride, but it turned out that the flags did not hold well in the ear, so their use was given up. Figures 30-50 cm high corresponding to the ear tag numbers were painted with a red nitro-enamel dye on the sides or on the back of the animals. According to observations, these figures are well noticeable at a distance of 1 km and more. In 1969, one female was tagged with a round polyfluoroethylene tag 20 cm in diameter, attached to her back by 'straps' of steel wire fastened under the forelegs. Each female bear was approximately aged by teeth examination and the weight estimated by comparing body length and fatness with those of the specimens studied earlier. The total body length was also measured. The frequency of breathing and rectal temperature of some females were recorded as well.

Fig. 2 Female bear lying immobilized in a den which has been half dug out.

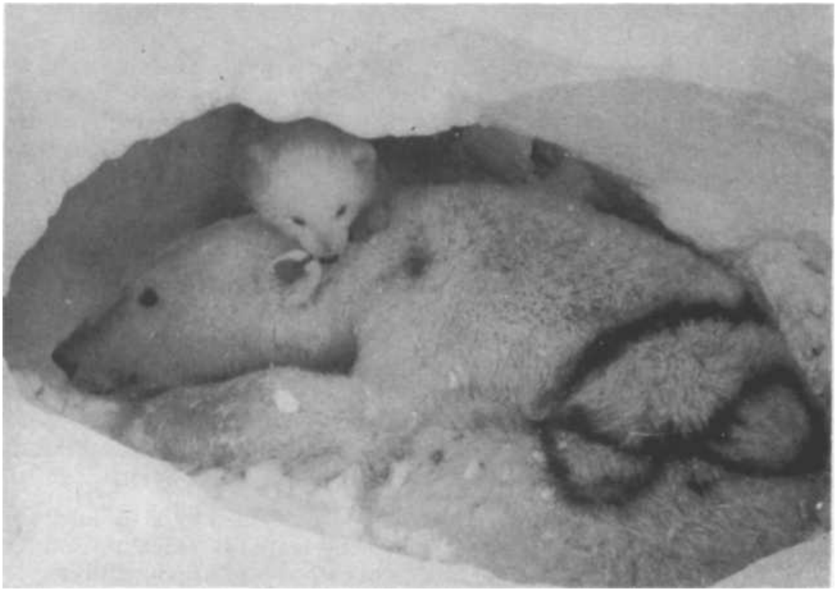

Fig. 3 Female bear marked with ear tags and dye.

Fig. 4 Close-up of the female bear's ear tag and showing also the metal only ear tag used for the 10 Kg cub.

RESULTS

Results of the experiments on immobilization by Sernylan are set out in Table 1. A standard 10% solution of the drug was used. The same or a little smaller quantity of ethyl alcohol was added to the drug to prevent freezing. All the animals were successfully immobilized; there was no mortality. Dosages of Sernylan were 250-600 mg, or 0. 8-3.0 mg per kg of body weight; in 1970, smaller dosages were used than in 1969. The period from injection to immobilization was usually 8-10 min. The completeness of immobilization varied: after dosages of 2.0-3.0 mg/kg females were utterly immobile; when smaller dosages were used, sometimes a bear could slightly move its head but could still be easily handled. One young female would not be completely immobilized, and even 66 min. after the injection moved her head and neck, and raised herself upon the forelegs. Young bears seemed to be, in general, more resistant towards Sernylan than the old ones. The animals usually recovered (Figs. 5 and 6) in 5-8 hours after being immobilized. The duration of the adynamic state in our experiments was larger than described in Canada, USA and Norway, with the same or even smaller dosages of Sernylan.

It is quite possible that such differences can be explained by still unknown pecularities in the physiology of lactating, non-feeding females as compared with migrating non-breeding animals. The breathing of the immobilized female bears was unstable; alternation of several deep inhalations and expirations, short cessation of breathing for up to 10-12 sec, and frequent superficial breaths were characteristic. The average frequency of breathing 1-2 hours after immobilization was usually 10-12 per minute; in one female it was 21-23 per minute. The minimum rectal temperature was 38. 2°-39. 2°C. There were side effects such as salivation (sometimes very intensive, followed by swallowing movements) and short (20-60 sec.) convulsions of the head and legs, repeated up to 4-5 times in the whole period of immobilization. In 1969, when dosages of 2.0-3.0 mg/kg were used, convulsions and salivation occurred in all the bears. In 1970, when dosages of 0. 8-2.0 mg/kg were administered, varying degrees of side effects were seen, and in some animals no salivation or convulsions occurred at all.

On the whole the reaction of polar bears to Sernylan in our experiments was the same as in experiments carried out in the USA, Canada and Norway.

In the course of our work, we carried out an experimental catching of cubs for the Zoos, as well as training field personnel in the techniques of immobilization. In most cases, therefore, cubs were taken from their immobilized mothers. Five of the females whose cubs had been taken away, after recovering went towards the sea at once, while another three remained in their dens or near them for about a day but were no longer to be found after two days. On two occasions the cubs were left in half-dug out dens with immobilized mothers. In one case, the family was still there on the next day, in the other, it left the den the same night.

Sernylan has proved to be an excellent drug for immobilizing female bears in dens. We believe that the best dosages are 1.2-1.8 mg/kg, so that the dose for a female of an average weight (150-200 kg) would be about 250 mg. Sernylan dissolves well in a mixture of ethyl alcohol and water. In winter the best mixture is a 2. 5 ml standard 10% solution of Sernylan plus 2. 5 ml of alcohol loaded into a 5 ml syringe. Such a solution does not freeze at —20 to —30°C. In the period when there is a mass departure from dens by bear families (March 15-April 5), one team using our method can tag 2-3 females a day when the weather is good.

Figs. 5 and 6 Female bears recovering after immobilization. The head and neck can usually be moved within 2 to 3 hours.

TABLE 1. DETAILS OF FEMALE BEARS IMMOBILIZED BY SERNYLAN

No.	Date	Age, years (appr.)	Weight, kg (appr.)	Dosage		Latent time (min.)	Duration of immobilization; comments
				mg	mg/kg		
1.	31.3.1969	8-10	200	500[a]	2.50	8-9	7 hours
2.	31.3.1969	4-5	150	300	2.00	10	After 100 min. moved head and forepaws; after 6.5 h. had left the den
3.	6.4. 1969	4-5	150	300	2.00	9	After 2 h. moved head and forepaws
	7.4. 1969			400	2.67	10	After 9 h. moved head; after 20 h. had left the den
4.	8.4. 1969	10-13	200	300 + 300	3.00	2[b]	8 hours
5.	8.4. 1969	8-10	200	300	1.50	10	more than 3 h.
6.	24.3.1970		170	300	1.76	8	more than 5 h.
7.	24.3.1970[c]		180	250+	1.39 +	8	?

8.	25.3.1970	12-15	220	250	1.14	13	more than 1 h.
9.	25.3.1970	5-6	150	250	1.67	21[d]	after 66 min. raised herself on forelegs, moved head, neck, front part of the body
10.	26.3.1970		300	250	0.83	8	?
11.	26.3.1970[c]	4-5	130	250 +	1.92 +	5	?
12.	6.4.1970	7-9	150	250 + 50	2.00	5[e]	After 2-3 hours slightly moved head and neck; after 7 h. freely moved head, neck, front part of the body; after 20 h. had left the den

Notes

[a] On the previous day this female received a small dosage (not exactly known) due to an unsuccessful shot.

[b] This female was shot not in a den but when being overtaken by a vehicle. After the first dosage she was weakened but continued to run for 20 min., after which a second dose was injected.

[c] In the course of testing new equipment, this bear received (before the dosage indicated) a very small, not exactly known previous dose which had failed to immobilize her.

[d] This bear was not completely immobilized.

[e] 30 min. after the first dosage the female was still not entirely immobilized and an additional dosage was injected.

One attempt was made to immobilize a female bear in a den using Myorelaxin (analogue of succinylcholine chloride). The experiment was a failure and the bear died of overdosage. Due to its physical properties Myorelaxin is inconvenient at low temperatures, and the conditions of work near or in a den do not allow the animal to be dealt with quickly enough. It is clear, therefore, that the drug is unsuitable for immobilizing bears in dens in winter.

The total number of bears tagged in 1969 and 1970 was 12.

ACKNOWLEDGEMENTS

The following people participated in the field work: the Manager of the Wrangel State Reserve, N. N. Vinkler, L. M. Baskin, B. G. Kramarenko, A. M. Kuropatov, B. V. Novikov, V. O. Targulian and E. A. Yavorski, Mr. Y. A. Gerassimov and Mr. V. A. Paponov not only took personal part in the studies but also prepared and improved the immobilizing equipment. The aid and advice of Dr. J. Brooks (USA) have also been of great value.

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New Data on the Winter Ecology of the Polar Bear *(Ursus maritimus* Phipps) on Wrangel Island

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SUMMARY

Winter ecology of the polar bear was studied in March-April of 1969 and 1970. About 190 maternity dens were found. The dens' distribution is different in different years and it probably depends on the ice conditions of the previous autumn. Dens may be up to 25-27 km from the sea (usually not more than 8-10 km) and are often in groups of 2-5 on a slope, 8-12 m from each other or even closer. The location and structure of dens, and behaviour of female bears and cubs during the denning period and after leaving den, are described. Bear families spend from 0. 5 to 7 days in an opened den. Killing and eating of cubs by females have been recorded. The average litter size in 1969 was 1·85 and in 1970, 1.68. Triplets have been extremely rare in recent years. The weight of cubs at the time of den breaking is from 4. 5 to 12 kg. The time of den breaking is evidently determined not only by the age of cubs, but by external conditions as well.

A mass emergence from dens took place between 20th March and 5th April one year and at much the same dates in other years. Non-breeding bears are common in waters around Wrangel Island, mainly near Blossom Cape, especially at the time of seasonal movements. Counts of female bears breeding on the Island were carried out; census methods are discussed in detail. The best method is the counting of opened dens from aircraft at the beginning of April, in good weather. The number of female bears breeding on the Wrangel Island in the winter of 1969/70, was estimated to be 180-200.

INTRODUCTION

Biology of the polar bear in winter, when parturition takes place, has been poorly studied up to recently. Only of late have these researches made progress, and papers have appeared dealing with winter ecology of the species in different arctic regions (Uspenski & Chernyavski 1965; Parovshchikov 1967; Harington 1968). Many aspects of the problem are still far from clear.

In the course of field studies on Wrangel Island in March-April, 1969 (by both authors) and March-April, 1970 (by A. A. Kistchinski),new data were collected. We have carried out traverses (by dog team, tractor, light track vehicle and on foot) of a total length of more than 1300 km, in order to find and study polar bear maternity dens. For finding and counting dens, we also used a single-engined AN-2 plane. In the Drem-Head mountains where the number of dens was especially high, fixed stations were established for observation purposes.

BREEDING ECOLOGY

General information

Pregnant female bears come to the land in September-October and make dens in snowdrifts in hilly or mountainous terrain. In these dens they spend winter and, from the end of November to January[1], give birth to cubs. When cubs are 3-4 months old the female digs out an exit from the den, but continues for several days to live with the cubs in the den, although taking them for walks of up to 1-2 km away. At this time, cubs probably acclimatize to the low and unstable outdoor temperatures. Then the family leaves land and goes to the sea ice. By the location and structure of dens one can judge of the way in which females and cubs live through winter.

Location of dens

Some data on polar bear dens on Wrangel Island are presented by A. I. Mineev (1935), S. M. Uspenski & F. B. Chernyavski (1965) and, for dens in other arctic regions, by A. Manniche (1910), P. Freuchen (1935), A. Pedersen (1957), F. Van de Velde (1957), V. J. Parovshchikov (1964), O. Lønø (1970), C. Harington (1968) and others. The paper by C. Harington (1968), in particular, deals with denning habits of bears and is of great interest. Our study of more than 100 dens in 1969-1970 has added considerable data to that which already existed.

As a rule, females den in mountainous terrain no more than 8 km from the sea shore, although dens are sometimes found at a distance of 25-27 km from the coast.[2]

The distribution of dens in different years varies. For instance, on Wrangel Island many females commonly den in the eastern and northern parts of the East Plateau and on the Hawaii Hills, but there were very few in the winter of 1968/69 (Table 1). A possible explanation is that in the autumn of 1968, on the east coast of the island, water remained free very long (up to December) and there was no ice; bears therefore approached the island mainly from the west. The same irregularity in the distribution of females depending on the ice conditions of the previous autumn was noted by Harington (1968) in the Canadian Arctic and by Lønø (1970) in Svalbard.

In the north-western part of the island, in the small mountain massif of Drem-Head (8 x 3 km: Fig. 1), which was carefully examined, not less than 60 female bears gave birth in 1968/69, and in 1969/70 not less than 45. On the majority of slopes there were hardly any dens, but in the places where dens were situated their density was often very high. Dens were made close to each other, sometimes as close as 8-12 m (Fig. 2). In one case, six dens were found within 300 sq.m, and three of them—at a distance of 135 and 200 cm from one another. Such 'density of denning' is probably unique in the Arctic[3]. There even was a case when two family rooms were situated next to each other being connected

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[1] Data on the time of birth are scarce; they have been mainly obtained either in Zoos or calculated according to the weight of cubs caught in March-May (Kostyan 1954; Harington 1968; Jacobi 1968; Khutoryanski & Nemov 1969; Lønø 1970)

[2] Similar data were obtained in the Canadian Arctic (Harington 1968)

[3] C. Harington (1968) writes of several cases when dens on the Southampton Island were situated at a distance of 15—30 m from each other. This was considered to be very unusual.

TABLE 1. DISTRIBUTION OF POLAR BEAR DENS IN DIFFERENT PARTS OF WRANGEL ISLAND

Area	The number of dens[1]		
	1964 (according to Uspenski & Chernyavski, 1965)	1969 (our data)	1970
Drem-Head Mts.	21	57	42
Bezymyannye Mts.	28	4	4
West Plateau	4	2	—
Yevstifeyev Mts.	2	—	—
Tundrovaya Mt.	7	2	6
Kitovaya Mt.	7	1	10
East Plateau (north part)	32	—	25
East Plateau (east part)		6	23
Area of Rodgers Bay and Hawaii Hills	15	3	8
Total	116	75	118

[1] As various regions were investigated in different years with variable accuracy, these data do not show the precise distribution of dens, but they do give an idea of relative abundance. In 1969-1970, the Drem-Head Mountains were best investigated while the Bezymyannye Mts. were least studied.

by a passage 50 cm long (see Fig. 4/3). At the time of making dens females are probably quite indifferent to each other.

Dens were built from 0 to 300 m above sea level, in snowbanks with, usually, a 20-40° slope and near the upper part of the slope (Fig. 3), but sometimes at its very foot (Tables 2 and 3). Once a den was found very near the sea, on the gentle (10°) slope of Cape Florence, and once on an equally slightly sloping alluvial fan. Rarely, dens can be found in snowdrifts on steep banks of small rivers within a relatively flat tundra.

In different years dens are made on slopes of different exposure. For instance, in 1964, the majority of dens occurred on the north-east and east slopes, where snow depth was the greatest (Uspenski & Chernyavski 1965). In 1968/69 the thickest snowbanks were still on the eastern and north-eastern slopes, but there were hardly any dens and the majority of females, especially in the Drem-Head mountains, denned on the south-east and south-facing slopes. But in 1969/70—they again denned on the east and north-east ones (Table 4). Denning sites in the Drem-Head mountains in 1968/69 and 1969/70 did not coincide. It is interesting that in the spring of 1969, on the south and south-east slopes, snow cover was not deep; as a rule, the depth of snowbanks did not exceed 2 m.

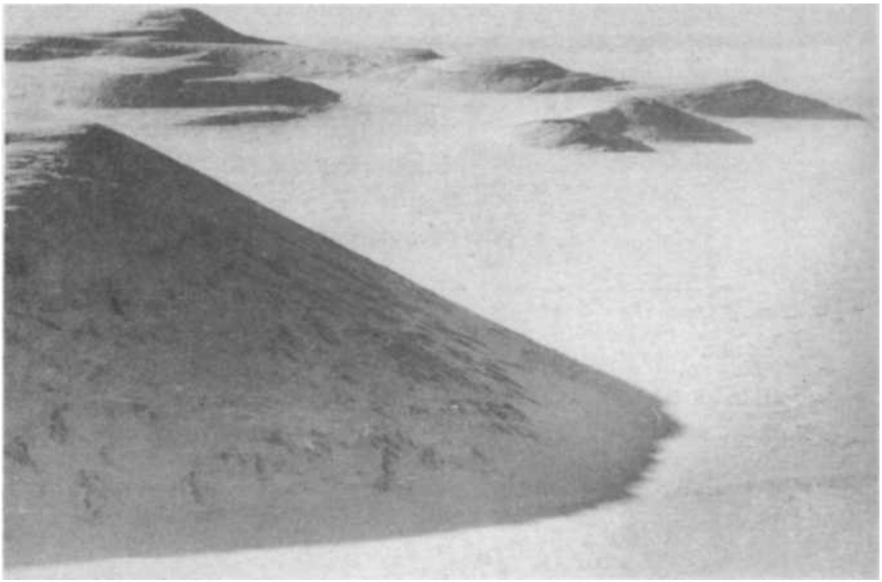

Fig. 1 The Drem-Head mountains, an area of mass denning of breeding female polar bears.

Yet we sometimes found 2-5 dens together on slopes which in March-April could hardly be considered as convenient for dens, because snow depth was so shallow. One den was found in quite a thin pocket of snow (see Fig.4/4). There were no dens on such thin snow-slopes in 1970. On the other hand, in several sites where in 1969 there were dens in deep snowbanks, we found denning female bears in 1970 as well. Finally, on some slopes where in the spring of 1969 dens were absent but the snowbanks were very thick, we found maternity dens in the following winter.

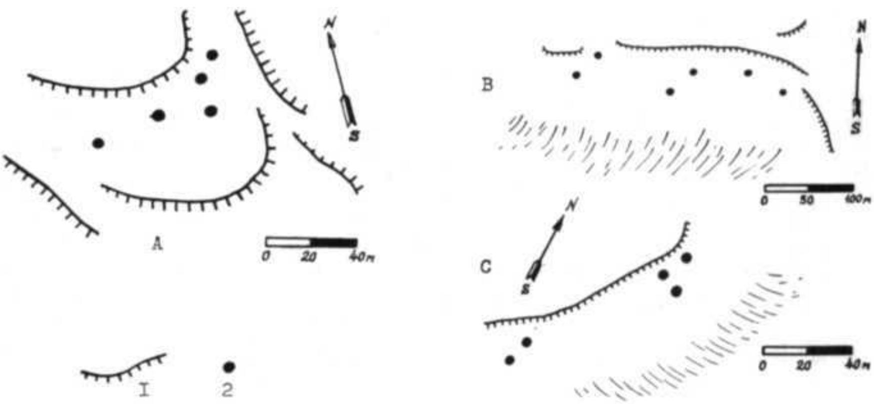

Fig. 2 Positioning of dens in three areas of the mountains. I indicates the upper edges of slopes and 2 the den site.

Fig. 3 The exit of an inhabited den on the Drem-Head mountains. The female's tracks can be seen above and below.

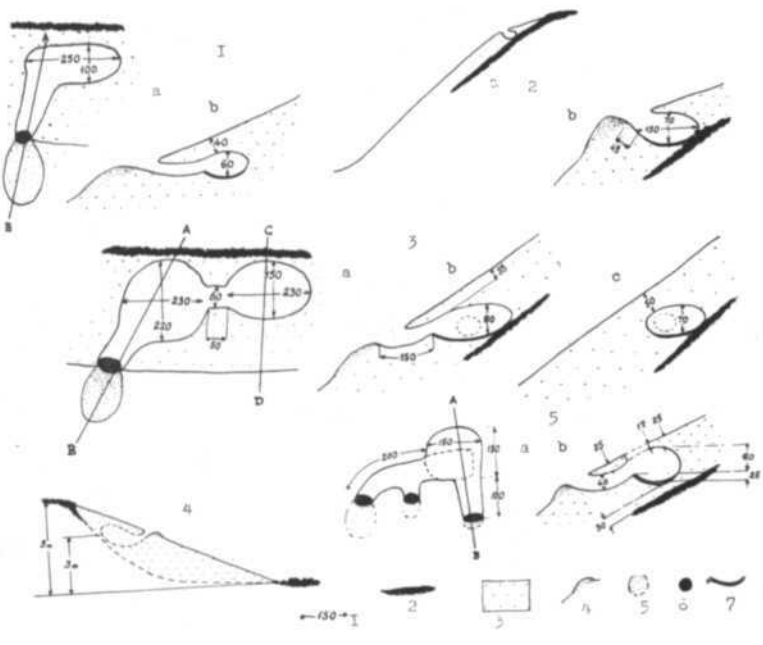

Fig. 4 Structure of 5 dens:

1. (a) plan; (b) vertical section on line AB.
2. (a) section of the snow drift, (b) vertical section of den.
3. (a) plan; (b) vertical section on line AB;and (c) on line CD.
4. Approximate section of snow drift containing a den.
5. (a) plan; (b) vertical section on line AB.

Symbols: 1: measurements in cm; 2: substrate; 3: snow; 4: excavated snow 'doorstep'; 5: excavated snow (plan): 6: exit; 7: ice floor of chamber.

TABLE 2. DISTRIBUTION OF DENS ACCORDING TO HEIGHT OF SLOPES

Height of slope, m	Number of dens 1969	1970	Total
0-15	4	1	5
16-30	19	5	24
31-60	15	11	26
61-150	12	14	26
151-350	4	4	8

TABLE 3. DISTRIBUTION OF DENS ACCORDING TO DISTANCE FROM FOOT OF SLOPE

Distance of den from the foot, m	Number of dens 1969	1970	Total
0-10	14	8	22
11-20	13	7	20
21-50	22	18	40
51-100	4	3	7
101-300	1	2	3

TABLE 4. DISTRIBUTION OF DENS ACCORDING TO EXPOSURE OF SLOPES

Exposure of slope	Number of dens					
	1964, total (Uspenski & Chernyavski, 1965)	1969		1970		
		total	Drem-Head Mts.	total	Drem-Head Mts.	Total
Northern	14	2	1	7	3	21
North-eastern	36	2	1	19	12	57
Eastern	26	14	12	12	11	52
South-eastern	14	15	15	13	8	42
Southern	8	22	19	2	0	32
South-western	7	2	0	2	1	11
Western	1	3	1	3	3	7
North-western	10	5	3	3	0	18

All the data considered show that the principles according to which pregnant females choose suitable places for denning are not quite clear. There are hardly any direct observations on the actual den making. Judging from spring examination of dens and the tales of aborigines, some students (Mineev 1935; Uspenski & Chernyavski 1965, etc.) have supposed that sows either settle down in autumn in unthawed snowdrifts of the previous year or excavate dens in such snowdrifts, or they excavate dens in new drifts already accumulated in the current autumn. Further snowstorms cover the female bear with snow and make a snowy roof over the den. According to Harington (1968), the den excavated by a female in a newly formed snowdrift is approximately of the same form as it is found to have in the spring.

Another point worth mentioning is that the floor of the den is separated from the ground by a layer of snow usually 10-30 cm thick. However, while in some of the dens small patches of bedrock were observed on the innermost wall (see Fig. 5/2 and 3), in others, the inner wall was separated from the substrate by a very thick bed of packed snow. In the former case it seems that the bear had denned in fresh snow, which later on thawed beneath its body, and that in the latter case it had denned in snow of the previous year.

Harington (1968) wrote that in Canada dens occur more frequently on slopes facing away from the sea. This is also generally true in the Drem-Head mountains, but in some other areas (south-eastern coast of Wrangel Island, northern slopes of the East Plateau, etc.), due to the peculiarities of relief, the majority of dens face the sea. The situation in each area is conditioned by the local relief and also the predominant winds.

Structure of dens

The typical structure of polar bear dens on Wrangel Island has been described by S. M. Uspenski & F. B. Chernyavski (1965). In 1969 and 1970, we surveyed many dens including ones of very simple as well as very complicated structure (Figs. 4, 5 and 6). Usually an active den has a simple oval chamber with a passageway 1-2 m long and outside the exit a deposit of excavated snow up to 70-100 cm high, forming a 'doorstep' which helps one in sighting the den from a distance. However, in the spring of 1969 and 1970, on many slopes where dens were situated, there was little snow; therefore, these doorsteps were small and difficult to distinguish. For the same reason, the roof of some of the dens was very thin (5-15 cm) and the female tended to break it when emerging. In 1970, we often found 'half-open' or completely 'open' dens; they were simply pits in the snow with bear families lying in them (Fig. 5/3 and 4). In such cases, the 'roof was broken since, even before the den was opened, it was no more than a few centimetres thick. On some slopes winds blew away the snow and uncovered the procumbent female (Fig. 5/3). By contrast, some dens were located in very deep snowbanks. We also found complex dens consisting of several chambers like those described by G. P. Gorbunov (1929), G. Mary-Rousseliere (1957), V. J. Parovshchikov (1964) and others. The structure of the den shown in Fig. 6, as well as that of other complex dens, indicates that the digging activity of the female (i.e. her total activity) does not stop in winter. In this case (the den had 5 chambers), we may presume that while widening the first 'living-room' the female met a rock wall: the presence of this rock aggravated heat conditions in the den and she began to dig other tunnels and chambers but, again encountering the rock wall, abandoned each in turn until she reached and managed to dig a big chamber in continuous thick snow. The fact that the walls and ceilings of dens often have claw marks confirms digging activity in the dens. Dimensions of dens are shown in Table 5.

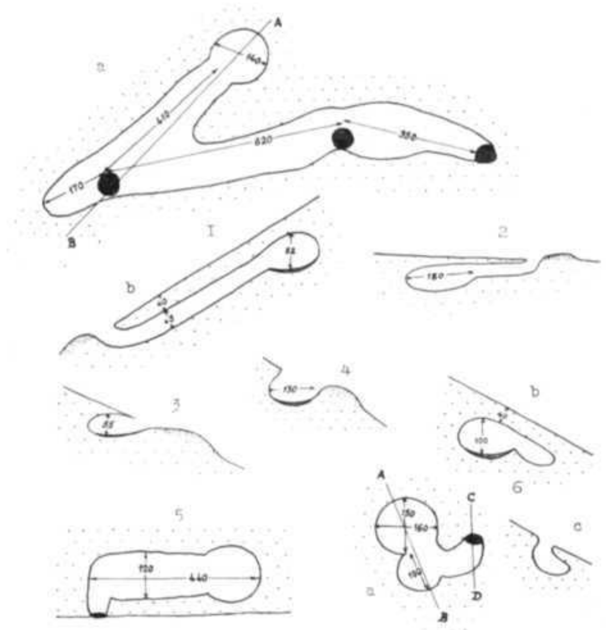

Fig. 5 Structure of 6 dens:

1. (a) plan; (b) vertical section on line AB.
2, 3 and 4. Vertical sections.
5. Plan.
6. (a) plan; (b) section on line AB;and (c) section on line CD.

Symbols: as in Fig. 4.

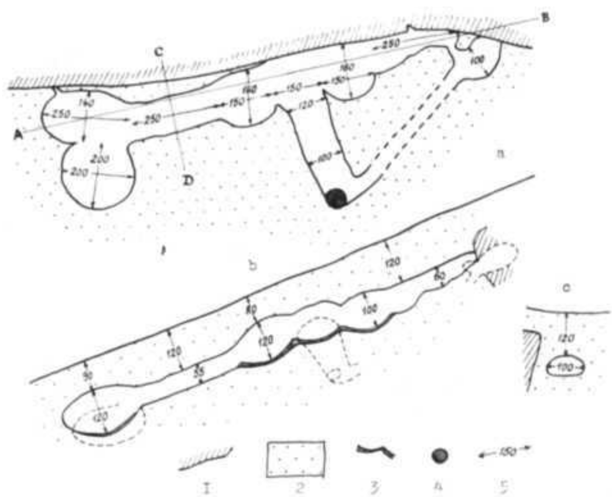

Fig. 6 The most complex den structure examined (9 April 1969): (a) plan; (b) vertical section on line AB;and (c) on line CD.

Symbols: 1: rock wall; 2: snow; 3: ice floor of 'living-room'; 4: exit; 5: measurements in cm.

TABLE 5. MEASUREMENTS IN CM OF MATERNITY CHAMBER OF DENS

Dimension	min	mean	max
Length of the room	110	165	250
Width of the room	100	140	220
Height of the room	55	80	120
Minimum thickness of the roof*	5	32	100†

* Dens of 'open' type were not taken into account

† Some dens, not measured, undoubtedly had even thicker roofs: they were too difficult to dig up.

Sometimes dens have ventilation holes which may help to disclose dens that have not yet been opened.

As already stated, the floor of the den is separated from the ground by a layer of snow.

The passageway leading from the den outside is from 1 to 6 m long (usually 1-2 m): the height is 50-60 cm, the width 70-110 cm. The exit is round or rectangular, 50-60 cm in diameter. Sometimes the floor of the tunnel near the chamber is icy and even its roof may have a crust of ice; the ceiling and walls, including those of the den itself, tend to have claw marks and fragments of hoar-frosted bear hair hanging from them (Fig. 7).

This indicates that in these cases part of the tunnel has been dug in autumn and, being closed by a snow 'plug', the signs of excavation last through the winter. In spring, the female lengthens the tunnel, digging up towards the snow surface. Sometimes (Figs. 4/5 and 5/1) a den has 2 or 3 exits. Faeces of cubs can be found in the tunnels.

In spite of the differences in the length of the tunnels, the number of chambers, etc., there are certain common features in the structure of all dens. In almost all cases the passageway slants downwards. This feature is shared with the Eskimo 'igloo' and no doubt similarly serves for conserving warm air.[1]

Occasionally, however, the tunnel slants upward or, when the chamber is close to the snow surface, may not follow the shortest line (perpendicular to the slope) but travel parallel to the surface to left or right for distances up to 6 m; the thickness of the snow roof over the tunnel is kept more or less constant and approximately equals that of the den's roof. We believe that when digging such a long corridor (which also helps to conserve warmth in the den) the female is guided by the intensity of light penetrating through the snow 'ceiling'.

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[1] The temperature recorded in one opened den (—17. 8°C) was higher than the outdoor temperature by 7.8°C; Harington (1968) recorded a temperature of –9.9°C in a closed den, higher than the outside temperature by 21°C.

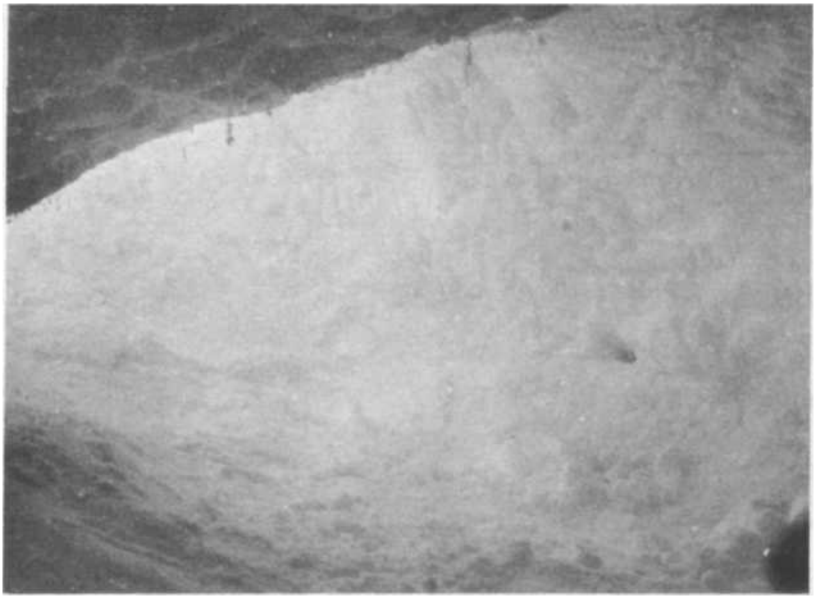

Fig. 7 Interior of den, showing claw marks in the walls and ceiling and some bear hair covered with hoar frost hanging from the roof.

The tunnel is separated from the living-room by a sill, the floor of the chamber being cup-shaped. Sills and floors of dens consist of strongly iced snow. No female bear excreta are found in the chamber but sometimes small amounts of cub faeces. There are often traces of urine in the snow. We have never found any additional spaces set aside as lavatories. Evidently the female licks up most of the cub droppings; in the intestines of one or two female bears that have been dissected we have found hair of cubs and a liquid gruel-like mass with a characteristic smell. Droppings of adult females can be found only outdoors, usually 10-50 m from the dens. There are many tracks around the dens and often excavations resembling den exits can be observed. In some of these females probably spend the night after leaving dens; their floors are often strongly iced.

Behaviour of female bears and cubs

We never met any bears in dens except females with cubs. We could see into one den with a broken roof quite well and kept it under observation from 26 to :29 March 1969. The female was lying on her side so that her hind- and forelegs were touching (Fig. 8). The cubs were always near her head and belly, inside the circle made by her paws. They crawled over their mother, under her paws, and very often reached for the nipples. In windy cold weather the female turned her back towards the hole in the den so as to protect the cubs against the wind. The den was deserted on 29 March, but contained one dead cub, badly damaged, and there was evidence that the female and the second cub had left shortly before we came. In 1970, in one of the dens we also found the half-eaten remains of a cub frozen into the icy floor to a depth of 2-5 cm. The cub had probably been killed long before the den was opened. Similar cases are also known to occur in zoos.

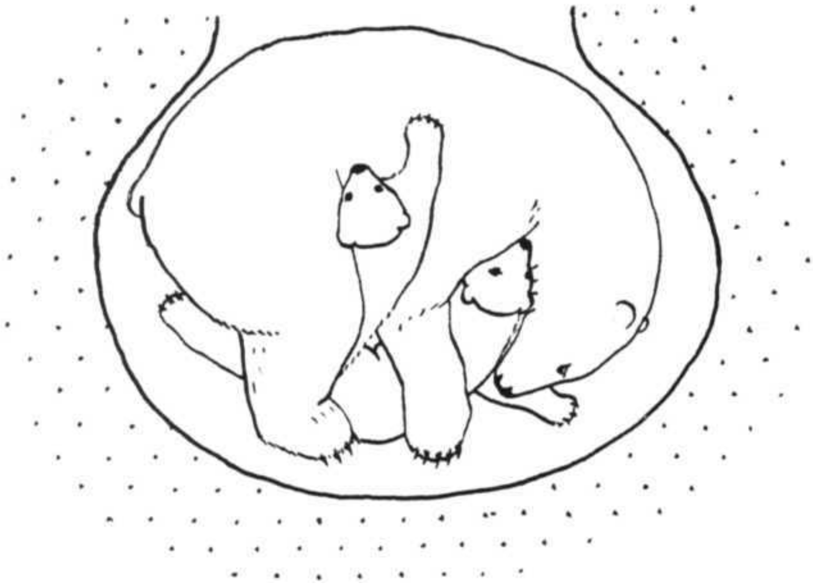

Fig. 8 Drawing of a female and two cubs in a den on the Drem-Head mountains, 27 March 1969.

After opening the den, the family continues to use it for several days. In 1969, the weather at the end of March was cold (near —30°C) and windy. Bear families remained in the opened dens for 3-7 days. In 1970, this period was warmer, and in days without strong winds and frosts females met after breaking out of dens left the latter quite quickly, sometimes in 0. 5-1 day. For example, on the 5th of April, the first fine day after a five-day snowstorm, we found a den which had been opened that very morning and was already abandoned. The amount of time for which a family stays in an opened den thus ranges from 0. 5 to 7 days. O. Lønø (1970) states that in Svalbard the period is longer, 8-14 days.

When the den has been opened the female hardly ever leaves her cubs. If a man approaches the den she sometimes puts out her head and snorts, after which she hides herself again. More often, especially in deep dens, she does not show herself at all. She retreats as far as possible into the den and keeps silent, and it is rather difficult to make her even show her head.

In the morning, the female bear takes her cubs for a walk up to 1-2 km from the den and during the walk she keeps close to them. Only once, on a warm day, we found two cubs of about 8-9 kg in a den; having examined the tracks, we saw that their mother had gone to the sea ice. After being away for several hours, she returned and took the cubs. However, on first opening a den, the female goes out alone, usually not more than 50-100 m from the den.

At the beginning of the lactation (in the den), the milk is secreted in small amounts and the cubs probably suck very often. We did not manage to extract more than 5-10 drops from an immobilized lactating female. Captive cubs required to be fed very often throughout the day and night. At 3-4 months old cubs in captivity must drink up to 6 times a day (Kostyan 1954). The duration of sucking at the age of 2. 5 months is 15 min. (Meyer-Holzapfel 1957).

We were lucky to observe three times how cubs sucked outside the den, standing on their hind legs under the mother's belly. Once both cubs sucked simultaneously, one from the front nipple and the other from the back one.

Three females killed in 1969 when leaving dens, weighed 150-180 kg. They had little fat; even on the sacrum and the buttocks its thickness did not exceed 35-50 mm. In 1964 (Uspenski & Chernyavski 1965) females which left dens were fatter.

Number and weight of cubs

The data on litter size are given in Table 6. Small but reliable differences in the number of young were observed in different years.

TABLE 6. NUMBER OF CUBS PER LITTER

Year	Litter size 1	2	3	Mean litter size	Number of litters
1964 (Uspenski & Chernyavski, 1965)	7	7	0	1.50	14
1969	3	17	0	1.85	20
1970	11	19	1	1.68	31
Total	21	43	1	1.69	65

Based on his observations in the 1920s to 1930s, A. I. Mineyev (1935) wrote: 'the female bear gives birth to three cubs as often as to one'. More recently records of three cubs have been very rare. V. A. Starchenko, who has taken part in the capture of cubs over the last 13 years, told us that he met families with 3 cubs only four times.

The majority of female bears, which had one cub each in 1970 (8 out of 11), left dens later than the rest, after 5 April. The same phenomenon was observed in 1964 (Uspenski & Chernyavski 1965) but not in 1969.

The weight of a female cub taken from a still closed den on 31 March 1969, was 5. 0 kg. The weight of cubs from opened dens is shown in Table 7. Sex differences in weight at this age were not established. The male-female ratio was 14:8.

Observations show that the weight of cubs at the time of leaving dens differs considerably (Table 7). As we can hardly suppose such marked differences in the rate of growth, we believe that the dates of den-opening do not strictly correlate with the age of cubs. It is interesting that the smallest cubs were found in dens of an 'open' type or in those with a very thin roof. Probably the opening of the den is also stimulated by the conditions outdoors; thus, the blowing away of snow from the roof and thinning of it (at the end of the passageway) may make the female leave the den earlier.

TABLE 7. WEIGHTS IN KILOGRAMS OF CUBS IN OPENED DENS

Date	WW	00?	XX
March 24	12		
March 24	11		11
March 24*		4-5	
March 25	8; 8		8
March 25	4½		
March 26*		8; 8	
March 26		12; 12	
March 26		8-9	
March 30	9; 9		
April 2	8		
April 6*			10
April 7	9		9
April 8	9½		11
April 8	10; 10		
April 9	8¼		8¼
April 10	8		8

* weight estimated by sight

Departure from dens

The first female was encountered out of the den on 11 March in 1969, and on 7 March in 1970. A mass opening of dens took place in 1969, between 20 March and 5 April, followed by departure from dens by bear families between 25 March and 8 April. In 1970, bears left their dens a little earlier. A mass departure occurred on 20-25 March and from 23-26 March we often saw polar bear families moving across the tundra and onto the sea ice. We met with such families in 1970 up till 10 April and in 1969 we found dens recently deserted on 15 April. Following the tracks of departing families, we observed, in places with thin snow, shoots of dwarf willows which had been dug up and gnawed by females.

The directions which bear families take when going to the sea ice vary. Usually they chose the shortest way or moved from the mountains into the nearest valley and along the latter directly to the sea. However, this was not always the case. On the 19-21 March 1969, we observed near Mt. Tundrovaya fresh family tracks moving straight from west to east over a great distance. There was no doubt that their dens were situated westwards of the area. Instead of heading for the sea by the shortest way they were going in the opposite direction with at least 70 km to cover to the sea. It well may be that the bears somehow oriented themselves by the presence of free water: at that very time there were large pools of free water off the east side of the Wrangel Island.

In the upper reaches of the Neozhidannaya river, separated from the sea by a steep and rocky ridge 5-10 km wide, V. A. Paponov saw a family which had just left the den, and kept watch on its movements for 20 km. The animals were moving in the direction opposite to the sea, down the river, which meant that they would have to travel not less than 40 km before reaching sea. It is possible that the female was leading her cubs the same way by which she had come in autumn.

Some families after leaving dens wandered in the mountains for one or two days. Once a family, frightened out of a small den-like shelter, ran away and hid themselves in a real maternity den. Probably this family had left the den shortly before and had spent only one night in the shelter.

NON-BREEDING PART OF THE POPULATION

Polar bears are common in waters around Wrangel Island. Very often they visit Cape Blossom where thousands of walruses are landing in autumn. There are great numbers of dead walruses and remains of others that have been killed, which provide abundant food for bears. When moving between the East Siberian Sea and the De-Long Strait in autumn and spring, bears pass the Blossom Cape and stay there for some time. According to inquiries, a great number of bears were there in the springs of 1954, 1955, 1956, 1964 and 1967, and in autumns of 1966 and 1968. In the autumn of 1968, 15-20 animals were observed simultaneously. As a rule, single bears moves across Cape Blossom; females with cubs are uncommon there.

On 12-13 April 1969, in 16 hours, S. M. Uspenski saw near the Cape 6 single bears moving along the coast to the north (including a male following a female). At the same place, from 20 April to 6 May, V. A. Paponov observed four bears, one of which stayed for two days. The animals fed on the walrus corpses and rested the greater part of the day among ice hummocks.

During the air survey (15 April 1969) we saw many bear tracks between Wrangel and Gerald Islands and around the latter. There were many leads and cracks; on the ice we saw seals. Some of the tracks were those of couples; it was the rutting time.

From time to time tracks of single bears were observed even in the central parts of the Wrangel Island. These tracks were usually going in one direction, following a straight line for many kilometers. Probably animals having found themselves on land where there is no food, cross it without stopping. Excreta of these passage animals contained much seal hair.

ESTIMATES OF POLAR BEAR NUMBERS

More or less accurate estimation of polar bear numbers is extremely difficult, primarily because of the bear's migratory habits. The only part of a population which is static for a certain amount of time consists of breeding females spending winter in their maternity dens. However, their ratio to the population can be found by observation, so that the enumeration of breeding females by more or less accurate spring counts of opened dens may be used for evaluation of total bear numbers.

Such a count was carried out on the ground by terrestrial techniques in 1964 on Wrangel Island by Uspenski & Chernyavski (1965). They discovered 116 dens and estimated the total number of females breeding on the island to be about

150. In 1969, we repeated the count by similar techniques but on a smaller scale, with special attention to the Drem-Head mountains. In 1970, we again surveyed the Drem-Head mountains in detail, visited some adjacent areas, and then made an aerial den survey.

This work has helped to clarify some aspects of the techniques of searching for and counting dens. In the spring of 1969 and 1970, we often found dens on slopes relatively poor in snow. The snow 'doorsteps' near the exits which usually help to locate dens, were small; in the majority of cases, dens were difficult to detect from afar. From a distance of 200-500 m we could usually spot only 30-40% of dens, while the majority of them (especially those already deserted) could be found only at a distance of 20-50 m, after careful examination on foot. Special surveys have shown that of dens deserted before a severe (up to 5 days) snowstorm, 75% could not be found after the snowstorm. In short, reduced visibility of the deposits or mats of snow at den exits together with snowstorms, tend essentially to cause underestimates of den numbers.

A second problem was that female bears often made dens next to each other, 2-5 dens on a small slope. Therefore, to ascertain their real number the census-maker had to approach closely. Sometimes, having located an open den from afar, we examined the site carefully and then discovered other dens, one or two, occupied or deserted. More often, we could mistake temporary bear diggings, heaps of stones covered with snow or ice, some forms of 'snow relief, etc., for dens. Sometimes even a very experienced man can only distinguish dens from the other formations mentioned (especially in a diffuse light) at a distance of 10-20 m.

We conclude, therefore, that, when carrying out land counts of polar bear dens by going around foothills with a dog team, tractor or light track vehicle, one can make serious errors both underestimating or overestimating data. In such springs as those of 1969 and 1970, the errors may be so great that the count cannot be considered reliable. There is no time to define correction factors, as the opening of dens lasts for not more than one month, and extrapolations from this count are impossible. In short, such land surveys may give only a general picture of distribution and relative abundance of dens in a given year; full counts are possible only by careful and repeated examination on foot. Such examination is naturally very laborious and time-consuming and it cannot be undertaken everywhere, so it must be carried out in sample areas where there is maximum density of dens.

Altogether, in 1969, 77 dens were found on Wrangel Island, but for the reasons mentioned above we do not believe that this figure can be used as a firm basis for judging the change of numbers of breeding females since 1964. During an air survey of Gerald Island we did not discover any dens; the island is hardly suitable for them.

An aircraft allows good opportunities for counting polar bear dens. On the 10 April 1970, we made an aerial census of dens on the whole eastern part of Wrangel Island. We chose the route in such a way that we could inspect nearly all the places where dens were numerous. We surveyed the area from an AN-2 plane at a height of 100 m and at a speed of 150 km per hour. The weather was sunny, with excellent visibility. All dens were time-registered and afterwards approximately plotted onto a map; when possible, dens were mapped during the flight. Fresh tracks of families going from the mountains to the sea, at right angles to the route, were also registered as 'dens' if they occurred not less than 1-2 km from dens observed earlier. Altogether we registered from the air 57 dens and 8 such tracks.

In good weather, opened dens with snow doorsteps and tracks of females and cubs, can be easily seen from a height of 100-150 m at a distance of 0. 5-1 km. The count is especially efficient if in the previous 10-12 days there have been no strong winds. Sometimes even dens which are deserted and covered with snow can be observed and correctly identified. However, the majority of the dens which have been deserted long before are impossible to discover after heavy storms, so that anyhow some underestimation is inevitable. On the other hand, to mistake a den for something else from the air is impossible.

Summing up the results of the complete count in the Drem-Head mountains, observations in the adjacent areas, aerial and other data (Table 1) and making approximate allowances for the incompleteness of the counts and the areas which could not be examined, we estimate the true number of female bears breeding on Wrangel Island in 1969/70 to be between 180 and 200.

Aerial survey makes it possible to get reliable data quickly and with minimum error. Its technique has to be developed, but we believe it to be the best method for den counting.

ACKNOWLEDGEMENTS

The following persons took part in the field work: the Manager of the Wrangel State Reserve, N. N. Vinkler; L. M. Baskin, Y. A. Gerassimov, B. G. Kramarenko, A. M. Kuropatov, B. V. Novikov, V. A. Paponov, V. O. Targulian & Y. A. Yavorski.

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PANEL 3: POLAR BEAR STUDIES

SUMMARY OF DISCUSSION

F. Craighead. I'd like to just make a few comments and then ask Dr. Jonkel a question. The summer dens that he mentioned, we have termed day beds and we have located quite a few of these in Yellowstone for the grizzly bear. There have been 2 types, one the shallow excavation, usually excavated down to mineral soil, and then an occasional burrow type den going back 3 or 4 feet. In addition to this, we have found that none of these are lined, but occasionally we find one in the fall of the year, just prior to entering the den for the winter, where the grizzly bear will line it with 5 or 6 inches of boughs or, in some cases, grasses and sedges. I was wondering whether you found any of these summer dens that had been lined in this manner?

C. Jonkel. Yes. One of my slides (Fig. 12 in the paper) showed where a bear had used lichens and mosses which she had raked from a great area. Whether she actually used this for a winter den, I don't know. It was about a 2 year-old den when we found it. I did find a den, though, on North Twin Island that I was certain was a winter den or had been used also as a winter den and again she'd raked mosses, not from such a large area, and also some willow and birch branches into the area—or into the den.

F. Craighead. Mr. Brooks, I'm not aware of the type of equipment that you're using but I thought I'd mention that the National Aeronautics and Space Administration in their Earth Resources Satellite Programme are using multi-sensing and multi-scanning devices, including infra-red, which they have indicated to me could quite conceivably be used to census big game animals under winter conditions. It may be that they're utilizing some equipment with greater refinements, I don't know, but it might be worth contacting them if you're not familiar with their equipment.

J. Brooks. There is some very refined equipment that is classified. It is possible to employ a variety of detectors which will allow you to essentially screen-out, according to emission frequency, and focus in on certain things. Then if you could tune out the trees and the rocks and focus in on the distinctive and characteristic radiations from a deer or a bear or moose, it might open a whole new field of opportunities for us but this equipment is not yet available. There are many applications for infra-red sensing. It's especially good for something like satellite scanning of ocean areas, it will certainly show you the edge of the Gulf Stream very precisely, or thermal pollution in a river. You can get beautiful pictures of this but these are rather gross targets and when you consider the size of a white-tailed deer from an over-flying aircraft or satellite, it becomes quite microscopic and the definition is usually not good enough to reveal it unless you have everything else going for you like we have on the polar bear. Here we have a trail that allows us to identify a very small target and distinguish it from the background.

Reproductive Synchrony in the Female Black Bear

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INTRODUCTION

One of the serious drawbacks in black bear (*Ursus americanus*) research and management studies in the past has been the lack of an accurate way to determine the age of wild black bears. The development of the tooth section technique for annuli counts to determine ages of various mammals has provided biologists with a most useful and effective tool. Its application to the wildlife field has been widespread and rapid. In areas where large samples of a wildlife population can be obtained each year, accurate aging provides a reliable means of keeping tabs on the annual dynamics of these populations.

The black bear of New York State have been protected since 1904 and, during that time, have been harvested primarily by hunters incidental to seeking white-tailed deer. Samples of the hunter-bear take have been examined since 1953 at volunteer big game check stations. The information recorded on bears at these stations has been used mainly to aid in determining the total number of bears harvested annually. This has been the principal statistic collected annually on our wild bear population. However, the verification of a means of age determination for bears in New York by examining sections of canine teeth made the collecting of bear teeth an important new aspect of our bear research and management program..

PROCEDURES

Efforts were made to obtain lower canine teeth from bears harvested during the legal hunting seasons from 1964 through 1968. All licensed taxidermists in New York State were contacted in an effort to gain the cooperation of those handling bears. Each was furnished an illustrated instruction sheet with information on how to cut the anterior portion of the lower jaw to include both canines. Emphasis was placed on making the cut close to the first molar so that the lower canine root would not be disturbed. They were also furnished plastic bags, ties, labels, a postcard for requesting additional materials and a reprint describing the age determination technique (Free & Sauer 1965). Cardboard shipping boxes for sending the excised lower jaw via express collect were furnished in 1964 and 1965. Special expansion envelopes of sturdy paper were used in 1966, 1967 and 1968 for sending the excised lower jaw directly through regular mail service. Taxidermists handling the largest numbers of bears were contacted individually prior to the hunting season and several times during the hunting season. Successful bear hunters were contacted at big game check stations on major highways and at hunting camps and homes and asked to cooperate in this study. Whenever possible the anterior portion of the bear's lower jaw containing the canine teeth was removed. When this could not be done, the hunter was given a set of instructional materials and shipping containers similar to those provided the taxidermists.

Canine teeth were loosened from the lower jaws by boiling and pulled for an initial examination. Canine teeth from cub and yearling bears were separated from older bear teeth by gross examination (Sauer *et al* 1966). Three experienced observers examined each tooth independently for yearling determinations. Whenever any differences of opinion occurred between the observers as to whether the tooth was from a yearling bear or not, the tooth was sectioned and processed along with the older teeth.

When sex was not determined by examination of the carcass by qualified personnel, sex was determined by tooth measurement using the gauge and techniques described by Sauer (1966).

Canine teeth from bears 2½ years and older and from questionable yearling bears were decalcified, sectioned, stained and mounted as described by Sauer *et al.* (1966). The tooth sections were then examined under a microscope and cementum layer counts made. Three observers made independent counts in 1964, 1965, 1966 and 1968. Two observers made independent counts in 1967. These counts were compared and sections with differing counts were reexamined, discussed and reconciled in most cases. Summary tables were then prepared showing the sex and age structure of the sample by year of collection.

FINDINGS

The cooperation of taxidermists and successful hunters resulted in a collection of canine teeth from bears. Teeth from 421 bears were collected from the Adirondack Region during the 1964-1968 period, representing 19.0 percent of the 2, 213 bears calculated to have been harvested. The regular big game (deer and bear) hunting season ran from October 25 through the first Tuesday in December each year. In addition, a special bear season was held prior to the regular big game season in 1964 (October 2-11) and in 1968 (October 1-15). Actual numbers collected and the percent representation by age and year of collection are shown in Table 1.

Cubs were not included in this paper because it is felt that they were not represented in true proportion to their abundance. Hunters are reluctant to harvest them in the field and just as reluctant to bring those killed to check stations or taxidermists.

Note, in Table l,the similarity between the age structures for 1964, 1966 and 1968 in contrast to the age structures for 1965 and 1967. A multinomial chi-square test substantiated the even year similarities, the odd year similarities and the contrast between the two groups. The age distributions of the odd numbered year group of 1965 and 1967 were significantly different from those of the even numbered year group of 1964, 1966 and 1968, while there was no significant difference within each group.

By examining the first three age classes in Table 1 for the five year period a consistent pattern of high and low representation of animals in these age classes is apparent. The sample was composed of 101 yearlings or 37.1 percent during 1964, 1966 and 1968 and 12 yearlings or 8.0 percent during 1965 and 1967. There were 15 age class 2 bears or 5.5 percent for 1964,. 1966 and 1968 and 50 age class 2 bears or 33.6 percent for 1965 and 1967. Age class 3 animals also show this alternate pattern with 52 bears or 19.1

TABLE 1. NUMBER AND PERCENT OF ADULT BLACK BEARS SAMPLED FROM THE ADIRONDACKS, 1964-1968, BY AGE AND YEAR OF HARVEST.*

	1964		1965		1966		1967		1968	
Age Class	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1	41	41.5	5	5.9	41	37.0	7	10.9	19	30.7
2	4	4.0	30	35.4	6	5.4	20	31.2	5	8.1
3	17	17.2	8	9.4	24	21.6	4	6.3	11	17.7
4	8	8.1	9	10.6	3	2.7	2	3.1	2	3.2
5	3	3.0	8	9.4	8	7.2	3	4.7	7	11.3
6	6	6.1	4	4.7	2	1.8	2	3.1	—	—
7	1	1.0	2	2.3	3	2.7	5	7.8	1	1.6
8	1	1.0	7	8.2	5	4.5	7	10.9	4	6.5
9	5	5.1	2	2.3	—	—	—	—	3	4.8
10	1	1.0	2	2.3	4	3.6	3	4.7	3	4.8
11	3	3.0	1	1.2	—	—	2	3.1	—	—
12	1	1.0	—	—	2	1.8	—	—	4	6.5
13	3	3.0	1	1.2	3	2.7	1	1.6	—	—
14	—	—	1	1.2	—	—	3	4.7	—	—
15	1	1.0	1	1.2	1	0.9	1	1.6	—	—
16	1	1.0	2	2.3	—	—	1	1.6	—	—
17	—	—	—	—	3	2.7	—	—	2	3.2
18	—	—	—	—	1	0.9	2	3.1	—	—
19	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	1	0.9	—	—	—	—
21	1	1.0	—	—	2	1.8	—	—	—	—
24	1	1.0	—	—	1	0.9	—	—	—	—
25	1	1.0	1	1.2	1	0.9	—	—	1	1.6
29	—	—	1	1.2	—	—	—	—	—	—
30	—	—	—	—	—	—	1	1.6	—	—
Totals	99	100.0	85	100.0	111	100.0	64	100.0	62	100:0

* This table include/3 216 males, 193 females, and 12 bears of unknown sex.

percent for 1964, 1966 and 1968 and 12 age class 3 bears or 8.0 percent for 1965 and 1967.

Figure 1 shows that high cub productivity during 1963, 1965 and 1967 directly influenced the number of yearlings present in the population 1964, 1966 and 1968. The high number of 3½ year olds in 1964 presupposed high cub production in 1961. For example, from Figure 1 it can be seen that the contribution of the 1963 year class made up 41. 5 percent of the 1964 sample (age class 1), 35.4 percent of the 1965 sample (age class 2), 21.6 percent of the 1966 sample (age class 3), 3.1 percent of the 1967 sample (age class 4) and 11.3 percent of the 1968 sample (age class 5). In the total five year sample of 421 bears, there were 104 bears or 24.7 percent from the 1963 year class.

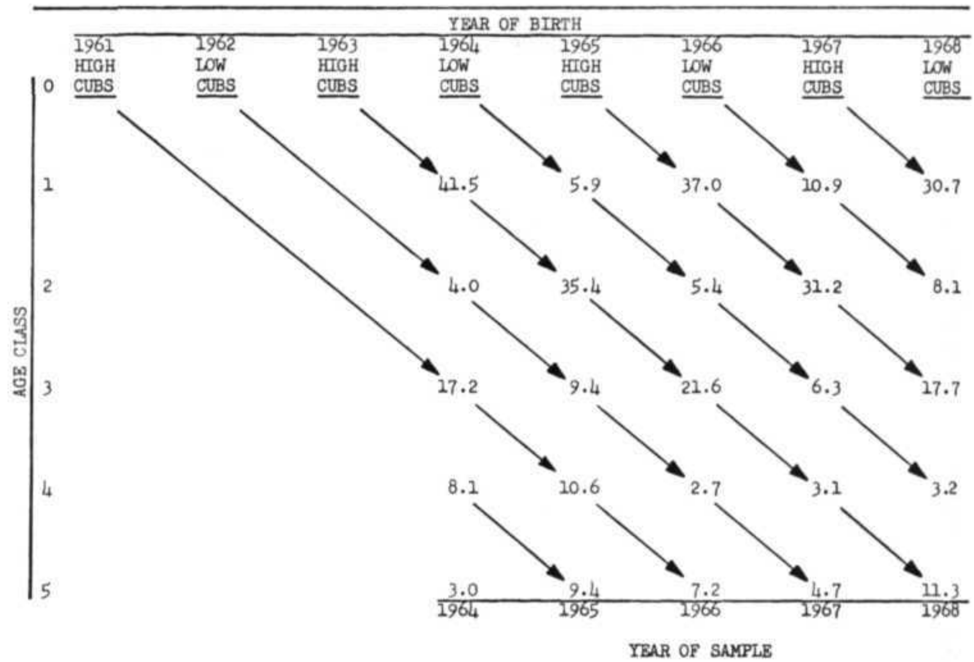

Fig. 1 The contribution of year classes to the annual harvest sample.

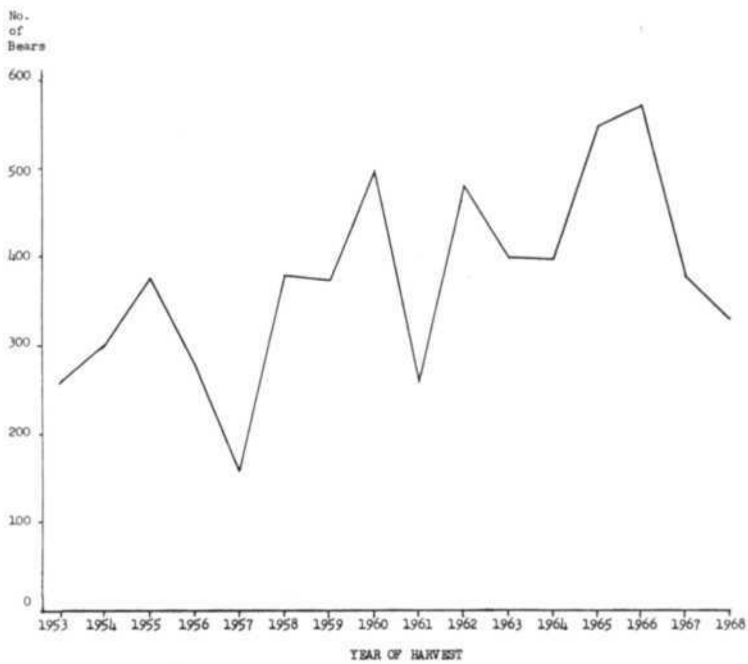

Fig. 2 Black Bear Harvest from Adirondack Region—
New York State.

Conversely, the 1964 year class made up only 5. 9 percent of the 1965 sample, 5.4 percent of the 1966 sample, 6.3 percent of the 1967 sample and 3.2 percent of the 1968 sample. For the four year sample (1965-1968) of 322 bears only 17 (5.3 percent) were from the 1964 year class. For the three year sample (1966-1968) of 237 bears, 72 (30.4 percent) were from the 1965 year class. These alternate year patterns substantiate the establishment of synchronous breeding behaviour for female bears from the Adirondack Region of New York State.

The influence of this synchronous behaviour resulting in high productivity in alternate odd-numbered years reflected in the five year sample can also be demonstrated in the annual harvest data. Table 2 summarizes the calculated bear harvest in the Adirondack Region from 1953 through 1968, including the special early season harvests of 127 in 1963,22 in 1964, and 58 in 1968.

TABLE 2. CALCULATED BLACK BEAR HARVEST FROM THE ADIRONDACK REGION OF NEW YORK STATE

Year of Harvest	Number of Bears
1953	256
1954	298
1955	374
1956	274
1957	156
1958	377
1959	370
1960	495
1961	255
1962	479
1963	397
1964	395
1965	545
1966	569
1967	376
1968	328

Figure 2 is a graph of the calculated legal bear harvest from the Adirondack Region for 1953 through 1968 including the early bear season. Of the eight odd numbered years expected to be low, one (1955) was a peak, while of the eight even numbered years expectedto be high, two (1964 and 1968) were troughs.

DISCUSSION

Fluctuations in bear harvests have been noted in New York and other states. These fluctuations in harvest have been related to food availability, weather and hunting pressure. While all of these factors certainly play a role in influencing harvest rates through bear availability and behavior they do not account for the regularity in harvest fluctuations. The presence of a synchronous breeding pattern does, however, provide a logical explanation for an up and down harvest pattern. The alternate year pattern of high and low productivity had a direct bearing on the numbers of yearling bears available to hunters.

A synchronous pattern of alternate year productivity can be maintained with the assumption that;(l) first successful mating occurs at an odd numbered year of age, i.e. three years of age, and (2) subsequent successful mating occurs during alternate years. Figure 3 illustrates the results if these two assumptions are held true for a period of years. In this example, the female was a cub in 1957, bred in 1960 and produced a first litter in 1961. Subsequent litters were produced by this female in 1963, 1965, 1967 and 1969. When her offspring follow the same assumptions, a synchronous pattern is established with litters being produced in odd numbered years. Once established, this pattern continues as long as the first successful mating occurs at three years of age and successful matings occur in alternate years. Figure 4 illustrates

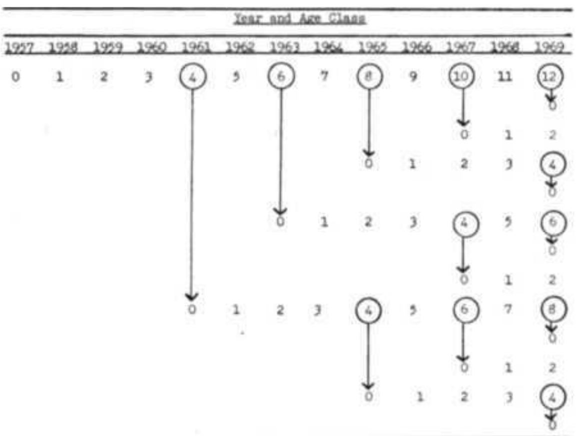

Fig. 3 Theoretical example of synchronous breeding behavior

Assume: (1) First successful breeding at age class 3, first litter therefore being produced at age class 4.

(2) Alternate year successful breeding.

Key: The circled numbers represent the age class of the adult female when cubs are produced. The arrows follow the female cubs and their subsequent establishment and maintenance of synchronous breeding behavior.

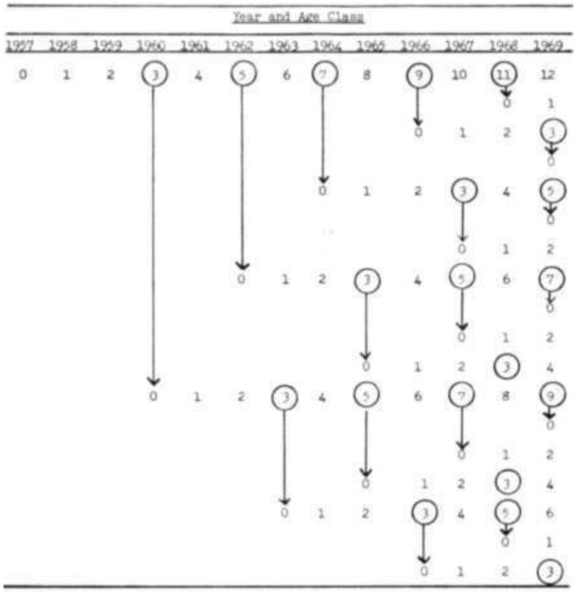

Fig. 4 Theoretical example of non-synchronous breeding behavior

Assume: (1) First successful breeding at age class 2, first litter therefore being produced at age class 3.

(2) Alternate year successful breeding.

Key: The circled numbers represent the age class of the adult female when cubs are produced. The arrows follow the female cubs and their subsequent breeding behavior.

the results of first successful mating at an even numbered year of age, i.e. two years of age. Even if alternate year mating subsequently occurs, litters are produced every year and a synchronous pattern is not established.

It it quite possible that over a period of time the synchronous pattern established in New York will be upset. A disaster, resulting in large loss to a cub class, would contribute to this break. It has been demonstrated that female bears losing cubs will, in many cases, successfully mate the next year. This behavior would upset the present synchronous pattern possibly to the point where synchrony of mating could occur on even numbered years instead of odd numbered years.

ACKNOWLEDGEMENT

The authors wish to acknowledge the contributions of Peggy R. Sauer in making cementum layer counts and the aid of Robert Miller for making counts, running statistical tests and making valuable suggestions.

This work was done under the Pittman-Robertson Federal Aid in Wildlife Restoration Project W-89-R.

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Notes on the Behavioral Development of Two Female Black Bear Cubs: The First Eight Months

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INTRODUCTION

To understand the behavior of the black bear (*Ursus americanus*), field studies are naturally of primary importance. While substantial beginnings (e.g., Herrero,in press; Jonkel 1967) have been made, much of this information has been gathered coincidentally in projects dealing with more general ecological questions, such as numbers, movements, growth, age distribution and reproduction. This is especially true of our knowledge about cub behavior. There are good reasons for this: the size and potential danger of the mother hinders close proximity in observational and tracking studies, and the often rugged forested habitat makes observation from a more practical distance impossible.

Ethologists have been most distressed by the erroneous assumptions and conclusions concerning animal behavior put forth by those who have never seen or considered the animal's behavior outside of highly artificial and restrictive environments. In captivity, however, detailed observations on behavioral development can be made along with experiments impossible in the field, especially with a large and potentially dangerous species. One must, of course, always be aware of the possibility that captive conditions have produced abnormal behavior. However, even the abnormal behavioral aspects of an animal raised under deprived conditions can illuminate our knowledge about how the behaviors seen only in their highly adaptive settings in the natural environment function.

Our subjects, through tragedy, became dependent upon us suddenly, and the luxury of expertise had to be set aside for Ursine reasons.

There have been many studies on the comparative development of a variety of vertebrate species including mammals ranging from mice to primates. However, those studies most relevant in the present context have been performed with other members of the Carnivora, especially canids which belong to the same super family as the bear and about which a large body of knowledge is being accumulated (e.g., Kleiman 1967; Rabb, Woolpy,& Ginsburg 1967). Comparative work of a developmental nature on canids has been performed most systematically by Fox (1969, 1970).

Bears, because of their evolutionary position in the carnivore scene, merit the same type of treatment that has proved most valuable with other carnivores. Three unique aspects of bears add to the importance of such endeavors. (1) The bipedal habit which, aside from its behavioral interest, seems to be behind much of the anthropomorphic adoration, respect, and fear of bears by many cultures. (2) The bear's unique carnivore brain has unusual features which are remarkably similar to the primate brain (Papez 1929). These include the ursine lozenge, the slyvian fissure, and structures which in gross appearance resemble the primate temporal lobe which is involved in complex sequences of behavior and memory. (3) Most bear species are the highest ranking members of the species community in areas where they are found. Their omnivorous and non-specialized feeding habits, along with size and strength creates direct competition with man, although bears have given way to humans in most parts of the world. Since man is also the highest ranking species in his environment and capable with his technology of destroying if not ruling all ecosystems on earth, insight into bear behavior may untimately shed some light on our own.

Black bears are often successfully raised in captivity (e.g. Crandall 1964). Unfortunately, only scattered information has reached the literature about the behavioral development of black bear cubs (Herrero 1970; Leslie 1971). An ethological study dealing with behavioral development by Leyhausen (1948) was based on observations of one black bear cub (Nelly) for a period of about ten months (about the fifth through fourteenth) and was performed under rather limited circumstances regarding equipment and facilities. Krott (1961, 1963) performed field observations on wild brown bears (*Ursus arctos*) in Europe and developmental observations on cubs. Kuckuk (1936) also observed brown bear cubs. While this work is most valuable, much remains unknown. Detailed comparisons with the literature will appear in forthcoming papers.

Two cubs, approximately one kilo each, weak and near death were found abandoned by their injured, probably killed, sow on April 18, 1970, in the Great Smoky Mountains National Park (GSMNP). They inflicted painful bites on the ranger's hand as he picked them up. Although the exact date of birth was unknown, we assume that it occurred at the beginning of February, leading to the conclusion that the cubs were two and one-half months old when they were found. The cubs were reared by Jack Collier in his cabin until May l, when they came into our possession. During the interval, a large wooden variant of a covered playpen was constructed so that the larger, and by now healthy and active, bears would have better accomodations when they were not running free in our house or in the back yard. The bears remained in our house until June 18 at which time they were moved to a large converted shop in the Tremont Environmental Center, which is operated by Maryville College in the GSMNP. They remained here until the large 60 × 60 foot (18.3 × 18.3 meter) enclosure that was being built in a wooded area of the Park was completed in July.

Our aim was to familiarize ourselves with bear cubs and problems in their maintenance and rearing, while working out a rough classification and ontogenetic description of behaviors. The main method used was observation, mainly participant observation since unobtrusive observation was impossible. Only now, with construction of the enclosure and observation tower can we begin to approach relatively candid observation. Most of the observations were written; however, many 35 mm slides in addition to 8 mm and 16 mm movies were made, and vocalizations were recorded on tape. Only selected aspects of some behavior can be discussed here.

FEEDING AND DRINKING

From April 18-20 the cubs were fed whole warm cows' milk and honey every two hours. By the 20th they were fed only every four hours. This was reduced to four or five times daily on April 25 and to three or four feedings by May 10. Honey was eliminated shortly after we began taking care of the bears, but vitamin drops (0.6 cc Poly-Vi-Sol) were added to the milk once daily.

The sucking behavior of the bears would appear to be typical for a mammal. While holding the bottle, they would stretch out their claws and knead as if to facilitate the flow from their 'mother's' breasts. Often their eyes were closed and utter contentment would be the usual state. When the milk ran out, their noise level rapidly increased and changed to growls as they attacked each other. This was noticed the last week in April and was the first agonistic behavior seen between the cubs. It became noticable that Kate often did not suck the nipple normally when compared to Kit. Kate would turn her head to the side and chew the nipple with her molars. This hastened the milk flow, and she was frequently finished well ahead of Kit.

By the end of April both bears were receiving solid food, such as canned chopped-up peaches, applesauce, and strained fruit baby foods. Such items were lapped up with the tongue almost as a cat laps milk. By May 9 the bears were eating 'chewy' items, such as pieces of apple, leaves and grass brought in from the outside, and a Chop-Chop dog toy made of beef hide. They would use their claws to hold the item down, to turn it over, and to pick it up. This was only one of the many examples of precise manipulation that we were to see. At this time they would sometimes refuse milk in favor of fruit baby food. Raw meat was not eaten or even nibbled although they did begin eating vegetable and meat-flavored strained baby foods.

Beginning the first week in May, after drinking only a small amount of milk, Kate and/or Kit would often prefer to suck another object, such as an arm, a finger, etc. Even in April Kate often sucked Kit's ear until it was extremely soggy. Such behaviors were usually accompanied by the pulsating sound made when sucking milk. Perhaps the nipples were too free flowing. There is evidence that puppies have a certain 'need' to suck (Beach & Jaynes 1954). If they satisfy their hunger with minimal sucking from bottles with large holes in the nipples, the sucking behavior is directed to other objects. Consequently, we thought that if the nipples were made less free flowing and more sucking effort had to be expended, perhaps the sucking of 'inappropriate' objects would cease. Using smaller openings did appear to enhance their 'pleasure' at first, but then the bears could not get the milk fast enough, and this resulted in some frustration-induced aggression towards us and their sibling. Although both would suck on the human arm (Fig. l),Kate would rather suck on Kit's ear. This usually took place when they were in the pen or when we were in the room but not paying particular attention to them. Although boredom or frustration might be involved in this behavior, its development as soon as the cubs recovered their health in April would seem to argue against this as the sole explanation. Kate could not be dissuaded from engaging in such activity. Slapping her snout repeatedly only caused her to back off for a few minutes and sneak back after a short interval. Repeatedly punishing her in this way would lead to her beginning to 'cry,' a response given by lowering the lips of the lower jaw accompanied by a low simpering. But no lasting result was accomplished. After moving the cubs out to the Park, the behavior continued (Fig. 2), and Ellis Bacon repeatedly attempted to eliminate the ear sucking by coating Kit's ear with distasteful substances. Unfortunately, Quinine, Vaseline, tabasco sauce, vinegar and salt, among others, did not succeed. Bear feces was more effective, but it was rather distasteful for Kit to have on her ear—not to mention for the person who had to apply it. Kit's right ear was, however, becoming more and more dilapidated. The fur was disappearing from the ear, and it was always wet and moist. In order to easily identify the cubs on still and movie films, a blue tag was placed on the favored sucking ear, but Kate soon grew adept at sucking around the tag. The sound of sucking whether taped or live often was the stimulus for this behavior. The sound of Kit sucking on the arm or leg of a person

Fig. 1 The two cubs sucking on the human arm (May).

Fig. 2 Kate sucking Kit's ear, although no longer being fed with a bottle (September).

would bring Kate over, and she would immediately engage in sucking on Kit's ear. Attempts to dissuade Kate by cuffing her snout or merely blocking access to Kit's ear led to clear examples of redirected aggression against Kit. Preventing Kit from engaging in sucking behavior with humans proved to be the most effective control of this behavior after the cubs were weaned.

On May 11 an intriguing and disconcerting behavior, which was also noted by Leyhausen (1948), began which involved the bears turning over their food dish with the paws and then lapping up the contents. They often pawed out the solid items first, but the presence of a liquid did seem to stimulate the turning response. The messes caused led us to purchase a weighted 'spill-proof dog food container. The behavior, nonetheless, continued throughout the summer. We noted that it was very similar topographically to the way they turned over stones and pieces of wood when outside in the yard, leading to the hypothesis that it is a fixed action pattern associated with food finding.

Milk continued to be highly favored, although by the end of May the two began chewing frankfurters and Milk Bones, which certainly are neither fruity nor sweet, indicating further changes in food preferences were occurring. Their response to canned dog food was variable. Following Leyhausen, we began in early June to prepare an oatmeal mixture laced with honey, milk and the syrup from canned fruit. This proved to be a very useful way of giving the bears bulk and also of weaning them from milk. In fact, less than a week later the bears were down to only two bottle feedings a day. The total daily amount of milk drunk by each bear averaged over 4-day blocks (to reduce some of the variability) is shown in Table 1 for May 2 to June 18. While the total amount ingested decreased from a peak during the first week of June, Kit's decline was the more regular. Kate drank more milk than Kit on 30 of these 48 days, while

TABLE 1. MEAN DAILY AMOUNT OF MILK TAKEN BY EACH CUB IN FOUR-DAY BLOCKS (LITERS)

Date	Kate	Kit
May 2—5	0.52	0.46
May 6—9	0.97	0.83
May 10—13	1.01	1.16
May 14—17	1.21	1.07
May 18—21	1.20	0.92
May 22—25	1.26	1.50
May 26—29	1.38	1.29
May 30— June 2	1.28	1.26
June 3—6	1.65	1.53
June 7—10	1.26	1.48
June 11—14	1.19	1.09
June 15—18	1.39	1.02

Kit drank more on only 15. In June they began eating more fresh vegetables and fruit. Fresh berries were greatly relished. When first given blackberries on the vine, they daintly pulled the fruit from the prickly branches, although by now their resistance to aversive, normally painful stimuli had become very apparent.

By July the main diet was dry dog food (bite size, Wayne Feeds, Inc.) amply supplemented with fresh and canned fruit and fresh vegetables, particularly lettuce. At first applesauce had to be mixed with the dry dog food in order to entice them to eat it. Two liters or more of milk per day were drunk from bowls and, although gradually reduced, they did not seem to really miss it. Fresh ground beef was sometimes taken, and they began to enthusiastically chew cooked meat bones as described by Herrero (in press). It was not until their seventh and eighth months that meat and fish were taken in any quantity. Individual differences between the bears in food preferences were often striking but rather transient. The similarities were more important in our estimation.

In Fig. 3 is shown the weights of the two bears over the several months that we had them in captivity. Note that Kate remained heavier throughout. She consumed more and remained dominant in food competition. The large dip in Kit's weight occurred during the days shortly after they were moved to the large maintenance building in the National Park. Kit was always more sensitive to her surroundings, and her temporary period of minimal feeding seems consistent with this personality trait.

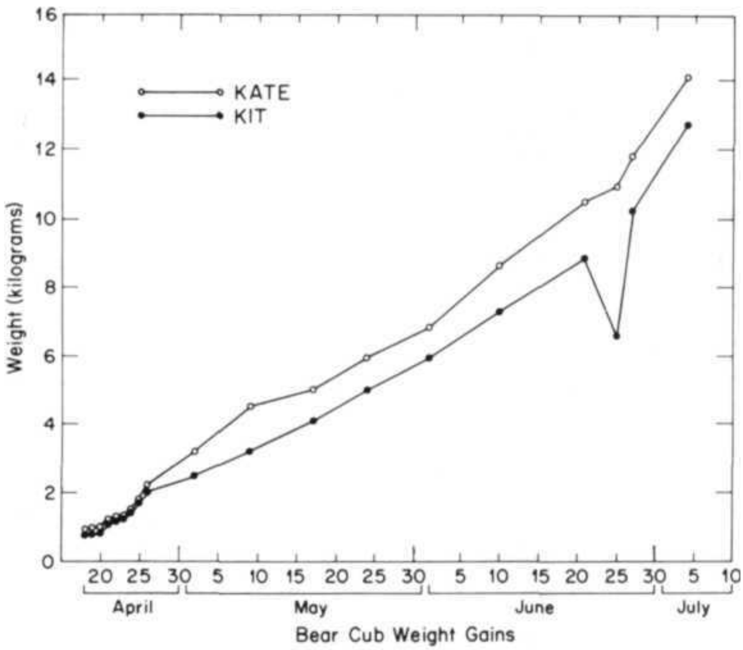

Fig. 3 Weight of the two cubs from April to July. By the end of September they were close to 25 kilograms each.

CLIMBING AND LOCOMOTION

The young cubs took to climbing trees from the end of April. As when on the ground, both bears tended to stay in very close proximity. They often would rest together in the fork of a tree or on the same limb. Kit climbed higher and actually was a little more dexterous in the tree which countered other evidence that Kate was the more inquisitive, the more bold and the more aggressive of the two bears. Bears use two basic means of climbing trees which parallels their terrestial locomotive patterns. One is a hopping behavior which involves the rear legs moving in unison. This is used for rapid movement. The second type involves a more leisurely walk. Both of these behaviors would be used in the trees. Usually when they ran towards trees, they would hop and start up the tree very quickly with this pattern. They then would slow down to the walk. In most cases, they used a reverse walk to descend, always rear end first, from the trees. The bears, even when very young, were agile in trees and were good judges of the strength of the limbs. Rarely were there any mishaps.

Usually the cubs would climb down the tree to us if we called them, gestured, brought out food, or merely disappeared from sight. From May 14 on they asserted more independence, remaining in the trees for hours, even during rain or darkness, despite our coaxing. Nonetheless, almost invariably when they were first taken out of the house, they were reluctant to stay in the yard. They would try to return to the house. After realizing that this was impossible (after bumping against the glass doors), they then would begin to scamper around, to play with objects and each other, and to climb trees.

DEFECATION AND URINATION

On the first day that we had the bears, we noted that Kate defecated within 15 minutes after drinking her ration of milk. A pattern was soon established whereby we would place them in their pen immediately after feeding. Both would defecate and often urinate within 5 to 10 minutes. This controlled almost all defecation in the house, even if the cubs were nor formally housebroken. Urination, on the other hand, was less predictible. Both females 'dribbled' when they urinated, usually down the tuft of fur below the tail. Male bear cubs reportedly squirt.

On May 8 the cubs were out in the yard, and we fed them milk. After finishing, Kate immediately came to the sliding glass door and scratched at it, indicating that she wanted to be let inside. After the door was opened for her, she ran in the house, up the stairs, and into the pen where she proceeded to defecate. Immediately afterwards she exited from the cage. This would indicate that an association with the newspaper covered floor of the pen had been established. About one month later the bears began urinating from the trees. Prior to this time, they had always returned to the ground to urinate.

RESPONSES TO WATER

At first the cubs were hesitant about going into water, particularly when it was descending from a faucet or showerhead. They would slowly explore around it and eventually walk right into the water. This was very apparent when they were placed in the shower room which has a large sunken tub-shower combination. When one of us took a shower with the bears free in the vicinity, they would immediately show interest, come over to the person, walk down the several steps into the tub, and before long be romping under the water spray.

Groos (1898) reports observations which suggest that either a person or the cubs' natural mother is needed to guide cubs to a new locale, such as a bath. Kate would always venture in before Kit.

After we had the bears several weeks, we placed a plastic wading pool about two meters in diameter in the yard and filled it with about 12 cm of water. They soon discovered it and, without much coaxing, would play and wrestle with each other in the water.

EXPLORATION AND CURIOSITY

From the first day in our possession the bears preferred dark places. This was not just an escape reaction, but a true preference. For instance, they soon learned to open and climb inside the clothes dryer, kitchen cabinets and the clothes hamper. They would play or relax in these situations, which indicates a lack of fear. If frightened, however, they would run and hide in dark places.

Early in May the bears began to 'mouth' objects. By May 14 they were using their paws to drag out objects inaccessible or difficult for the jaws alone to procure. Teething on the wood cage bars and chair arms also began about this time. By May 19 Kit learned to open the sliding glass door leading to the outside if it was left unlocked and there was a small space in the door jam into which she could hook a claw. At about the same time Kate learned to open the cabinet doors in the kitchen by hooking her claws between the doors and the wall. By this time they could climb virtually anywhere in the house they desired. Often they would climb to the top of a chair, which, if it was a wooden straight chair, would begin to topple as their weight caused the center of gravity to shift. They would fall with a crash, give an immediate startled response, and then return for more. Outside they performed similar feats with small trees and shrubs. By June 13 they began carrying off objects like rolls of paper towels, purses, etc., from where they found them to somewhere else, e.g. behind a couch, where they would shred the paper or daintily remove each item from the purse to examine, chew a bit, and play with.

An extension of the upper lip often occurred when exploring strange or novel stimuli, each other, or when a strange sound or other 'distinct' stimulus occurred (Fig. 4). This lip extension was very pronounced when they were small and would often be done at a considerable distance from an object. This behavior may facilitate the detection and/or discrimination of odors. The bears would often approach and sniff and paw humans before proceeding with attempts to play more overtly with them. Strange humans were never really accepted over the few hours the bears were exposed to them. They were inclined to hide if inside the house or climb a tree if outside. Frequently however, they would ignore the stranger almost entirely and play with each other in front of him. Rarely would they play with the stranger or even offer play invitations (next section).

One indication of their response to other species was seen when a neighbor's part collie dog came running over to Lori who proceeded to pet it. Kit descended a tree 100 feet away and came within two feet of Lori and suddenly stopped, reared high upon her hind legs, and made a very monkey-like snuffling sound. After freezing for about 30 seconds, she ran to a tree and quickly climbed it, again making the same sound. This sound was subsequently made

Fig. 4 The upper lip extension, shown by Kit in September. When the cubs were younger, it was even more evident. Note also the straight back ear position, and the light markings on ear and muzzle.

in response to other dogs. The bears generally were frightened by small animals, as Leyhausen (1948) also noted with Nelly.

PLAY BEHAVIOR

Play behavior can be classified into several different kinds: self-play often involving inanimate objects, social play with humans, and social play with each other. Self-play was often associated with the exploration of objects. They would roll around on their backs in and on blankets and comforters, and inspect the contents of purses, paper bags and other containers. Once they were moved into the Park enclosure, a favorite pastime was to lie flat on their backs, stretch out their legs, and pull down branches, twigs, or leaves from low-growing shrubs with their paws and bring these into their mouth (Fig. 5). These they would alternately chew, rub, or even 'tickle' themselves with. Kit played alone much more readily and for longer periods than Kate.

Kate engaged in social play more than Kit did. Kit, however, often gave many play invitations to Kate which Kate would ignore in her endeavors to gain responses from people rather than from her sister. From the beginning we noted that play with each other and with people occurred most frequently shortly after feeding. After a play bout, a rest or sleep period would follow. Most play with each other was of a rough and tumble sort. In play-fighting silence was the rule. No growling or other sounds were heard. This can be contrasted with the 'serious' fighting that would break out over food or when one bear became annoyed. This distinguishing characteristic of true play was

Fig. 5 Resting self-play with branches and leaves (August).

virtually without exception. During the first week in May we noted that the ears were usually in the back position when the bears were inviting play and that they would move forward with the mouth open usually at a rear flank. By the last week of May the bears were noticeably more gentle when playing with us. That is, the teeth very rarely broke through the skin or caused pain. It was as if the bears were learning to distinguish playing with people versus playing with each other. This has been noted with the canids in developmental studies by Fox (1970).

By the end of May, bipedal wrestling and swatting out at each other with the front paws was occurring. This contrasts with Leyhausen who states this first happened at six and a half months. However, Leyhausen did note that this was later than had been recorded in other species of bears. On the basis of our observations, it would seem that the black bear engages in stand-up play closer to four months of age.

Rolling on the back seemed to signify submission in the cubs' play in a manner quite similar to puppies and other canids (Fox 1970). What we term the 'play invitation' seems derived from this response. A cub would come running toward her sister or to one of us and flip over onto her back in what is best described as an off-balance, head-first somersault (Fig. 6). If this did not elicit the desired response and the human or cub stayed near, the next stage was to sink her jaws into the foot or leg (if human) or the thigh or side (if bear).

Also involved in play behavior, particularly when it concerned people, were certain elements of threat towards the interloper. One bear (usually Kate) would freeze with her mouth open and ears back in a posture that inhibited further approach and appears very similar to the 'jaw-gape' described by Fox for canids. This became more common and fleeting as the bears aged. It eventually extended to a 'jealous' attitude by Kate, who would drive Kit away whenever the latter was receiving human attention.

Fig. 6 Play invitation by Kate (September).

COMMUNICATION

Unlike canids, bears do not possess a tail which can signify various meanings. Neither are black bears' faces very brightly marked. The main methods bears have of communicating are through sound, ear position, jaw position, body posture, and perhaps odors. Vocalizations cannot be adequately covered here and so will not be discussed. All these communication signals are presently under quantitative study, and only some will be touched on here.

Ear position seemed to be quite important; we can state roughly that four ear positions occur. The ears can be straight up, a normal alert posture; they can be moved forward with the opening rotated forward; moved straight back, as in the jaw-gape; or they can be moved up and out almost perpendicular to the side of the head. Both ears are almost always in the same position simultaneously. That these ear positions are important for communication is indicated by two morphological facts: (1) black bear ears are larger in proportion to face than those of most other bears including the polar, brown and grizzly; in cubs this is even more pronounced; (2) the ears themselves have a distinctive marking, at least in black bears of the Smoky Mountains which, unlike some variants, are in most respects almost jet black; however, there is some light-colored fur around the snout, above the eyes and, when our bears were young, inside and on the back of the ears. During June and July the interior of the ears was an almost luminous rusty even orange color. By fall, however, these markings had faded out although they were still evident. Perhaps these ear and face markings have a communication function during the summer of the first year when the bears are more playful and interact more extensively with each other than at any other time in their lives. The muzzle markings and the white spots above the eyes got progressively more distinctive as the bears got older (Fig. 7). Often the 'whites' of the eyes flashed during social interaction, and this too might be a social signal.

A highly developed greeting ceremony was not noted. However, if the two bears were separated for even a short time, they would run towards each other and very briefly and gently interlock jaws or pass their snouts close to each other, wrinkling them in their sibling's direction. Sometimes a play fight or a chasing bout would follow this brief greeting. Since the cubs were prevented from close contact with the human face, the greeting could not be detected in its 'normal' manifestation to humans. However, the attempts of the bears to nibble briefly on exposed parts of humans (hands or ankles) after approaching them would seem to be the greeting. Tentative or 'teasing' play with humans or each other was often marked by an ambivalent threat expression (Fig. 7).

Fig. 7 Kit in 'ambivalent threat' attitude towards a human (September). Note lower jaw, ear position and muzzle and eye markings.

Although the response to exposed human skin was usually a sucking (by Kit) or nibbling-chewing (by Kate), licking did occur at times. Usually it occurred when the hands obviously smelled or tasted of food. However, in September when the bears came down temporarily with some unknown illness which obviously discomforted them, they became remarkably more gentle and, in fact, would often explore and lick the human face with no attempts whatever to nibble, suck or bite (Fig. 4).

ADDITIONAL MAINTENANCE BEHAVIORS

The bears engaged in a variety of postures. They would frequently lie on their backs or sides. During the summer months when the temperature was around 80 degrees, they would respirate at 130-140 times a minute while resting in this fashion. Sitting was also common especially when eating or manipulating a novel object. While sleeping they often might lay on their backs. Scratching behavior, usually the rear foot to the ear or side, was performed infrequently. Licking of the paws occurred from May on, but otherwise little grooming was noted. Only one observation of mutual grooming has been made up to the present time.

CONCLUDING COMMENTS

In this paper we have briefly given an interim report of some of our experiences and findings on two black bear cubs. Space precluded a more thorough presentation or discussion. Certainly, young bears, at least, have a wider range of predictable facial expressions than has been generally thought. Further studies of bears in the wild and captivity will help answer not only the broader questions concerning behavior in a group of unique carnivores but may also help to preserve and manage the living bears of the world and reduce the number of unfortunate incidents involving humans and bears—both physical damage and human injury (Stokes 1970).

ACKNOWLEDGEMENTS

This study was supported, in part, by USPHS grant MH-15707 and the Agricultural Experiment Station, Institute of Agriculture, University of Tennessee. We thank Jack Collier, Ellis Bacon, and Cheryl Pruitt for assistance. The cooperation of the administration of the Great Smoky Mountains National Park and Lloyd Foster of the Maryville College Tremont Environmental Center is gratefully acknowledged.

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Aspects of Evolution and Adaptation in American Black Bears (*Ursus americanus* Pallas) and Brown and Grizzly Bears (*U. arctos* Linné) of North America

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SUMMARY

Certain behavioural, ecological, morphological, and physiological differences between grizzly/brown bears and black bears are related to the different habitats favored by each species. It is suggested that care of black bear cubs and hence reproductive success for black bears is tied to the forest biome, and that the grizzly/brown bear in branching out from the forest onto non-treed areas such as tundra, grasslands and prairie edges, gained rich new food sources, but also became more aggressive than the black bear, a behavioural adaptation to cub care in this new habitat.

INTRODUCTION

Few persons need a scientist to tell them that black bears differ from brown and grizzly bears. Still there are levels of understanding of differences as is illustrated in the following story.

A young national park naturalist, fresh from training, was lecturing to a crowd of tourists, discussing the differences between black bears and grizzly bears. The naturalist said that a good way to tell the species of a given bear was to sneak up on the bear in question and kick it in the rump, then to immediately run and climb a tree. If the bear climbs up the tree after you it is a black bear.

An old-timer in the audience thought this test too elaborate. He said all you have to do to discover the species identity is to sneak up on the bear, kick it in the rump, wait a split-second, and then if you are still alive the bear was a black.

There is both sense and nonsense in this fanciful story as there is in most "folk-knowledge" about these species.

In this paper I discuss some behavioural, ecological, morphological and physical differences between black bears and the North American brown/grizzly bear group, trying to interpret these differences in terms of the evolutionary adaptations of each species to their respective habitats.

EVOLUTION OF BLACK BEARS AND THE BROWN/GRIZZLY BEAR GROUP

The phylogeny postulated here is adapted from Kurtén (1968) and Thenius (1959). There is little original work of my own, although stress on certain relationships and errors of interpretation may be mine. Both Kurtén and Thenius, who as palaeontologists could be classified as lumpers, recognize two living sub-familial groups of bears, the Ursinae and the Tremarctinae. Simpson (1945), an even more classical lumper, is not even sure whether bears deserve familial separation as the Ursidae, from the dogs, the Canidae, and he certainly does not recognize any valid subfamilial differences among the living ursids. He points out that the ursid group is of quite recent origin, first appearing in the fossil record during the Burdigalian of the lower Miocene.

The Ursinae line, whether formally designated or not, is of importance here. The genus Ursus, the major modern day genus and the only genus with a well documented fossil record, first appears in the fossil record in Europe during the Astian (upper Pliocene) as the Auvergne bear, *Ursus minimus* Devèze & Bouillet. This was a small bear about the size of the Malay Bear, *Helarctos malayanus* Raffles, but anatomically it resembled the black bears. This species persisted until earliest Villafranchian (lower Pleistocene) but was gradually transformed into the typical Villafranchian species, *Ursus etruscus* Cuvier, the Etruscan bear.

The Etruscan bear is of interest for several reasons, especially if you are already interested in bears and their phylogeny. Early forms of this bear were small, about the size of the modern Asiatic black bear, but the fossil record shows that they subsequently increased in size and the terminal forms were as large as the brown bear, *Ursus arctos* Linné. The Etruscan bear was probably a forest adapted type, much like its precursor the Auvergne bear.

From the time of *Ursus etruscus,* things began to move for the bears in the theater of evolution. The geomorphology of the world was beginning to change rapidly in many areas. The age of ice was coming. In parts of the Northern Hemisphere Pleistocene glaciers advanced during cooler phases but during warmer interglacial periods the great ice sheets retreated and left bare, vast, denuded areas which because of local climatic factors probably had a tundra type of treeless vegetation. The bears responded to these and other changes with significant adaptive radiation. *U. etruscus* formed the nucleus of the middle and late Pleistocene branching of the genus which apparently led to all of the living members of the genus. The scene of this radiation was in the palaearctic region and the three species known from the nearctic are immigrants.

The Etruscan bear probably gave rise to three evolutionary lines. The first and second were localized in Asia and led to the brown bears and the black bears; the third line started and ended in Europe and was represented by the endemic cave bears *Ursus spelaeus* Rosenmüller & Heinroth. Only the brown and black bears will be of concern here.

The Asiatic black bear might almost be regarded as a surviving but slightly modified Etruscan bear, resembling especially the early, small variety of the middle Villafranchian. By 2-Mindel the black bears had entered North America where the earliest forms date from D-Holsteinian (a cave find near Port Kennedy in Pennsylvania). This form is still very similar to the Asiatic mother species.

The earliest members of the brown bear line are recognized from remains in Choukoutien in China during 2-Mindel. The brown bear group did not cross to North America until 4-Würm and even then it appears to have been confined to

Alaska by the continential ice-sheet. Only during the post-glacial times did it spread southward. All pre-Wisconsin *Ursus* finds in the United States appear to be those of *U. americanus.*

Ursus maritimus Phipps, the polar bear, is the most recent bear in the fossil record and appears to have evolved from a coastal brown bear population which specialized for life on the sea ice margins of the far north.

Fig. 1 summarizes the phylogenetic chronology of the Ursinae. While the brown bears are commonly recognized as one species widely distributed in the Palaearctic and Nearctic (Rausch 1963; Couturier 1954; Kurtén 1968), local populations in Europe, Asia, and North America may be somewhat distinct. In North America Rausch recognizes two reasonably distinct populations. The

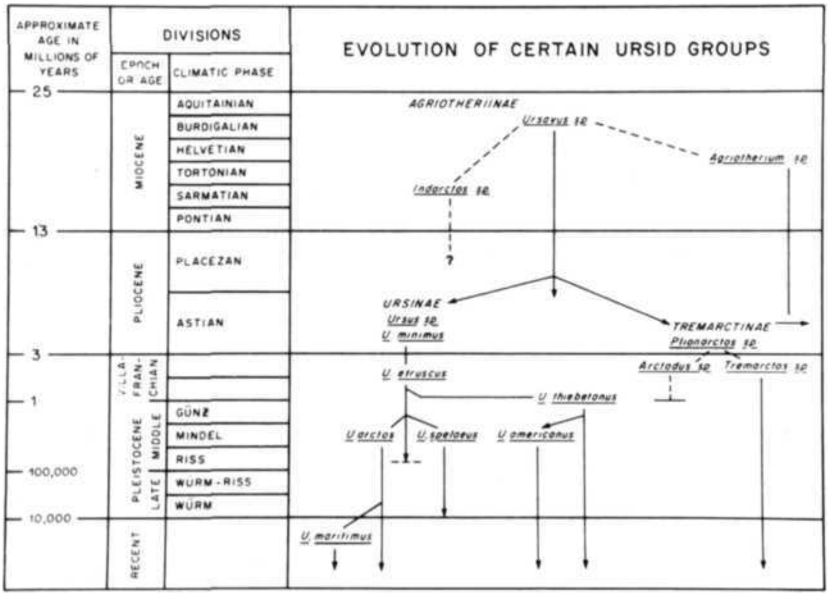


Fig. 1

brown bears inhabiting the Alaskan Islands of Kodiak, Afognak, and Shuyak, he claims are reproductively isolated and 'possess distinctive cranial characteristics. . ..'. He suggests that this group be designated as *U. arctos middendorffi.* All mainland North American brown bears and grizzly bears he places in one subspecific group *U. a. horribilis.* My comments in this paper with respect to *Ursus arctos* in North America apply to all island and mainland representatives of the species usually referred to by the common names of (big) brown bears and grizzly bears.

ADVANCED SPECIES ADAPTED TO OPEN HABITATS

The bears evolved from the Miacidae which were a family of small, carnivorous, tree climbing mammals. While the bears ultimately became much larger in size than their myacid ancestors and most bear species became omnivorous, they did not in general cease their association with the forest or lose their tree climbing ability.

The earliest representative of the Ursinae group, *U. minimus*, was probably a forest adapted type, for anatomically it resembled the black bears although it was smaller (Kurtén 1968). *U. minimus* gave rise to the Etruscan bear from which the three lines I have mentioned diverged. One of these lines, the black bears, remained a pure forest specialist and another led to the brown bears. I regard *U. arctos* as a basically forest adapted type that ventured often into a new habitat, open tundra areas, left bare by retreating ice during pleistocene interglacials. Entry into this new habitat resulted in significant changes from the pure forest type ancestor and these changes will be discussed in detail later. The climax of this trend away from the forest biome appears to have been reached with the polar bears.

FAST AND PRESENT DISTRIBUTION OF THE BLACK BEAR AND BROWN/ GRIZZLY BEAR GROUP IN NORTH AMERICA

Today as in the past there is significant overlap in the ranges of the American black bear and the brown/grizzly bear group. Typically however the black bear occupies forested areas, preferably somewhat open, and the brown/grizzly bear group occupies more open areas such as tundra (arctic and alpine), although individuals of the brown/grizzly bear group may sometimes be found in the forest. An examination of the extremes of the two ranges and the specific habitats occupied is revealing (Figs. 2 and 3).

In the far north while the grizzly ranges onto the actual barrengrounds, a tree-less tundra area, it more often is found in association with open wooded and watered areas such as lakes, delta channels, and rivers. At the eastern extent of the barren-grounds grizzlies are rarely seen away from or beyond the Thelon, Back, Dubawnt and Kazan rivers (Macpherson 1965).

A map of the northern extent of the forests of North America reasonably well defines the northern extent of the black bear distribution (Fig. 2). Recent observations by Jonkel & Miller (1970) suggest that on parts of the barren-grounds of Canada and on the Ungava Peninsula the black bear may be extending its range somewhat onto treeless areas. This they tentatively attribute to the possible extinction of the Ungava grizzly (a questionable population according to Elton 1954) and to a general decline in the numbers of barrenground grizzlies (Harrington *et al.* 1962).

In the southwestern extreme of the range we find another interesting situation in the grassland, and in some of the chaparral (sclerophyllous scrub) of California. Here, prior to its recent extinction, the grizzly once was numerous, extending fully to the coast and even ranging onto the beaches. Areas that were not forested seem to have been avoided by the black bears but if productive they were favored by grizzlies (Fig. 4).

In the interior of North America the grizzly found at least the edges and river bottoms of the great plains suited to his habits. Here the grizzlies' range probably extended eastward to the great bend of the Missouri River in the present North Dakota, southward to the Moreau River in South Dakota (records for Kansas and Minnesota, Hall & Kelson 1959, are probably aberrant), and possibly eastward to the Red River region (Stebler 1972). Buffalo carrion, supplemented with occasional kills, and a steady availability of grasses and forbs must have made this an area containing high quality food for grizzlies.

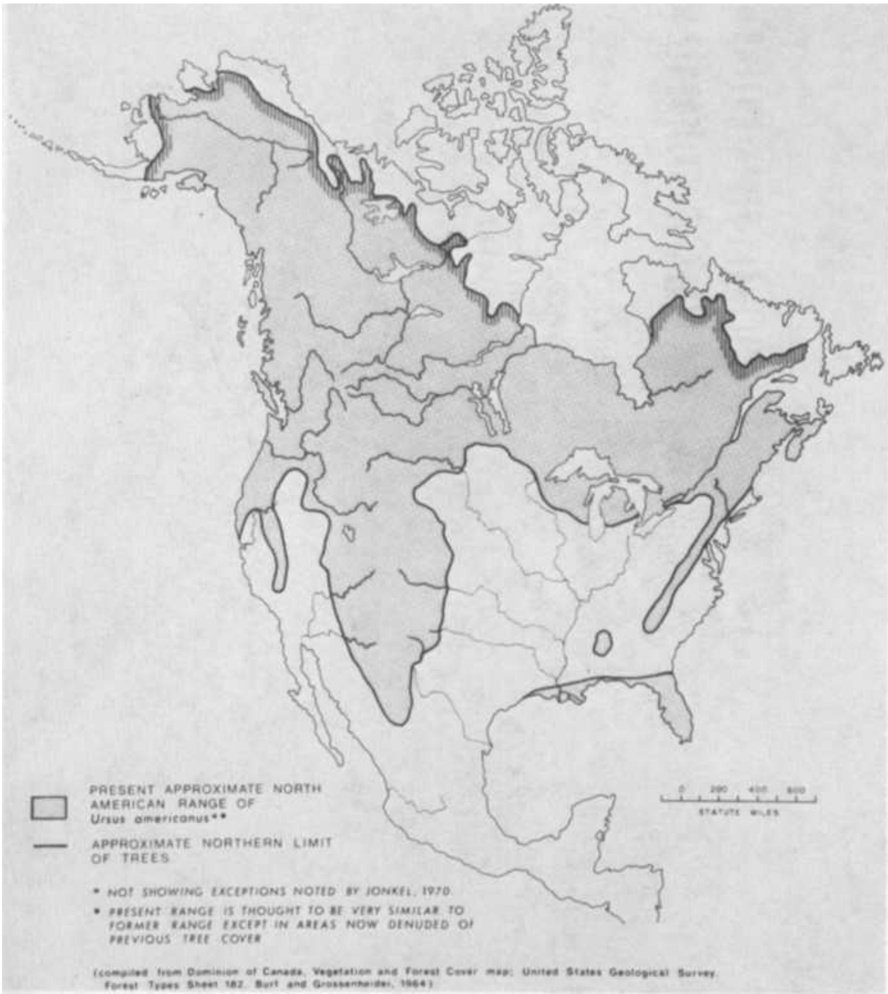
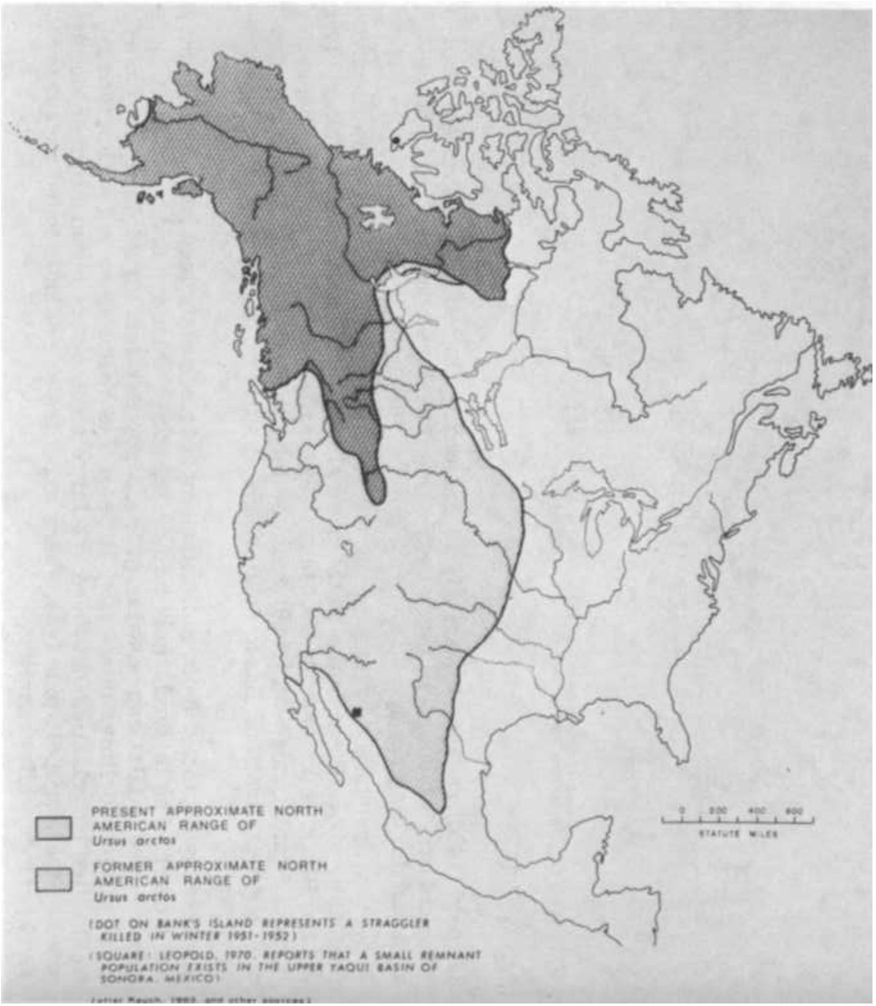


Fig. 2

Leopold (1970) regards the grizzly as primarily adapted to river valleys, foothills and brush lands. The black bear seldom ventured onto the open plains areas as did the grizzly.

In certain mountainous areas during the summer we find grizzly/brown bears frequently above the treeline on the open alpine tundra meadows and other open areas. Black bears seldom visit these seasonally rich habitats. The observations of Frank Craighead (1968) could be interpreted as giving partial support to this generalization. Based on 10 years of study of the grizzly in Yellowstone he says:

All the ranges plotted from radio fixes or bearings embraced both open country and timber. The factor largely influencing range selection and location is the open country habitat composed of grass, sagebrush, and forbs. This is a sagebrush grass subclimax type. Very little of this Yellowstone vegetation type is uninhabited by grizzlies, but there are large stretches of mature timber, dominated by the lodgepole pine type, where grizzlies are seldom found except for short periods while traveling.


PRESENT APPROXIMATE NORTH AMERICAN RANGE OF Ursus arctos
FORMER APPROXIMATE NORTH AMERICAN RANGE OF Ursus arctos
(DOT ON BANK'S ISLAND REPRESENTS A STRAGGLER KILLED IN WINTER 1951-1952)
(SQUARE: LEOPOLD, 1970, REPORTS THAT A SMALL REMNANT POPULATION EXISTS IN THE UPPER YAQUI BASIN OF SONORA, MEXICO)
0 200 400 600
STATUTE MILES


ORIGINAL DISTRIBUTION OF BEARS IN CALIFORNIA
GRIZZLY and BLACK
GRIZZLY
GRASSLANDS (1770)
(from STORER, T.I. and TEVIS, L.P. Jr., 1955; DASMANN, 1966.)

Fig. 4

Fig. 3

In summary, data show that in North America the black bears range is mostly limited to treed areas wherever the grizzly is also found. In certain areas such as the Ungava Peninsula, the present day absence of grizzly bears is coupled with occasional black bear venturing onto the tundra. The grizzly/ brown bear on the other hand may sometimes visit or live in forest areas, but mainly utilizes semi-open areas, such as the barren grounds or the alpine-tundra meadows of the mountains.

ADAPTATIONS OF THE BLACK BEAR TO THE FOREST BIOME

Black bears after reaching a certain minimum age are capable of expert tree climbing. This ability is reflected anatomically when they are compared to the grizzly: they have shorter and more narrow front claws, which are also more curved and are not much longer than their hind claws. The black bears' hind feet are also relatively shorter than those of the grizzly. The black bear is on the average lighter in body weight than the grizzly, although occasional old males may be larger than female grizzlies. This latter fact is not surprising since both species show significant sexual dimorphism with respect to body weight. Other morphological differences between the species suggest that the body of the black bear is adapted to climbing whereas that of the grizzly is not Conversely the longer front claws of the grizzly are more specialized for digging than are those of the black bear.

Over the course of several field seasons of observing black bears, I came to appreciate how significant trees can be for the day to day existence of the black bear (Herrero, unpublished observation). The ability to climb matures early in young black bears, probably around three months of age. In cold temperate regions climbing ability is probably developed in cubs by the time the family leaves the winter den (Herrero 1970a). Cubs climb in response to a variety of intrusions, especially close approach by non-family bears or by human beings. Thus they climb in response to potentially dangerous situations created by the presence of other animals, although they also climb for what seem to be many other reasons. Immediately or soon after perceiving an intruder, young cubs climb and, if the sow is nearby, she often positions herself near the base of the tree that the cubs occupy, or may even climb the tree herself. I believe that defense of cubs is intimately related to their climbing trees. Defense against what?—conspecifics, grizzly bears, or other carnivores both present day and extinct. As the cubs grow older the tendency to climb at the slightest disturbance seems to diminish, and more direct possible threats are required to tree them. Sub-adult animals (1½ to 4½ years) still climb, especially when directly threatened. Most old boars are able to climb as is shown by the ability of hunting dogs to tree them; however, in several years of field observations I have never observed a fully mature boar climbing or in a tree. The implied 'safety-factor' of tree climbing may last to a significant degree until a black bear matures and the behaviour patterns of the adult bear develop.

Black bears, however, also often climb trees when no intruder or obvious disturbance is present. I concluded that they also climb for the implied functions of shelter, sleeping, nursing, playing and protection (Herrero, unpublished observation). While difficult to quantify it seemed that alert vigilance often shown on the ground would be relaxed once in a tree. I believe that the main significance of tree climbing to black bears was that it led to a position of relative safety.

Many field observations suggest that black bears are very reluctant to venture far from trees. Erickson (1965) noted that garbage dumps in Alaska if located in open areas tended not to be visited by this species. Conversely dumps close to forested areas where there are black bear populations are almost always used for feeding. The distribution of black bears being correlated with the forest zone has been mentioned in this context. Meadows and forest edges are often choice feeding spots and will be utilized provided they are not too far from trees. Over a period of six months I repeatedly observed black bears crossing an open slope several hundred meters in extent. The slope contained several isolated large trees, and the path used by the bears commonly zig-zagged across the slope so as to go nearby these trees.

By contrast the grizzly/brown bear, while willing to enter the forest and to travel through it or shelter and feed in it, is more often found in more open habitats as already mentioned. Young grizzlies/browns are capable of tree climbing (reflecting this ability of their tree climbing ancestors) but this trait is lost by the time the animal becomes a sub-adult. There is no indication that trees are an integral element for the grizzly life style as they are for the black bear.

ADAPTIVE BEHAVIOURAL AND PHYSIOLOGICAL DIFFERENCES BETWEEN BLACK AND GRIZZLY/BROWN BEARS

I hypothesize that black bears are less aggressive, or less inclined to serious actual attack than are grizzly/brown bears, because of different selective pressures that acted in the past and are acting today on these two species.

First I want to try to establish and clarify my claim that the two species differ in their use of serious actual attack. The best evidence that I know of that is relevant to this claim comes from analyzing records of interspecific encounters between black bears and human beings, and grizzly bears and human beings. In the entire history of the North American National Parks which shelter the grizzly bear there have been at least 20 clearly documented cases of persons hiking in backcountry areas, suddenly coming on a grizzly sow with cubs, and the sow charging and subsequently injuring member(s) of the hiking party (Herrero 1970b). I have found no recorded instances of a black bear sow with cub(s) being involved in such an incident. However, each year many more persons are injured in parks by black bears than by grizzlies. This reflects a totally different factor—the willingness of black bears to associate closely with humans, and to beg or steal man's food or garbage. While not as aggressive as is the grizzly, the black bear is still a very powerful animal and is strongly motivated towards food.

Further support for aggressive differences between black bears and grizzly/brown bears comes from examining North American hunting records. No one needs to tell a keen and experienced hunter that grizzly bears are more dangerous than are black bears. Many hunters have been injured by brown/grizzly bears (Anonymous 1969 a & b), whereas even wounded black bears are seldom dangerous to man (Page 1969).

Analysis of very limited data on intraspecific interactions also supports the contention of differences in aggression between black bears and grizzly/brown bears. While intraspecific physical encounters are rare for both species because of highly ritualized agonistic behaviour, when such encounters do occur they probably more often lead to significant injury in grizzly/brown bears than in black bears. Limited data suggest the existence of more extensive facial and body scarring, and bone and tooth damage in grizzly/brown bears than in black bears. This question is now under study by the author.

Interspecific encounters between black bears and grizzly bears usually show that black bears avoid or flee from encounters with grizzlies. Cahalane (1947) has observed grizzlies to tree blacks. Grizzlies have also been observed to prey on blacks (Jonkel 1962), although the converse situation has not been seen. Black bears have been observed to leave dump areas when grizzlies arrive (Finley & Finley 1940; Herrero, unpublished observations). In some feeding competition situations, however, black bears may show dominance over grizzly bears (Barnes 1967). The general situation is that grizzlies dominate or even may on rare occasions kill black bears, and this I attribute to differences in aggression between the species.

I postulate that because of the use of trees it has been phylogenetically advantageous for black bears to be much less aggressive than grizzly/brown bears. When threatened by potential predators the grizzly/brown bear sow defends her young on the ground, and because of this terrestial habit the cubs are more vulnerable to attack than are black bear cubs. With the grizzly/brown species a highly aggressive sow is probably the most successful mother. However, this carries with it the risk of injury or death (albeit rarely) to the sow and thus decreased reproductive success. With extremely powerful animals such as bears, evolution has resulted in a minimum of serious intraspecific individual injury, and a maximum ritualization of agonistic behaviour, especially with reproductive units such as sows. However, with the grizzly/brown, given its habitat requirements and other characteristics, an incidence of injury must still exist because the cub(s) are defended upon the ground.

Because of possible injury to the bear sow during defense of the cubs it would be advantageous to have low violent aggressiveness provided that the cubs are still well protected. This has been possible with black bears because of the protective function of tree climbing. Aggressive tendencies shown by each species have probably been genetically transferred from sows to the species as a whole.

Given the significant difference in aggressiveness between the species, which I conclude is an adaptive specialization to different habitats, we may ask whether there are other related differences.

The answer is a tentative yes. Certain differences in reproduction may be related to the basic difference in habitat specialization and its by-product, aggression. Firstly, black bear cubs only stay with the sow for their first year and then part of the second year, until they are about 1½ years of age (Jonkel 1962, Cahalane 1947). Brown/grizzly bear cubs, in contrast, often remain with the sow for about 2½ years (Hensel *et al.* 1969; Craighead *et al.* 1969), As Cowan (1972) has pointed out there must be some advantage to remaining with the sow for 2½ years or those sows who wean at 1½ would come to dominate the population. This reproductive difference between black and brown/grizzly bears might be related to the evolutionary differences which I have postulated. Grizzly/brown bear cubs which remain with the sow for an additional year might be receiving among other things physical protection from grizzly/brown bear boars since they do not have the assured self-protection of tree climbing.

Additionally there is evidence that grizzly bear populations feeding extensively at dump areas have high mortality rates expecially in young age groups (Craighead & Craighead 1967), compared to mortality rates in young age groups of more naturally existing populations (Hensel *et al.* 1969). There is limited evidence that black bears do not show this sharp rise in mortality in young age groups even with very frequent dump feeding (Herrero, unpublished observations). In order to feed on a dump crowded with other grizzlies, a sow grizzly with cubs must either leave her cubs on the periphery of the dump or take them into a potentially dangerous congestion. Either situation is dangerous to the cubs, and is stressful for the sow. Grizzly bear boars have on more than four occasions been observed to prey on cubs in this situation (Craighead, J., pers. comm.). The Craigheads have also observed predation on cubs taking place in areas of more natural habitat. More important, I believe, would be the effect of stress on the sows, this in turn affecting the overall care of the cubs. A black bear sow, even with very young cubs, needs only to leave them up a convenient tree to assure their safety while she goes and feeds at a congested dumpsite where many conspecifics are feeding. Hence direct mortality from boars or other predators would be infrequent and non-specific stress would be less. Of course, this is only one of many possible interpretations of the observed species mortality differences in dump areas.

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Social Behavior of the Alaska Brown Bear

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INTRODUCTION

This paper concerns the social behavior of the Alaska Brown Bear (*Ursus arctos L.*) and the visual signals it uses to set up and maintain a social structure. Under most circumstances the brown bear is asocial. Exceptions are the relationships between mother and cubs; between siblings recently split off from their mother; and between male and female during the breeding season. Where especially good sources of food are available- in certain areas, bears may concentrate as at garbage dumps and salmon-spawning streams. If bears are to use such limited resources efficiently they must develop some form of stable society. The concentration of salmon at the McNeil River Falls provided the opportunity to study the formation of a social structure and to see how bears divided the food resource over space and time.

The study was supported by the Boone and Crockett Club, Carnegie Museum (Alleghenly Foundation Fund for Animal Behavior Studies), Theodore Roosevelt Fund of the American Museum of Natural History, Society of Sigma Xi, National, Park Service, U.S. Fish and Wildlife Service, and Alaska Department of Fish and Game. We wish to acknowledge the special help of James Faro, Robert Rausch and Lee Glenn of the Alaska Department of Fish and Game, and the field assistance of Ronald Spry and Molly Stonorov; and the drawings for figures by Martha H. Lester.

METHODS

Brown bears were observed from June 1 to September 1, 1970 at the McNeil River Bear Sanctuary managed by the Alaska Department of Fish and Game (Fig. l). Just above tidewater the river descends over and between a 150-yard stretch of large rock slabs—the so-called McNeil River Falls. The falls form the only obstacle for salmon on the river. Above and below the falls the water is too deep for bears to catch salmon readily. For these reasons 30 or more bears may use the falls at one time during the height of the salmon run (Fig. 2). For the same reason photographers are coming in increasing numbers at the very time the bears are at maximum numbers.

All observations of bears were made from a small cave 20 yards from the river. Most bears using the falls were habituated to humans and fished within 50 yards of the cave, but a few never came to the same side of the river as the observers. Thus when our field crew of 2-4 persons arrived at the falls in the morning, bears were usually well-spaced on both sides of the river. Later in the morning as the photographers arrived many bears would move to the opposite side of the river. When this happened considerable fighting or threatening would break out. But this did not disrupt the actual social structure.

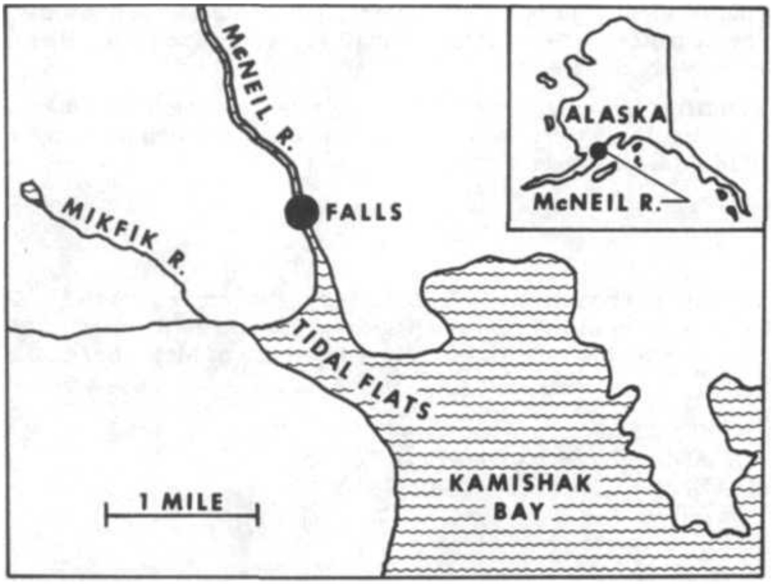

Fig. 1 Map of Alaska showing location of McNeil River Bear Sanctuary and detail of area around McNeil River Falls.

Fig. 2 McNeil River Falls, showing three single bears fishing and a mother and cubs awaiting their turn.

The capture and tagging of 13 bears with dart guns created temporary disruptions as did the occasional overflights by small aircraft. Except for these factors the bears were unmolested.

Bears were identified by facial characteristics, size, sex, scars, ear tags and collars. Our observations were made at various hours between dawn and dusk (4 A.M. to 9 P.M. Alaska Standard Time).

RESULTS

Fifty-two different bears visited the falls during the summer (Table l). At least 18 more were seen in the surrounding area, usually as they fished along Mikfik River and fed on the tidal flats at the confluence of McNeil and Mikfik rivers.

TABLE 1. AGE AND SEX COMPOSITION OF 54 BEARS SEEN AT McNEIL RIVER, JULY 1-AUGUST 15, 1970.

	Number Seen
Males, adult	11
Females with older cubs (12)	5
Females with spring cubs (3)	2
Females, single*	11
Subadult sibling groups (2 + 3)	5
Subadult (?) small and unsexed	4
Cubs	15
Total	54

* 7 known breeders and 4 of unknown age

When we arrived on the study area no salmon were running up McNeil River. Only the occasional bear passed by the falls. Instead, bears were feeding mostly on vegetation of the tidal flats and catching salmon that had begun to migrate up Mikfik River about June 7. Bears first appeared at McNeil Falls July 12, shortly after salmon arrived at the falls. Bears built up quickly in numbers, reaching a peak by July 28 (Table 2).

Final disappearance of bears from the falls came while some salmon were still present. The rapid disappearance of bears followed a sudden rise in the river which made fishing much more difficult. Bears were considerably more numerous at the falls in the afternoon than on mornings, a ratio of about 3:1.

Aggression between bears occurred as soon as they begun to arrive at the falls. An aggressive encounter is defined as any situation where two or more bears reacted with each other in such a way as to disrupt their ongoing patterns of moving, feeding or resting. We observed about 600 aggressive encounters and described the separate components of behavior for each bear during many of these encounters.

TABLE 2. NUMBERS OF BEARS SEEN AT McNEIL RIVER FALLS, 1970

Period of Observation	Mean No. Bears Seen/Day
July 7-11	0
July 12-16	10
July 17-21	19
July 22-26	24
July 27-31	31
August 1-5	27
August 6-10	22
August 11-15	11
August 6-20	5
August 21-25	2

It was possible to distinguish between the dominant and subordinate bears in most encounters. A bear was called subordinate when it backed up, walked or ran away. It might rarely lie down and approach a dominant like a fawning dog. The dropping of the head and facing away were additional criteria.

The social rankings of 22 bears are shown in Table 3. These include only those bears seen in at least 7 encounters, and excludes cubs. For the most part very large males were highest in rank. Two males (A and B), both present at different parts of the summer, never lost a decisive encounter to another bear. The disappearance of A the day before we first observed B makes us suspect these two bears had a decisive encounter at the falls when B first arrived there. While large males were normally dominant, one very aggressive medium-sized female (G) who had three large aggressive cubs, could on occasion back down every bear except A.

Below the top males came females with cubs one or more years old. Then came single females and smaller males, both presumably of breeding age as judged by comparing their size with known-aged bears. These single bears were almost completely subordinate to those above them, but were aggressive among themselves. Below these single males and females came sibling groups of non-breeders that traveled together. On occasion these non-breeding bears would dominate single bears in the group above them, but were mostly ineffective in dominating bears other than lone subadults. These lone subadults were at the bottom of the social ladder and largely avoided the falls. Three females with spring cubs also avoided the falls but probably for the safety of their cubs rather than any social inferiority.

The hierarchy was established and maintained by aggressive encounters. Four situations released aggression (the threat of, or actual, physical violence): (l) violation of individual distance, (2) loss of an encounter with subsequenc re-directed aggression toward a third bear, (3) competition for a choice fishing spot, and (4) what appeared to be initial meetings between strangers.

TABLE 3. SOCIAL RANK OF 22 BEARS OBSERVED AT McNEIL RIVER FALLS–1970

Losers Bear	Sex	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	Total wins
A	m	–	–	1	3	–	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	7
B	m	–	–	1	–	3	–	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	8
C	m	0	0	–	2	1	2	5	3	7	–	4	3	5	1	–	1	2	1	1	1	7	–	46
D	m	0	–	0	–	2	0	1	6	–	1	1	–	2	1	–	–	–	1	–	–	1	–	16
E	m	–	0	1	1	–	4	9	3	2	5	2	3	1	1	2	–	5	3	2	–	–	–	44
F	m	0	–	0	2	1	–	8	1	2	4	–	1	1	–	1	1	–	2	–	1	–	–	25
G	f*	–	1	6	1	3	0	–	5	11	12	1	2	5	–	–	–	–	3	–	–	8	–	58
H	f*	–	0	1	3	1	0	0	–	4	4	–	–	–	4	–	1	–	2	2	1	7	–	30
I	f*	0	0	3	–	0	0	1	3	–	2	4	1	3	4	–	–	4	7	1	–	7	1	41
J	f	–	–	2	0	5	0	1	2	1	–	1	3	1	1	2	–	3	2	1	–	2	–	27
K	f	–	–	0	0	0		0	–	0	0	–	–	2	–	4	0	1	3	8	1	–	–	19
L	f	–	–	0	–	0	0	0	0	1	0	0	–	2	1	2	1	6	0	11	1	3	–	28
M	f	–	–	0	0	1	0	0	–	0	0	2	–	–	3	0	–	4	3	–	1	3	–	17
N	f	–	–	0	–	0	–	0	0	0	–	0	1	0	–	2	5	–	3	5	–	1	5	24
O	m	–	–	–	–	0	0	–	0	–	0	0	0	1	0	–	0	0	2	4	–	–	–	7
P	f	–	–	0	–	–	0	0	0	–	–	2	0	–	1	3	–	2	4	4	1	–	–	17
Q	f†	–	–	0	–	0	0	–	–	1	0	6	3	0	–	3	2	–	–	14	–	–	–	29
R	f	–	–	0	–	0	0	0	0	0	3	0	1	0	2	1	0	1	–	1	0	2	0	11
S	f	–	–	0	–	0	–	0	0	1	0	3	2	–	–	1	0	6	1	–	–	0	–	14
T	f	–	–	0	–	–	–	–	0	–	–	0	–	0	–	–	0	–	1	–	–	1	–	2
U	f	–	–	0	–	–	–	0	0	0	0	–	0	0	2	–	–	–	4	3	–	0	–	9
V	f	–	–	–	–	–	–	0	–	0	–	–	–	–	0	–	–	–	1	–	–	1	–	2
Total losses		0	1	15	12	17	7	26	25	33	29	24	20	23	21	19	11	34	43	57	7	43	6	

• Females with cubs. † Three subadult females traveling and acting as a unit.

We recorded the individual behavior components seen during encounters to see to what extent bears used threat or appeasement signals to reduce actual physical contact. These components are described below and summarized in Table 4.

LOCOMOTION

Approach: Walk towards opponent.

Charge: Short run towards an opponent.

Run or Walk Away: Leaving opponent at run or walk.

Back Up: Backing slowly away from opponent, usually only step or two.

Stiff-legged Walk: A general tensing of muscles, especially of front. legs with knees locked. Animal walks slowly and deliberately with stiff-legged or rocking gait.

BODY ORIENTATION

Frontal: Body and head directly aligned with opponent.

Lateral: Standing broadside to opponent.

Sitting: Like a sitting dog.

Lying Down: Prone position with rib cage touching ground

Higher Elevation: Standing on higher ground than opponent.

HEAD ORIENTATION

Head Down: Head held below horizontal, often almost touching ground.

Head Drop: Sudden drop of head almost to ground and lower than head of opponent. Head held down until encounter ends.

Facing Away: Turning the head away from opponent (Fig. 3).

Neck Stretch: Head and neck extended forward with nose, ears, hump and rump horizontally aligned. Orientation toward opponent.

MOUTH

Mouth Open: Mouth open with lips covering canines.

Mouth open, but canines showing.

Muzzle Twist: As above but head rotated sideways. Often leads to jaw to jaw contact with opponent.

Jawing: Stereotyped, often mutual behavior consisting of up and down head movements, mouth open with no canines showing, ears back, lateral orientation, and stiff legs if not done from sitting position (Fig. 4).

EARS

Ears Back: Ears lying back on or near head with the openings not conspicuous from the front.

CONTACT

Bite: Mouth contact with opponent, usually directly at head.

Swipe: A blow with paw usually to opponent's head.

TABLE 4. BEHAVIOR COMPONENTS OF BEARS DURING ENCOUNTERS AND THEIR RELATION TO SOCIAL STATUS.

Behavior Component	Dominance	Subordinance
Approach	70	5
Charge	55	10
Run or walk away	0	82
Back up	0	52
Stiff-legged walk	31	24
Frontal orientation	51	21
Lateral orientation	3	12
Sitting	4	10
Lying down	0	4
Higher elevation	11	5
Head down	21	21
Head drop	0	12
Facing away	0	9
Neck stretch	32	10
Mouth shut	13	23
Mouth open	24	23
Mouth open, canines showing	35	17
Muzzle twist	13	2
Jawing	17	11
Ears up	13	14
Ears back	57	56
Bite	10	3
Swipe	17	4

Because of its short ears, short tail and long fur, a bear can not effectively use these parts as signals as do many mammals. Instead, orientation with respect to the rival and various movements are the primary means of conveying information to opponents. Certain components were associated largely with dominance: frontal orientation, approach, showing of canines, muzzle twist and neck stretch. Other components were shown largely by subordinates: lateral orientation, turning away and dropping of the head, and sitting or lying down. The data are inadequate to show whether any of these components have signal value, i.e. modify the behavior of an opponent. Nor can we reliably predict the

Fig 3 Subordinate bear on left showing 'facing away'.
Dominant bear on right showing 'frontal' orientation.

Fig 4 Bear 'jawing', directed at bear off the picture to the right. The jawing bear is seated at a good fishing spot.

sequence of behavior patterns as an encounter rises in the intensity and likelihood of attack. However, a typical high-intensity encounter went as follows. The two animals directly faced each other with front legs stiffened, heads slightly lowered, and began a dramatic slowdown in movement. Ears of both combatants were back with mouths wide open, exposing the canines. Salivation sometimes occurred. This phase of the overall encounter was called the 'confront' (Fig 5). If one bear did not back down at this point, a second stage, the 'charge' usually ensued. In a charge one or both bears ran at the other with head slightly lowered, ears back, mouth slightly open, and head and body oriented directly toward the opponent. If neither bear turned aside at this point there were swipes, biting, and locking of jaws. As the fight continued one bear eventually slowly backed away while dropping its head to an even lower position than its opponent. The fight usually ended at this point as the subordinate walked or ran away.

Fig 5 Bear 'confronting' an opponent off the picture to the left. Note lowered head and stiff posture.

When two bears widely separated in rank met, the dominant would typically face the known subordinate and slowly advance. The subordinate would then back away with mouth shut and head facing away (Fig. 3).

When bears of nearly equal status met, 'jawing' was likely to occur, often by both bears at once (Table 5). During jawing bears made rapid head lifts while facing each other and also low vocalizations. One bear often did this while sitting down (Fig 4). Jawing rarely led to actual fighting. More often one bear eventually deferred, i.e. turned aside, backed up, or walked away. 'Jawing' bears gave the impression of being in conflict between moving and staying put. Usually they were actually fishing or close to fishing positions where it would

TABLE 5. FREQUENCY OF 'JAWING' IN RELATION TO DIFFERENCE IN SOCIAL RANK BETWEEN BEARS.

Difference in rank between bears	Number of Encounters	Percent of total 'jawing' seen
1	7	13
2	7	14
3	6	9
4	7	13
5	8	16
6	5	10
7	3	6
8	5	9
9	3	8
10-21	0	0

have been disadvantageous for a bear to relinquish the place. Of the 52 instances of jawing recorded, 73 percent were between females, 12 percent between a male and female, and only 4 percent between two males.

As summer progressed the nature of encounters changed (Table 6). Encounters involving charges fell sharply; and deferrals rose correspondingly. Contacts and flight did not materially change. It appeared that dominant animals shifted to less intensive threat. Body and head orientation tended to replace showing of canines, and subordinates might inhibit attack by orienting laterally and sitting down.

TABLE 6. CHANGES IN THE FORM OF AGGRESSIVE ENCOUNTERS THROUGHOUT THE SUMMER, McNEIL RIVER FALLS, 1970.

	Percent Occurrence of Behaviors					
Date	Encounters seen	Charges	Contact	Deferrals	Flight	Jawing
July 14-18	66	62	14	36	19	1
July 19-23	101	43	11	52	29	5
July 24-28	168	33	9	53	18	13
July 29-August 2	81	15	10	73	16	12
August 3-7	60	27	10	67	23	7
August 8-12	58	16	5	67	21	17
August 13-17	3	0	0	100	33	0

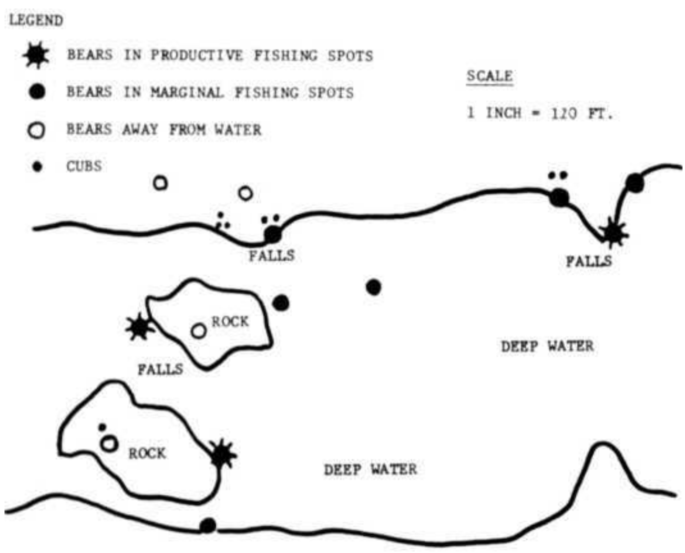

Fig 6 Typical distribution of bears at McNeil River Falls

Bears at the falls minimized competition and conflict not only by spacing out over the available fishing positions, but also through time. The longest a bear stayed at the falls was six hours, and usually much less. So a single fishing location could be used by many different bears during, the course of a day. Some bears were absent altogether some days. Whether this was caused by a need for a change in diet or through aggressive behavior, it served to reduce competition. In addition some bears were excluded entirely from the falls, notably mothers with spring cubs and lone subadults. Large bears forced these subadults away from the actual falls. This domination was so effective that some subadults would lie down close to an empty fishing location without ever making an effort to fish.

On a typical mid-July afternoon 15 to 20 bears would be in sight at the falls. Only four or five would be actively fishing. The others would be in marginal fishing spots or back from the river waiting for a fishing spot to become vacant. Figure 6 shows the best fishing locations at the falls and typical spacing between bears on such a day.

CONCLUSIONS

Brown bears meet at McNeil River Falls and contest over fishing locations for less than 45 days a year. During this time they develop a social hierarchy based upon sex, age and size. The social intolerance manifested in various forms of agonistic behavior results in a division of the fishing resource. The most dominant bears gain access to the most efficient fishing locations at will. Lower-ranking animals must wait their turn, use less efficient fishing spots, or even be forced to stay entirely away from the falls. If salmon is critical in the nutrition of the coastal Brown Bear of Alaska, high social rank may bring considerable advantage in weight gain and its subsequent influence upon over-winter survival and reproduction success. Social intolerance might therefore be an important factor in the population regulation of this unshot population.

PANEL 4: BEAR BEHAVIOUR

SUMMARY OF DISCUSSION

V. Geist. Mr. Stonorov, did you observe, at any time, any lengthy interactions between two males, very long drawn out interactions?

D. Stonorov. Yes, I did.

V. Geist. Could you describe a little bit more how these began and what kind of postures were used.

D. Stonorov. These long encounters between large males are more apt to happen earlier in the year. They probably would start with one bear being at the falls and another one arriving. You can get various kinds of body orientation between the bears—they might start out facing, pretending that the side seems to be important. Different head levels also seem to be important. They might stalk around and stop for a while. You know, nothing might happen and then you could get a very fast actual contact. These contacts could end violently. We saw one bear throw another bear down a river bank. It picked the other bear up in its teeth which is certainly a non-typical encounter.

V. Geist. Did you see any open wounds on the animals ?

D. Stonorov. We drugged the one that was bitten by the other bear and looked at it and it had quite an extensive wound. It did heal up though.

V. Geist. Where was the wound located?

D. Stonorov. Right below and back of the right shoulder on the bear. It was about, I think, 8 inches long and 6 inches wide. The bear was actually lifted up off the ground by the other bear.

G. Burghardt. I'll just make a couple of comments on the other papers where I think some of our observations may contribute. First of all, as far as tree climbing in cubs is concerned, we did extensive observations on tree climbing in our cubs and want to say that we certainly do support Dr. Herrero's comments on the ability of the cubs to climb very young. Our cubs, at 2 lbs, when they were found, were probably very shortly after coming out of the den. As soon as they were brought back to health, after 2 or 3 days, they were starting to climb trees, even though they were only about 2 lbs each. Also, as far as the forest preference of black bears is concerned, I think related to this is their great preference for shade. Part of this is certainly temperature but even on very cool days, where there's bright light even though it's cool, they would certainly prefer to be in the shade, which gave us great difficulty in taking photographs. Our cubs were very wary of small animals and of strange people. They would climb up the trees right away and sometimes, when visitors came over to see the bears, the bears would sit up in the trees until after dark. Sometimes the only way we could get them down—we didn't want to leave them up the trees all night—was with the flashlight and I had to guide them down. They sort of wanted to come down but were afraid.

S. Herrero. I wanted to comment on Mr. Stonorov's observed decrease in a number of encounters as the summer wore on, and the hint of increasing social stability after relationships were established. I observed a black bear population in Jasper which was feeding extensively at a dump. Early in the season, there were large numbers of encounters and then the number of encounters dropped off markedly as the season progressed, in what seemed to be exactly the same manner as Mr. Stonorov observed in the brown bear on the McNeil River.

Now I'd like to ask a question. Dr. Burghardt what do you see as the limitations of your developmental studies on bears, since they're done under somewhat restricted and unnatural conditions? In other words, what sorts of information can you get from such studies? Say that you conclude that olfaction has a certain acuity under your experimental conditions, then what do you conclude about olfaction in black bears?

G. Burghardt. Well this would set the limit, it would show that they can indeed discriminate such a concentration of a chemical from something else, or identify food sources. One type of study that we're hoping to do would be to put foods under various types of dishes or situations where they cannot see them or get any other cues under controlled conditions, and see how well they can identify bacon, say. We have a lot of actual evidence, how well they can perform on this, but not under controlled conditions. The general problem of captive bears, versus field bears is, of course, an important one. I think there are some advantages in studying captive bears. For instance by rearing animals under abnormal situations, you see behaviours that are triggered, that occur unnaturally. In the field, behaviours may seem to be more adaptive, more purposeful, as it were, than they perhaps really are. In captivity you can see behaviours misdirected, attachments formed which are not natural, and you can see what the limits of these are.

S. Herrero. A point that I'd like to make is that I would claim that you can see what the lower limits of sensory acuity are. In other words, you can say that the animal has, at least, so much acuity in the visual modality as you find, but you cannot say what the higher limits are in this acuity because you can't assume that you have a normal animal or that you've developed a maximum motivation or you don't know if you have your bear in its adaptively best testing situation.

G. Burghardt. Well, I might disagree in the long run. These are problems certainly which we would try to control. This is one of the reasons why we kept our bears in a large wooded area.

J. Craighead. I'd like to make a few comments on the social hierarchy of grizzly bears we've studied in Yellowstone National Park. Dr. Hornocker studied this rather intensively for three years and we've carried it on over the past twelve years. One of the things we wanted to determine is just how long a dominant male could hold the position as the alpha animal, under what conditions he was displaced, and how many males over a period of time would take over position of dominant animal in a population. At the Trout Creek dump, the numbers of individual animals coming in has varied between 90 and 120 in the course of the summer, over a twelve-year period. Beginning in 1959, there was a very, very old male. Judging from the ages that we've gotten from cementum layer technique on similar bears, he probably was 20-22 years old. He held the alpha position for one year, and then it was taken over by a young adult. He's one of the chief bears that we were unable to age, but we estimated his age at about 7-8 years at the time that he defeated this old male. He held the position for about 6 or 7 years, and every year he was challenged by a number of larger males. Generally 2-3 large males vied with this male at least once or twice in the course of every season. One year, a much larger male, again based on weights that we've taken of other males—he probably was close to 1100 pounds, maybe a little over—, dusted this particular male. He was fairly severely injured in one leg. He left the site for a period of two weeks and came back.

Whether he had another fight or not, we were not certain, we didn't observe one, but he did take over the commanding position, again dominant animal. And we've had now about 5 different males assume this role over a period of 12 years.

Our data on display behaviour has been very similar to that already discussed this afternoon. In general, the male starts aggressive behaviour by a stiff-legged walk towards another large male and the other male if he does not, or isn't prepared to, fight simply turns his head to one side, backs up slightly, and there is generally no encounter. If he doesn't do this, there will be a fight. Sometimes fights are very severe and particularly the neck regions of the bears are severely wounded. We've immobilized quite a few of these and looked at them carefully. The wounds may occur almost on any part of the body. In every case that we observed over many years, the bear that's defeated first shows this by lowering the head, turning it sideways, retreating a step or two, and then very often the winner of the conflict will turn his back on the defeated animal. In no case, I'd say, out of literally hundreds of observations have we ever seen the defeated animal take advantage and make an attack on the victorious male.

One other thing I wanted to mention in regard to Dr. Herrero's presentation is that we have now documented many more than 4 cubs that have been killed by large males in the spring, and these were not confined, by any means, to the dump area. We've also observations of male black bears killing young black bear cubs in the same manner.

S. Herrero. Do you have an idea of frequency or relative frequency for the black bears that you have observed?

J. Craighead. We had one observation, and there is another fairly authentic record of it occurring in Yellowstone. Two at least.

V. Geist. Dr. Craighead, may I ask what has been the mortality through intra-specific fighting amongst adult grizzly bears you've studied?

J. Craighead. As far as we know there has never been a mortality. We've found yearlings that have been killed, and severely chewed, mauled by another bear, but in all of the conflicts that we have observed we have no record of a grizzly ever killing another grizzly during combat, either during the breeding season or for favourable feeding positions at the dumps.

V. Geist. Could you possibly describe a little bit of the courtship behaviour of the grizzly bear ?

J. Craighead. Well, it's rather a long process. In general, the courtship begins in late May, early June. Females come into oestrus, but only about a third of the adult females in the population we observed. They remain so for varying periods of time, up to as much as 18 days with a quiescent period, and then comes a second period of oestrus. During this time, the dominant males will seek out the females. Subdominant males in some cases will travel with females during the time that they are in oestrus, up to sometimes 4 or 5 days or as much as 2 weeks. There are encounters then between the large males and very frequently the male that may win the encounter may not mate with the female. Females frequently run off during a severe encounter and then some other male may take up with her and they disappear into the timber over the hill.

V. Geist. You have no evidence of the female choosing a mate?

J. Craighead. There seems to be some selectivity, but generally the large males have their way. I'd say this, that there does appear to be definite preference on the part of some females for certain males, and a disinclination to mate with other males at any given time, but I hardly think that we could say the female makes a selection.

I would like to make one more point with regard to dominance. One large male, No. 12, which we observed closely for 6 or 7 years and that retained the dominant position, could almost have been likened to, you might say, a Churchill. He was far more interested in fighting and maintaining his position than in eating, and continually dispersed the other bears. He never backed down from an encounter. Whereas other bears that later took over his role were not anywhere nearly as aggressive. Whether this is an endocrine function or what, I don't know. This bear did not show up one year, we had no record of him being shot or killed and we don't know his final fate.

V. Geist. Did you ever see smaller males taking advantage of a male in the process of being defeated and backing down?

J. Craighead. Taking advantage in what way ?

V. Geist. Well, by attacking the second largest?

J. Craighead. No.

V. Geist. You don't have, in other words, gangs of grizzly bears.

J. Craighead. No. The other bears stay pretty clear of two large males when they are fighting.

S. Herrero. I wanted to add a few brief comments on the social hierarchy in the black bear population that I observed at Jasper, partly because it was organized differently from the social hierarchy that either Dr. Craighead or Mr. Stonorov has mentioned. What I observed was a more or less linear dominance hierarchy, such as they observed, except it was strictly a matriarchy. Here any sow which spent any amount of time in a dump-feeding situation was almost always dominant in any feeding competition situation, even over the alpha boar. Boars in addition had their own dominance hierarchy which was pretty well organized along size lines. But when you superimposed the sows on it, even the smallest sow would show dominance over even the largest boar and this was regularly and quite clearly brought out in quantitative data. I don't know if this would apply to all black bear populations, it's just a sample, but an interesting sample anyway.

F. Craighead. I'd like to add one comment to what John said, and then answer one of Dr. Herrero's questions. These dominant boars that have lost a fight permanently have all disappeared within the next year. Yet these animals have been in or close to their prime. We've never seen them again, even though they are large and have been marked, so that it's quite unusual that we haven't seen them. It's possible that there are psychological factors affecting these animals that held a dominant position and then lost it, and that they may die within a year or so. At least, there is indirect evidence that this might occur.

V. Geist. There is evidence from other species to support you fully.

F. Craighead. I think Dr. Herrero mentioned that, he didn't have an incident of black bears showing aggression in back country.

S. Herrero. I meant examples of black bear sows with cubs being surprised and then suddenly charging the human intruder and terminating the charge with contact.

F. Craighead. We had one incident where my son and a companion, working in the back country of Yellowstone were unable to chase away a large aggressive black bear that continually came after them in an area with just scattered timber, but close to extensive woods. This animal finally forced them up a tree, and they dropped their packs and let him get into them. There is another case where two subadult grizzlies and a very large black bear in back country were feeding on the carcass of an elk and the black bear at that time was feeding on the carcass several hundred yards from scattered timber. I had difficulty getting him to leave. I didn't see an encounter of this particular bear with the young grizzlies but I suspect from the time that we did see him on the carcass and the way he acted that he may, in this case, have been the dominant animal and kept the young grizzlies away, at least at certain times.

S. Herrera There were the observations made by Bray, who worked in Yellowstone setting out carcasses and observing feeding competition situations between black bears and grizzly bears. As I recall black bears were occasionally dominant, but not usually.

F. Craighead. I thought I'd comment on the other statement. I believe you mentioned that hunters had indicated that grizzlies were more aggressive than black bear. I won't argue with this, but there are quite a few incidents where hunters and others in the back country have killed grizzlies, either when they're hunting or not, out of the hunting season, feeling that they were being attacked. Their description of the attack is that the grizzly came toward them, then reared up and dropped down and came on. We had this happen many times. The grizzly has poor eyesight and there are occasions when we've been within 100 yards of them in the open, and the wind favourable so they couldn't detect us. Here they were unable apparently, to tell whether we were a coyote or human being. When this is the case, when they can't detect any smell, they approach and then rise up trying to get a scent, and then they drop down and come on. This has all the appearances of a charge, and it's one reason that many hunters or visitors to the back country will say that they have been charged by a grizzly. Of course, when the grizzly's doing this, even though he isn't charging, it's a good thing to climb a tree because if he gets within a certain distance, attack distance, and then finds that it is a human being, he may tend to charge rather than to flee, which is the usual form of action.

S. Herrera That's a very good point and is one of the reasons why I chose to talk about charges which were terminated with contact as opposed to just charges. I've been charged quite a few times by black bears, sometimes to very close distances, but fortunately these never terminated with contact. Again, what I'm saying is that the probability of charges terminating with contact, while it's very small with grizzly bears, is extremely small with black bears.

R. Russell. I had a firsthand opportunity one time in Alaska to observe aggressive behaviour, or inter-specific aggressive behaviour. In this case I was the other species. I surprised a grizzly which was eating berries at very close range, about 20 feet. I walked over a little hump in the ground and he had his head down in a berry patch and discovered me. We just froze in mid-step and looked at each other and then he turned and walked, didn't run, he walked very methodically in my direction and he came within 8 feet of me, facing me with his mouth open and occasionally chopping his teeth. At the time, we were photographing grizzlies and had had a number of encounters. Since there were no trees to climb in the Mt. McKinley Park we decided the best thing to do was to stand our ground. We always stood our ground and in every instance, it worked to turn the bear. This particular time, he came within 8 feet of me. I'd found a dead Dall sheep ram up on top of a mountain that day and I was on my way back to camp and I'd carried the two horns with me. When the bear approached, I started yelling at him and waving one of the horns over my head, I don't know why I did it, but I guess I figured I'd clout him over the nose if he made an actual grab for me. When he got within 8 feet he stopped and I continued to yell and wave my arm at him. Then he turned sideways and with his head lowered and made a very peculiar slavering noise, and then started to retreat, stepping sideways always with the head down, sort of looking at me out of the corner of one eye. He retreated in this manner, to about 30 feet and then turned and walked away, but periodically, he would suddenly turn and swap ends 180° and face me and then chop his jaws and sometimes paw the ground and flick his wrist. I think it took him about 20 minutes to retreat 300 yards. As he approached 300 yards I could tell that he was having difficulty in seeing me. He would peer in my direction and move his head around a lot. Finally after about 300 yards he turned" and started to run away. He ran right across the valley, I could see him for 5 miles, there were no trees. He ran right across the valley and over the range of mountains on the other side. Needless to say, once he started to run, I collapsed, but I did keep an eye on him with the binoculars until he was right out of sight.

A. Anderson. My question is on denning. I wonder if anybody has observed any establishment of territorial rights along with denning. Particularly I'm thinking of rubbing trees and this sort of thing.

F. Craighead. We've observed little or no territorial defence by the grizzly of a home range, or even feeding sites, other than the behaviour already described in the social hierarchy. The only opportunity that we've had observing a number of bears at a single den was one fall when two sows with three cubs between them continually visited back and forth between two den sites. There was no defence at all of an area or the den itself in this case. I think it's possible that there would be some defence of an area around a den or the actual den if a large boar was in the vicinity or came close but this apparently isn't too likely, because usually at this time of year they are either foraging off in an area different from the denning site or have already selected their own site and are preparing it.

V. Geist. Dr. Craighead, at what time of the year do you observe most of the rubbing behaviour that was earlier referred to? And who does most of it? Is there any difference within the sex-age classes?

F. Craighead. We've observed this most of the time soon after they come out of hibernation, and I don't think it has any connection with staking out a territory or territorial defence.

V. Geist. Would you agree that the bear is trying to scratch while the hair is coming off?

F. Craighead. Yes, I think he just wants to get rid of the hair or maybe there's some pitch from the boughs he's been sleeping on, or he just wants to scratch his back. I don't think it has anything to do with establishment of a territory, and all the ranges that we've plotted by radio and otherwise are overlapping; there's been no defence at all. The closest that we've seen to defence of an area was where an instrumented sow and her yearling were feeding on a buffalo that was drowned while crossing the Yellowstone River. A large boar also found it. It was in the spring with lots of snow on the ground and food was scarce. As the boar would approach this food source, the sow and yearling would move off and would remain away until he left. This came as close to defence of an area as any that we have observed.

S. Herrera. I'd like to confirm Dr. Craighead's observations for what limited data I have on the black bear population at Jasper. Here there did not seem to be territoriality as commonly conceived. Individual distance was maintained as we discussed previously. Other studies by Pierson in Washington and by Kemp in Northern Alberta, show that home ranges may have marked overlap.

With respect to rubbing or clawing of trees as a possible indicator of territoriality, I've observed near the city dump in Jasper several hundred instances of this, again more prevalent in the spring than the fall. I interpreted them more along the lines of the clawing being a sort of muscular movement in which the bears were sort of stretching and loosening up, and the rubbing either getting rid of hair or attacking fleas or just plain scratching their back. We did not detect evidence for this behaviour being a form of territorial marking. Dr. M. Holzapfel in Switzerland has however been working with captive brown bears and claims that they scent mark trees.

A. Anderson. In the Canadian Rockies I have observed that the grizzly goes back to the same tree, his rubbing tree, and the black does not, I just wonder if there's any significance there.

V. Geist. The mountain sheep does an enormous amount of rubbing. It has to, it's hair sticks in a very peculiar manner quite different from a deer. They also return to the same blocks and the same banks on which they rub themselves quite steadily. I would assume that a grizzly bear who has a certain area that he travels in, will use the same kind of trees, and frequently probably the same kind of bushes to go and just give himself a good scratch.

D. Stonorov. I think I can add one thing to this. Right near the McNeil Falls there is one grove of cottenwood trees and almost all the other vegetation is alders. Here I was wondering about possible scent communication. A lot of the times when you watch a bear it seems to mouth an alder bush. We did quite a little bit of identification of such places. We waited until another bear came along just to see whether it might mouth the same object. We found absolutely nothing other than randomness.

M. Pelton. I'd like to direct my question to Mr. Free. In 1968, we had a massive mast crop failure in the Smoky Mountain country which resulted in massive migrations of grey squirrels. It also had an effect on the bear population, I firmly believe, because in 1969, within the park boundaries, only two sows were reported with cubs. In the fall of 1969, we had one of the best mast crops that we've ever had, and this year, we have already reported numerous sows with numerous cubs, triplets, and quads in fact. I'd like to know whether in New York you've looked at your data in terms of frequency or intensity of mast failures as a possible answer to your synchronous breeding.

S. Free. We've considered this, in fact, we've had several meetings in past years with people from North Carolina, South Carolina, West Virginia and Virginia to see possibly if these mast failures weren't the cause of the harvest fluctuations. It's been unfortunate that we have no good way to document mast failures as such between states. Occasionally you will be able to, as in your case, document a specific mast failure, but we had no good way to document the relativeness of good mast versus bad mast. It's just been impossible to explain the effects of a mast crop, other than a complete absence of mast which will cause a tremendous migration of bears to some of the peripheral bear range. This has occurred, but we haven't noticed any change in cub production associated with it as you apparently did.

C. Jonkel. In regard to territoriality, I was certain that I found it with black bears in Montana. It was masked by groups of bears in that a group of bears in a certain part of a drainage that had some sort of relationship with one another and tolerated one another, would overlap in their feeding and in the places they travelled. However, at the same time, they could not apparently go out of the area that they lived in, nor would they tolerate another bear coming into that area, whether it were a transient subadult or bears living in adjacent areas. I felt quite certain that there was a territoriality, but that it was just masked by these groups of bears that had special relationships with one another.

Also, in regard to polar bears, both in James Bay and on Cape Churchill during our tagging studies we found again and again especially in the breeding season, and also during the fall, congregations along the coast in which there was real segregration by age as well as by sex. What it all means, I don't know yet, but there can be no doubt that certain age and sex groups stick together and exclude other age and sex groups from their areas.

I. McT. Cowan. I think we have to be very careful in generalizing from the very inadequate data that we're getting at this stage of our knowledge of bears in all parts of North America. We are too prone to say that this and that species is not territorial, when we've worked on it only in the deciduous hardwood forests of the east or only in the mountain forests of the west. I think that that territoriality is one of the adaptive behaviour patterns that can be associated with a particular kind of environment. This is the only way I can explain the vagaries of information that are coming out of different areas. This is one of the reasons why I'm particularly keen to see the diversity of studies on bears that are being generated in various parts of the world, because only in this way can we test and retest hypotheses that we're bringing out from certain detailed studies which tend to be localized and from which we're far to apt to generalize. After all, we've been brought up on generalizations. We say a mammal does this or that, when all we know is that somebody worked on white rats, white rabbits, white mice or perhaps domestic dogs. The number of species of mammals that we really know enough about to start generalizing is very, very small indeed. So I think that we have to be very careful in this kind of generalization and I would certainly support the comments that Chuck Jonkel has made; I don't see any other way of interpreting the data that he so laboriously obtained in Montana and that we worked over together many times.

F. Craighead. I think that this is true, that there might be variations from place to place but our observations in Yellowstone would indicate that where a social hierarchy is formed, it acts as a substitute for territorial behaviour and territorial defence.

G. Burghardt. I'd like to change the topic. I would like to ask Dr. Herrero, in particular, and anyone else with information from their field studies, what can they definitely say about the sow changing the behaviour of her cubs or shaping a specific type of behaviour? Let's take, for example, food preferences or food changes.

S. Herrero. There is the obvious example that the sow teaches the cub to feed at dumps and once this habit is established it can become a very strong habit and a very difficult one to break. The whole habit of feeding on human garbage, which we'll discuss tomorrow, is a classic example of learning in bears.

C. Jonkel. That's certainly what it looks like in the Churchill situation with the polar bears. Our study has shown that it's the same bears that return every year and the ones that learn from their mothers certainly return. I found a little bit of evidence of this in the black bear studies, also, in that I had two bears that behaved in a completely different manner than all the other bears. They weren't restricted by these different groups of bears or territories as I have mentioned. They would cross territorial boundaries to go to various dumps. These two did this every year and I assume that they probably had learned to do that when they were young. If this is operating in the polar bears, which it seems to be, and if from this dump feeding there is an advantage over the other bears in the area, then gradually the dump feeders will become more and more numerous in that area. This seems to be happening.

I. McT. Cowan. To me, it has always seemed that one of the most specialized forms of behaviour of a bear, particularly the grizzly-brown bear, is learning to kill large mammals. In my experience, it's fairly localized. It's many years since I did active field work in the parks, but at the time when I was working in Banff and Jasper parks, the killing of large game by grizzlies was, to my knowledge, unknown in Banff National Park. It was a frequent event in Jasper National Park, particularly in the bears that were localized about the Rocky Forks area of the Rocky River Valley. Over a period of years and I discussed this with the wardens that had lived for many years in the hinterland, there seemed to be a trend to disperse this habit from the Rocky area to a wider and wider circuit in Jasper Park, as if there was a spread of learning. I think that we can find plenty of parallelism for this. Young timber wolves at this time of the year weigh 70-odd pounds. They are scared of a sheep. They have to learn how to kill. Young mountain lions, so far as Hornocker was able to discover were virtually taught to kill and they were pretty inept at it when they first started. You find groups of young coyotes that are apparently taught to kill fawn deer. I can recall some groups that were living down in the Settlers Flats area of Kootenay National Park, living in the middle of established colonies of Columbia ground squirrels, eating no ground squirrels whatsoever. All of the scats that you could find in the whole denning area were of fawn white-tail deer. This group moved out of the park and lived on mule deer and white-tail deer during the winter. They were able to chase them down onto the ice of the rivers and lakes and have an easy kill. It seems to me that this learning is extremely important in predatory species, particularly with regard to the act of killing. The act of killing takes quite a lot of experience to acquire and where killing of large animals particularly is important in survival of these creatures, this is one the big hazards in becoming an established adult.

S. Herrero. Mr. Stonorov, is it also true that there is a large degree of learning of individual different methods in salmon fishing in brown bear populations? Do some of them specialize in catching salmon with their jaws whereas others scoop them out with their paws, or does this just depend on the situation? Does one bear have complete plasticity? Are these patterns transferred to the cubs?

D. Stonorov. I don't really know about the transfer of the patterns, but there's a great degree of learning when a cub learns to catch salmon all the way up until it gets to be near full size. At McNeil we sometimes saw a sow and cubs come down to the water. She would begin to fish and after a while they might start fishing too. Every once in a while one of them will pull a fish out. The fish does not become something to eat, the fish becomes a toy. The fish isn't killed. It might be grabbed by the tail and just run around. The mother will never notice, because this is complete reversal of the ordinary, where the mother catches the fish, and all the cubs chase it and tear it apart. Here the cub catches the fish and it's not really a food object. They have to learn how to fish. We had one bear down at the lake that we knew for two years. I estimated his age to be about 4. He was still having difficulty fishing. The younger bears like that, the subadults, usually get stuck in the tougher places to fish. A great degree of learning goes on.

E. Folk. There's some information about the polar bear which will contribute to this. I don't know what you think about some of the Walt Disney productions, but this comes from the Disney crew working with the polar bears at Point Barrow. The polar bears they had out on the ice at Point Barrow had been raised in captivity and brought from Holland. The trainers one day came back to camp talking of only one thing; there were some Eskimos that witnessed it also. A polar bear was down in the water and came back with a seal which it had killed. This animal had never been trained by its mother. I do believe we lack the information about transmittal of seal stalking and killing by the polar bear mother to the young. There are popular accounts of this. I wonder if there are any more careful accounts from anyone here who had seen a young polar bear catch a seal in the presence of its mother.

V. Geist. In regards to these yearling bears, I wonder whether the psychic factor could possibly enter into this. A bear that has lost its mother and is being chased around by other bears, may be physically a perfectly good specimen, it may be able to hunt, but it may not grow very well because of the fear that it has to endure. Chronic fear costs a lot of energy, incidentally. We do know, for instance, from studies on other animals that the defeated males can sometimes just wither away and die, but still be a perfectly good specimen. Everything is there but there is just that *something* that they had before when they were dominant that had disappeared when they became subordinate. In this context it was very interesting to hear from Dr. Frank Craighead about the defeated male grizzly bears.

T. Larsen. I would like to add some information about the capability of a polar bear to catch seals. We had an observation during our winter expedition in mid-May 1969 when we captured a yearling—she would have been about 15 months old—which obviously had lost its mother. It was an extremely skinny animal. It had no subcutaneous fat nor any internal fat. We concluded that it was not capable of catching seals, because there were many seals in that region.

I can also add some information about the aggressiveness in polar bears. I have seen a couple of times, out in the pack, old males or single males chase females with cubs in order, as far as we could see, to get the cubs and to kill them. We know from several trappers that when females have been killed, males who have accidentally come by have killed the cubs, or even yearlings.

Another thing, even more interesting, is looking through the skulls which can be found in the tanneries and which we have in the collections in Oslo. There are quite a few of these. They have damages in the lower jaw or even in the skull case itself caused obviously by other polar bears. So there seems to be a large amount of aggressiveness among polar bears. Certainly when we trap old males they have a lot of damage to the ears and they have scars everywhere.

V. Geist. Thank you. If I could just make one comment on the locality of damage in bears. One of the principles in the combat of animals is not necessarily to go to *kill* the opponent but to disarm his weapon system which he is about to use. One of these weapon systems is the mouth, and the defence is to snap and bite into that mouth and hold it tight.

This brings us to the question of cannibalism which appears to be cropping up with increasing frequency in the carnivores. I suppose nobody would object to saying that polar bears, grizzly bears and black bears, at times, can be cannibals. Now what are the times?

T. Larsen. What we found is quite strange. Out in the pack ice, in the summer, when bears were quite plentiful, I saw, at least 3 times, family groups that were chased by males. They actually killed some cubs even though these males were fat and is was obviously not difficult for them to get seals.

R. Russell. Dr. Jonkel and I in the summer of 1969—in August—found a female polar bear with two cubs of the year that had been killed by a large male bear near the Ontario-Manitoba border on the coast of Hudson's Bay. In this case the male was still at the kill and defended them against the helicopter. We hovered over the kills in a helicopter and the male did not leave. We came back the next day and collected the skulls and the female. According to measurements, she weighed about 500 lbs and the cubs about 100 lbs each. In each case they'd been killed by crushing or clubbing of the skull, although there were also cuts from scratch marks or tooth marks on the sides of the one—on one cub particularly which had not been eaten. The other cub was about 75 percent eaten. The female was lying on her back stretched out. He had partly skinned her and had eaten the fat but not the flesh. She was in very good condition. They had just apparently come off the ice. That summer the melting of the ice in the Hudson Bay was quite slow and all three of these bears had ring seal in their stomachs and intestines and they were apparently going inland. They had just come to the coast and were going inland and had either surprised him while he was sleeping in the willows or he actually may have stalked them.

In collecting scats in my food habit studies, I collected 550 faeces from the James Bay and the Hudson Bay coast and of those, I found traces of polar bear in many but I attributed this to grooming. There were 5 scats, however, in which there was solid polar bear hair and in two of these I found claws of young bears. Now, it could be that these had been scavenged but it's also very likely that they had been killed. But this was 5 scats out of 550, so there might not be a high instance of it but it certainly does happen.

G. Wakefield. Two observations on learning behaviour by bears. I had the honour, you might say, of raising two black bear cubs, as single ones. The first one I spent almost two years with. We got him after he'd been mauled by dogs in Virginia and nursed him back to health and then started taking him out into the woods. He had been taken away from his mother at a very early age, right after he came out of the den. I was taking him out and he was completely unfamiliar with what he was supposed to be doing in the woods. I started out by taking him up to the woods; I'd turn rocks over and he would show no interest until finally I turned one over and it had ants under it. I showed him the ants and he licked them up, and I kept doing this, and each time I would turn over a rock with ants under it he'd get a little more excited and finally he got to the place where, 'I'm going to beat you to the rock and I'm going to turn it over.' And this he started doing and after that he would do it. Then I'd take him into the woods he'd flip the rocks over and eat the ants.

Quite a few bears from Pennsylvania get into corn fields and feed on the farmers' corn. With this bear I took ears of corn, unhusked, and threw them in the cage with him. He didn't know what to do with them. I'd husk them for him and give them to him and he'd mouth them a little bit and put them down and then pick them up again and eat them and then I'd husk some more for him and throw them in and he'd eat them. Then I'd throw one in that wasn't husked, and he did nothing. He was really dumb. 'What am I supposed to do with this?'

The second observation I want to make is that we had four large black bear skulls in our collection, and I did not observe one of them having any damage to the skull at all. Mr. Free, I know has a good size collection of black bear skulls in New York. Have you observed any damage?

S. Free. They were damaged, but nothing that we could identify as having been damaged by another animal. There were bullet fragments and such like, but the most common damage was broken incisors and canines. As for having a mashed-in front of the skull possibly due to chewing or clubbing by a paw, in about 230 skulls the only damage we observed, outside of human interference, would be the broken incisors and canines.

G. Wakefield. With respect to these broken incisors and canines, I observed this once in one trapped bear that we had in a culvert trap. We were transporting it to where it was to be released. This was a female that we were separating from her cubs and she became so worked up that she started biting on the bars at the end of the culvert trap and she bit on those so much that she broke off just about every incisor on the upper jaw and both the gums on the upper jaw and lower jaw were bleeding very badly when we got her to her destination.

N. Payne. With regard to cannibalism in black bears we had only one instance this past summer on the program that we were undertaking in Newfoundland. In trapping at several dumps we had some 89 captures involving 69 animals and there was only one evidence of mortality that we experienced. This was a cub which we had tagged, and had caught in an Aldrich leg snare. It was killed by or presumably by a bear, during the night. We had sometimes up to 7 bears in snares during the night, around a single dump. But this is the only evidence that we had of mortality by cannibalism. The bear had been eaten, and the rib cage was exposed when we found it. It was a cub and it weighed 53 lbs with some of the meat removed.

L. Miller. I'd like to make a comment on cannibalism. I have seen it twice in brown bear. Once in 1961 when I was skinning-out a brown bear, I had another one jump me off Of the bear and, instead of coming after me, he immediately proceeded to eat the bear that I was skinning-out. Even when I hit him with rocks, I couldn't run him off of it. The next day when I came back to retrieve my gear, he had buried this bear and was lying on top of it and I had to kill the other bear to get it because I couldn't run him off even by shooting right in front of his nose.

The other instance was about three weeks ago on the Alaska Peninsula. We were flying and saw a large bear eating a cub and had a hard time chasing it off of it. Nearby we found the female with another cub. She was pretty scared and we couldn't run her out of the brush at all.

I'd also like to comment on these skulls. We've been collecting polar bear and brown bear skulls for the last ten years and have several hundred of each. I would say that, probably, percentage-wise there is more damage in the brown bear skulls as far as the jaws go. Some of them have very extensive damage and obviously damage that they've lived with for years because it has been healed over. In McNeil River in 1962 there was a big boar that had his lower jaw completely hanging down, and it looked like he was about ready to die. But we watched him for about a month and he did pretty good and next year he was back again with his jaw still hanging down.

Over the years we've seen quite a bit of scars on our brown bears at McNeil River and other places, some of them pretty extensive. Most were in the shoulder areas and in the neck and head but it didn't seem to bother them as they just went right ahead feeding.

Knowledge and Attitudes Concerning Black Bears by Users of The Great Smoky Mountains National Park

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INTRODUCTION

We have been interested in the interaction of black bears and people in the Great Smoky Mountains National Park. Beside its intrinsic interest, the primary impetus for the study is concern for the black bear's status in this area. As the land around the Great Smoky Mountains National Park has been developed commercially, the black bear has been confined to the Park and surrounding National Forest lands. The resultant reduction of the bears' foraging area seems to have reduced substantially the number of bears in the Smoky Mountains area. Further, the Park is used intensively by visitors (close to seven million in 1970). The close proximity of bears and people in the Park affects the habits of many, if not most, bears. They often lose their fear of people and become garbage eaters, campsite raiders and panhandlers.

It is unnecessary here to discuss in detail the many problems for both bears and people engendered by the intense use of the Park. These involve human injury and property damage by bears, foolish and even malicious behavior by tourists, roadbuilding and other developments by the National Park Service which encroach on the remaining wilderness, and serious poaching within the Park by local residents. Directly or indirectly all these factors combine to make the survival of the black bear in this area problematical.

One way to improve the general situation is to change the behavior of the Park visitors. If they became more informed about bears and the effects of their presence and actions on them and are familiarized with Park rules, presumably they would be more responsible in their treatment. More information would also enable Park authorities to take appropriate measures based on more objective data than is presently available. In order to facilitate this development, it is necessary to know more about the parameters of the visitors' knowledge and attitudes concerning bears. Even more crucial is actual observational evidence on how people respond to bears in various situations. Although some preliminary movie footage of roadside encounters between bears and tourists has been collected, we felt that prior to extensive observational studies (which by necessity will be limited to the more predictable and less serious types of encounters) a survey study was warranted to gather information on the general knowledge and background of tourists, which is difficult to obtain from individuals after candid observations have been made. Questionnaire studies are often a poor substitute for direct studies of an ethological nature. However, with unobtrusive, candid observations of groups of tourists interacting with bears *and* information concerning demographic variables, technical knowledge of bears and attitudes toward bears of various types of visitors, a relatively complete analysis of bear-human relations should be possible.

In the summer of 1969,Mr.Carlye Blakeney,then a graduate student in the Department of Forestry at the University of Tennessee, carried out a brief questionnaire study of 120 tourists in the Park. This study yielded some interesting findings. However, the relatively small number of visitors interviewed and the nonrepresentativeness of the sample made conclusions unwarranted. It was primarily a pilot study for the more intensive survey performed in the summer of 1970.

METHODS

A 42-item questionnaire containing questions roughly divided into bear knowledge, attitude, and demographic information was administered to users of the Park at seven different locations. Three of these locations were campgrounds (Cades Cove, Cosby & Elkmont);one was a tourist attraction(Clingman's Dome, the highest point in the Smoky Mountains National Park); one was the most popular hiking trail in the Park (Laurel Falls); another was a popular picnic area (The Chimneys); and the seventh was Newfound Gap, an overlook near the Tennessee-North Carolina line on the highest point of U.S. 441, the only road through the Park, which is heavily trafficked.

One hundred interviews were obtained at each site. The interviewers were instructed to obtain representative samples in age and sex of the people available. At each site half of the interviewed subjects were male and half female, leading to 50 interviews with each sex per site. This was considered appropriate since nearly all the Park visitors are in family groups or pairs. For age, the interviewers estimated the distribution of age at the site and sampled accordingly. Only one person from a given carload, campsite, picnic table, etc., was interviewed. The interviewers were also instructed *not* to avoid certain types of people, such as unpleasant or unintelligent looking ones (Sellitz, Jahouda, Deutsch & Cook 1959).

The questionnaire was administered in the Park primarily by Hietala with the assistance of volunteers (mostly graduate students and their wives in their 20's). These volunteers had a brief training period where the niceties of survey taking were explained to them. Interviews were conducted from July 2 to September 19, with over 95 percent of the interviews conducted during the peak summer vacation period from July 4 to September 7 (Labor Day). Prior to July 2 a 'dry run' of about 30 interviews was conducted to acquaint the interviewers with problems, such as misinterpretation of questions, embarrassment or annoyance at certain questions, and difficulties in sampling. Minor changes in wording and/or order of questions were made at this point.

RESULTS AND DISCUSSION

The survey forms were scored according to a code book and punched onto IBM data cards. Tabulation was facilitated by sorting the cards with an IBM card sorting machine. The data gathered permit a myriad of analyses, and only a partial and limited description of our findings can be presented here. Although 700 surveys were taken, only 500 were used in these analyses. Two of the three campsites were omitted so as not to weigh the data too heavily in their favor. Subsequent analysis of these other two campsites (Cades Cove & Cosby) will determine the amount of variation between sites of the same activity. This is only a preliminary report, and space limitations preclude consideration of the interesting site differences uncovered, as well as many other details and statistical analyses and discussion.

DEMOGRAPHIC CHARACTERISTICS OF THE INTERVIEWED PARK VISITORS

Age

Table 1A shows the age classes into which the 500 Park users fell. Here as elsewhere in this paper the unknowns primarily represent persons who did not choose to reveal the requested information. Persons younger than older teenagers were not interviewed since they were usually accompanied by adults; therefore, the first category listed is for those 25 and under. If we take that as one category and the rest of the ages up to 65 in 5-year blocks, it can be seen that until age 50 a rather even distribution of ages is represented.

Education

Table 1B indicates the highest year of education completed by the interviewed Park visitors. The modal and median level of education achieved was graduation from secondary school, that is grade 12. Less than 10 percent of the people had an education that stopped at grade school (grade 8) or less. However, over 20 percent of the interviewed did graduate from a 4-year college or attained even higher academic levels.

Occupation

The classification of the visitors into occupational groups was somewhat difficult. The classifications, if anything, probably erred on the high side. That is, a person is more likely to exaggerate his job than to underestimate it, and we were prone to rank people in the 'higher' category if questionable. Also, part-time workers, such as housewives, were ranked for the paid job, not as housewives. As can be seen in Table 1C, the occupational level of the visitors differed widely. Housewives were the largest occupational group, understandably so since 50 percent of the interviewees were women.

Population

Table 1D relates to the percentage of interviewed Park users who come from hometowns of various populations. It can be seen that 10.6 percent of the visitors are from rural areas, defined as communities of less than 1000. About one-third of the visitors come from small towns with population sizes of 5,000-50,000. Small cities of 50,000-100,000 are less represented, whereas over 23 percent of the subjects came from areas of 100,000-500,000.

VISITOR BEAR KNOWLEDGE

The survey contained 10 questions which attempted to assess technical bear knowledge on the part of the Park visitors. The questions ranged from factual ones, such as bear names, which are clearly right or wrong, to several for which adequate information is not yet available, such as longevity in the wild. However, based upon our best estimates, the response of a person was labeled as right or wrong. He was then given a score equal to the number of correct answers. Tables 2-4 present the scores given to the ten questions by all 500 people surveyed.

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF INTERVIEWED PARK USERS (Percent)

A. Age

<26	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	>65	Unknown
13.8	11.8	13.8	15.0	16.6	12.4	7.0	4.8	3.0	1.6	0.2

B. Highest Year of Education Completed

<5	6–8	9–11	12	13–15	16	17–18	>18	Unknown
1.4	7.6	11.2	37.6	19.8	13.8	5.4	2.6	0.6

C. Occupation

Unskilleci	Low level white collar	Skilled	House-wife	Student	Teacher (sub college)	High level white collar, executive	Profes-sional	Retired	Unknown
10.0	12.6	19.6	28.6	4.2	4.2	10.0	9.0	1.6	0.2

D. Population of Area of Residence

h 1,000	1,001–5,000	5,001–20,000	20,001–50,000	50,001–100,000	100,001–500,000	500,001–1,000,000	>1,000,000	Unknown
10.6.	11.0	16.6	16.8	8.0	23.4	5.6	7.6	0.4

Knowledge of Bear Names

Table 2 lists the response of all tourists to the questions concerning what young bears, female bears, and male bears are called. Virtually everyone recognized that a young bear is called a cub, while only about 10 percent knew that a female bear is called a sow and that a male bear is called a boar.

TABLE 2. KNOWLEDGE OF BEAR NAMES (Percent)

Young Bear		Female Bear		Male Bear	
Cub	97.6	Sow	10.2	Boar	9.6
Other	0.8	Other	20.4	Other	20.0
Don't Know	1.6	Don't Know	69.4	Don't Know	70.4

Food Habits

Table 3A shows that over two-thirds of the population correctly recognized that the black bear eats primarily material of plant origin. Since the bear is classed with the carnivores, such a high percentage of correct response indicates the familiarity that people have with bears at a certain level

Running Speed.

Table 3B gives responses to the question of whether the bear runs faster than, slower than, or about equal to human. Again over two-thirds realized that the bear, at its best, can run faster than a human, while only 12.2 percent felt that they, or at least a good physical specimen of *Homo sapiens,* could locomote more rapidly than a bear.

Recognition of Park Ranger

The Park presently has a policy of deterring bears from panhandling and bothering people along roadsides and campgrounds by 'tapping' them on the snout with a baseball bat. This stimulus does seem to dissuade the bear, and it soon learns to depart from an area upon the arrival of a Park ranger with or without a baseball bat, leading to the conclusion that the bear, in spite of his much maligned visual system, can recognize a Park ranger in uniform. Over two-thirds of the population agreed (Table 3C). However, this is one of those questions where 'yes' is considered a correct answer on the basis of present knowledge. Rigorous experiments of the type we are hoping to do with bear cubs will give us a better understanding of the bears' sensory abilities.

Bears as Pets

It is frequently claimed that many of man's foolish and unwary responses to bears stem from our culture which has in many ways attributed to the bear a friendly, gentle, even cuddly demeanor in addition to blatant anthropomorphism (largely due to its bipedal habits). Examples of this are comic strips such as Yogi Bear, Smoky the Bear fire prevention programs, teddy bear toys, etc. It is interesting then that over three-fourths said 'no,' to the question of whether a bear would make a good lifelong pet (Table 3D). If anything this answer is biased for having bears as pets since people limiting their answers to young bears or cubs were nonetheless classified as yesses. Our experience

TABLE 3. KNOWLEDGE OF BLACK BEAR FOOD HABITS, SPEED, VISUAL RECOGNITION, AND SUITABILITY AS PETS (Percent)

A. Diet

Mostly Plant Matter	Equally Plant and Animal	Mostly Animal Matter	Other Response
67.2	26.0	5.4	1.4

B. Speed

Faster Than Human	About Equal to Human	Slower Than Human	Don't Know
68.2	17.6	12.2	2.0

C. Recognition of Ranger in Uniform

Yes	No	Don't Know
67.0	31.0	2.0

D. Good Pets

Yes	No	Don't Know
21.6	77.4	1.0

is that while a bear cub may be an experience, even it would not qualify as a household pet except to those with the loosest concept of a pet or a house.

Newborn Cub Weight

In Table 4A are listed the responses of all the subjects to the question of the weight at birth of a black bear. The correct answer is approximately one-half pound. Scored as correct were all responses of less than one pound. Less than 10 percent of the population anwered this question correctly, and more people claimed that the bear at birth weighed over 50 pounds.

Average Adult Bear Weight

Table 4B shows the distribution into categories of replies on this topic. Our knowledge of the black bear in the Smokies, while not complete, leads us to believe that 200-399 pounds encompasses most adult bears. A black bear 400 pounds or more in the Smokies is a giant. Nonetheless, most people think the average adult bear is 400 pounds or more. Although the world's record for a black bear is somewhat over 700 pounds, more than 14 percent of the people thought that the average weight of the black bear was over 800 pounds, with some answers going as high as 2,000 pounds. Clearly, people have an inaccurate,

TABLE 4. KNOWLEDGE OF BLACK BEAR NEWBORN CUB WEIGHT, ADULT WEIGHT, AND LONGEVITY

A. Weight of Newborn Cub (Pounds)

<1	1–2	3–4	5–8	9–15	16–25	26–50	>50	Don't Know
9.2	4.0	7.6	11.8	20.2	17.6	16.0	9.8	3.8

B. Weight of Average Adult Bear (Pounds)

<100	100–199	200–299	300–399	400–499	500–599	600–699	700–799	>800	Don't Know
0.6	4.4	12.4	24.8	13.4	15.8	5.8	4.0	14.0	4.8

C. Longevity of Average Bear (Years)

<5	5–10	11–15	16–20	21–30	31–50	>50	Don't Know
0.2	15.6	20.2	27.0	17.4	19.0	1.4	9.2

conception of the size of the black bears. Perhaps they have been influenced by stories of the larger grizzly, brown or polar bears.

How Long Does a Bear Live?

Answers to a question on the longevity of the average black bear are presented in Table 4C. Although some actuarial studies indicate that the average black bear lives 10 years or less, the question seemed to be interpreted by most people as excluding mortality of cubs. Their interpretation was: Given a bear that is a young adult, how long is his life expectancy ? We scored 11-20 years as correct responses. Certainly bears have been known to live in captivity and in the field 30 years or more.

Conclusion

This bear knowledge group of ten questions yielded ten scores upon which we could classify people based on the amount of bear knowledge that they possessed. The number of people getting an answer correct ranged from less than 10 percent on some questions to over 97 percent on others, leading to a good mix of easy and hard questions.

CHARACTERISTICS OF PARK VISITORS IN RELATION TO BEAR KNOWLEDGE

Based on the 'correct' answers noted in the previous section, each interviewed subject could be given a bear knowledge score of from zero to ten. The modal and median score was 5 correct answers, and a rather remarkable normal distribution was found. Less than one percent of the subjects got all 10 items correct, and only about 2 percent had 9 or 10 correct. On the other hand, no persons scored zero, and only one percent of the people had as few as one correct response. In order to compare users more easily on bear knowledge, sub-groups were formed based on those who scored above the median (6 or more correct) and those who scored below the median (4 or less correct). In the high knowledge subgroup, there were 168 subjects, and in the low knowledge subgroup, 210 subjects.

Sex

A greater proportion of males scored higher than females. About 35 percent of the males scored 4 or less correct answers, whereas almost 49 percent of the females were in this category. Conversely, about 19 percent of the males scored 7 or more correct answers, whereas only about 9 percent of the females were in this category.

Hunting

It has often been claimed that hunters and other sportsmen are more knowledgable about the out-of-doors and wildlife in general than the nonhunter. Our findings somewhat support this conclusion. Approximately 37 per cent of the hunters scored 4 or less, whereas 43 percent of the nonhunters were in this category. When it comes to high bear knowledge, the differences are more marked with about 27 percent of the hunters and only 11 percent of the nonhunters scoring 7 or better. The median score for both groups, however, was 5 correct answers.

Age

Age did not show a consistent relationship with bear knowledge. In the under 36 categories, there were about 35 percent of the above median subjects and about 41 percent of the below median subjects. In the over 50 categories, there were about 15 and 18 percent respectively. The median category was 36-40 year for both groups.

Population of Home Area

In Figure 1 the percentage of above and below median scores is broken down by population of home area. It is clear that both rural (i.e., h 1000 population) and urban (i.e.,>50, 000 population) residents have more high bear knowledge people. A possible explanation for this finding for the rural resident is that he is likely to know about bears through personal experience and hunting as well as possessing general knowledge about large mammals. The highly urbanized person, on the other hand, probably benefits from a superior education or is motivated by the crush of the city environment to seek outdoor knowledge. The small town person, by this analysis, is deprived of both the personal and the 'academic' experiences which lead to greater wildlife knowledge and apprecia-tion.

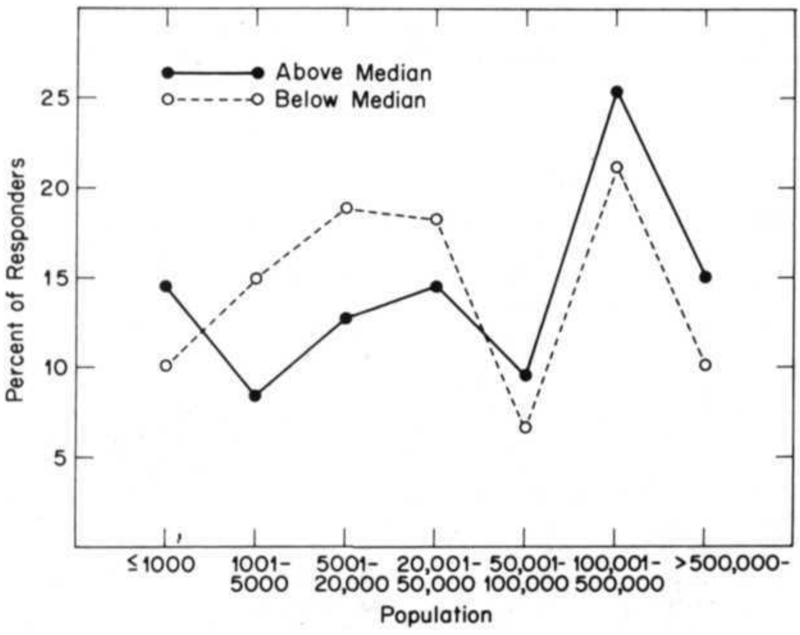

Fig. 1. The distribution in percent of the above and below median bear knowledge scores as a function of area of residence population.

Education

The median year of schooling for both high and low knowledge visitors was twelfth grade. However, while 49. 7 percent of the high knowledge visitors had at least some college education, only 35.1 percent of the low knowledge visitors fell in this category.

Occupation

Occupation was not related to bear knowledge to a marked degree. Unskilled and low level white collar workers accounted for 20.6 percent of the above median and 20.9 percent of the low median groups. Housewives were more common in the below median group, undoubtedly because it contained more women. Of the other occupational categories, only high level white collar and professional workers showed a divergence between groups with about approximately twice as many in the high knowledge category.

Attendance at Park Naturalist Talks

The Park Naturalist program is a popular one that entails considerable effort on the part of the Park personnel. However, primarily campers have access to this experience since most talks occur in the evenings at the campgrounds. Overall about 35 percent of the visitors had attended at least one Naturalist talk, although 68 percent of the campers at Elkmont had attended a Naturalist talk. With bear knowledge an encouraging but not dramatic relationship is seen with almost 40 percent of high knowledge visitors having attended a talk as compared to only 31 percent of low knowledge visitors. Such figures do not indicate that the bear knowledge was, in fact, acquired at the talk itself. The Naturalist talks vary in their content a great deal, and those who go out of the way to attend a talk may be those who already possess greater interest and prior knowledge of wildlife.

Source of Information on Black Bears

Although attending Park Naturalist talks did not dramatically raise the proportion of people scoring high in bear knowledge, perhaps there were other sources used which will better discriminate the high and low bear knowledge visitors. A question in the survey asked visitors their recent sources of bear knowledge. In Table 5 the various sources are listed in descending order of mention as determined by all subjects. More than one source could be mentioned. Almost 30 percent of the population had no recent source of information although the below median people were much more likely not to have any source of information. The second most popular response mentioned was the literature and brochures handed out by the Park. Again a large difference between the above and below median groups was apparent with the high knowledge visitors relying more on the Park literature. The road signs were the third most popular information source, and the below median groups mentioned this more than the above median group. Interestingly enough, the below median people were more likely to mention books and other written material as sources of information than the above median people. The exact meaning of this is not clear although it may indicate that most popular reading material dealing with bears is not very accurate.

Another interesting difference concerned the exhibit at the Sugarlands Nature Center in the Park. More than 4 times as many above median people mentioned that as a source than did the below median people. This indicates that these attractive informative displays could play a major effective role in visitor education. The Park Naturalist talks in contrast differed by only 0.5 percent, although in favour of the high knowledge visitor. Clearly such talks are not as effective as the Park literature and displays although a major effort to present bear information in them could alter the situation.

TABLE 5. PERCENT LISTING VARIOUS SOURCES OF INFORMATION ON BLACK BEARS AS RELATED TO BEAR KNOWLEDGE

Source (in decreasing order)	Above Median	Below Median	All
No recent source	25.9	36.7	29.6
Park literature	25.9	14.8	20.4
Road signs	14.5	20.5	17.4
Books, newspapers, magazines, etc.	10.2	15.7	14.0
Personal experience	6.6	5.7	5.8
Exhibit in park nature center	10.2	2.4	5.6
Television	4.2	3.3	5.4
Other people (friends, relatives, campers, etc.)	4.2	6.2	5.2
Park naturalist talks	4.8	4.3	4.6
Park rangers	3.6	2.4	3.4
Zoos or museums	1.2	1.0	1.0

Sighting of Bears in the Wild

Almost 71 percent of the visitors surveyed saw a black bear in the Park, whereas only 28.4 percent have seen a black bear in the wild elsewhere than in the Smoky Mountains. This indicates that of our population almost 50 percent (at the very least) of the population have experienced a black bear living free only in the Smoky Mountains. More persons in the high knowledge category have seen bears both in the Smoky Mountains and elsewhere.

VISITOR ATTITUDES

The questions discussed up to now have dealt primarily with factual information on bears and some of the characteristics of tourist bear knowledge. In this section attitudes and opinions are discussed.

Animals in the Park

Responses to a question as to what types of animals, if any, should be allowed in National Parks are given in the upper part of Table 6. In brief, combining all 500 persons together, almost 90 percent want all native animals to be in the Park. This result holds regardless of bear knowledge, but sex was a factor. Over 94 percent of the males wanted all animals in the Park as compared to only 85 percent of the females. As mentioned earlier, questionnaire studies are held somewhat suspect by the ethologist. He is convinced of the necessity of direct observation of behaviour. To check on the validity of this question, we immediately followed it with a similar inquiry as to what snakes, if any, should

TABLE 6. ATTITUDE TOWARD ANIMALS IN NATIONAL PARKS AS RELATED TO BEAR KNOWLEDGE (Percent)

Question		Above Median	Below Median	All
Animals to be allowed in National Parks	None	0	0	0
	Only small ones	6.0	8.6	7.4
	All	90.4	88.6	89.8
	Other responses	3.6	2.8	2.8
Snakes to be allowed in National Parks	None	21.1	34.3	29.0
	Only non-poisonous ones	17.5	22.9	21.4
	All	61.4	42.9	49.4
	Other responses	0	0	0.2

be allowed in National Parks (lower part of Table 6). Over 50 percent of all visitors would be in favor of eliminating either all snakes or at least poisonous snakes in National Parks. Whereas in the preceding question bear knowledge did not play an important role, in this question it did with more of the high knowledge people in favour of keeping all snakes in the Park and more of the below median visitors in favor of exterminating all snakes. In any event, over 45 percent of the people who said that they favored all native animals in National Parks did not 'really mean it' when snakes were brought to their attention. This example illustrates the influence one question can have upon another, as well as the problems in interpreting attitudinal as contrasted with factual questions. For instance, if the snake question has been asked first and was then followed by the animal question, it is probable that the response 'all animals should be allowed' would have decreased in both groups and perhaps also have then discriminated visitors in relation to bear knowledge.

What Bear Behaviour is Troublesome?

In asking a question attempting to uncover this information, visitors were allowed to mention more than one type of behaviour. The responses are shown in Table 7. Overall, aggressive behaviors, such as advancing threateningly or growling, were considered most troublesome with sheer proximity running a close second. Stealing food was also mentioned frequently with the other major classifiable responses being cited by less than 6 per cent. As might be expected, site of interview was an important parameter in the responses given.

TABLE 7. TYPES OF BEHAVIOR BY BEARS CONSIDERED TROUBLESOME BY PARK VISITORS (Percent)

Response (in descending order)	Site					Sex		Bear Knowledge		
	Chimneys	Clingman's Dome	Elkmont	Laurel Falls	Newfound Gap	Male	Female	Above Median	Below Median	All
Advancing threateningly, growling, etc.	33	37	27	28	29	30.8	30.8	31.5	28.1	30.8
Coming too close	18	18	24	36	22	22.0	25.2	19.0	26.7	23.6
Taking food from where it's being stored	16	16	28	18	10	18.4	16.8	19.0	16.7	17.6
Coming into campsites, doing damage	6	1	15	4	2	7.2	4.0	7.1	4.8	5.6
Just being around	2	2	4	4	7	4.0	3.6	3.0	4.3	3.8
Raiding garbage cans	2	0	9	3	5	4.8	2.8	6.0	2.9	3.8
Bears aren't troublesome	2	6	5	0	2	2.4	3.6	2.4	3.8	3.0
Injuring people, biting, killing	4	3	3	0	3	3.2	2.0	1.8	2.4	2.6
Blocking traffic	2	1	3	2	3	3.6	0.8	2.4	2.9	2.2
Other responses	14	11	8	7	17	10.8	12.0	12.5	11.0	11.4
Don't know	8	9	0	3	6	4.4	6.0	4.8	6.7	5.2

The Elkmont campers were most concerned with food stealing and were more concerned with campsite damage and garbage-can raiding than any other group The Laurel Falls hikers were the only group most troubled by a bear coming too close.

Although site was a factor, sex and bear knowledge, surprisingly, were not too important. Males and females had almost identical percentages and rank orderings. But it is interesting that 4 times as many men as women mentioned blocking traffic as a consequence of the presence of bears ('bear jams'). Men are undoubtedly more likely to drive and hence get annoyed in such situations, although a more basic sexual difference responsible for this result cannot be ruled out. It was surprising to us, nonetheless, that bear related traffic problems were not listed more frequently than they were.

What to do with Troublesome Bears

Bears that are potentially troublesome can lead to unpleasant incidents and, consequently, decisions what to do with them. Although the bear may not be technically at fault, it is easier and more politic for authorities to blame bears rather than visitors or their own policies. In asking a question as to what the Park should do with troublesome bears, a definition of a troublesome bear was not given, although if pressed the interviewer was instructed to say 'one that disturbed camping or picnicking.' As in the preceding question a person could give more than one answer. In Table 8 are the percentages advocating a given solution to a troublesome bear problem. Over half the visitors feel that the

TABLE 8. WHAT TO DO WITH TROUBLESOME BEARS AS A FUNCTION OF BEAR KNOWLEDGE
(a percentage of replies mentioned an alternative)

Response (in descending order)	Above Median	Below Median	All
Remove to another area in park	57.2	41.4	51.2
Put in cage or zoo	13.9	24.8	19.0
Destroy bear (usually qualified as a last resort only)	18.7	19.0	15.8
Do nothing with bear	8.4	6.7	7.6
Remove outside of park	9.0	2.9	6.0
Don't know	0.6	4.8	2.8
Other	3.0	2.9	2.6
Leave decision to authorities	1.8	1.4	1.6
Establish special feeding area	0	1.0	0.8

proper solution is to remove the bear to another area in the Park. The second and third most popular solutions are to put the animal in a cage or zoo or to destroy the bear, although the latter was qualified by many people to be employed only as a last resort. All the other response categories were mentioned by less than 10 percent overall, although 'do nothing with the bear' was mentioned by almost 8 percent, indicating a sizable fraction of visitors who perhaps feel not only that people are at fault in most bear-human incidents but that the solution is to control human behavior rather than do something to the bear.

The most popular solution, removing to another area in the Park, was much more frequently mentioned by above median persons than below median people. This is interesting in light of the evidence presented in this volume and elsewhere that removal to another area within a park's boundary is usually unsatisfactory because of the homing ability of the bear. Most National Parks are not large enough to exceed the homing distance. However, the above median people were also three times more likely to mention removal of the bear to a wild area outside the Park and were far less favorably inclined to put a troublesome bear in a cage or zoo. In view of the high popularity for removal operations and the fact that destroying is acceptable to most people only as a last resort, if at all, authorities who attempt to eliminate troublesome bears by other means should expect to encounter some criticism and be willing to publicly justify their procedures and even educate the citizenry. The educated layman may be greatly influenced by television shows and other semidocumentary evidence based on dramatic removal and stocking operations without being aware of the difficulties involved and the need for scientific evidence. Of course, it is assumed tha a park's bear-management techniques are based upon scientific information. Responding to criticism by referring to the aroused public as emotional or ignorant will be self defeating since it is the high bear knowledge person who is most in favor of removal operations and wants the bears to remain free.

Why Are People Injured?

The evidence discussed above shows that troublesome bears are not primarily thought of as those which physically injure people. Yet human injury or death caused by bears are perhaps the most feared and certainly the most sensational types of bear-human encounters. Such incidents can precipitate campaigns and actions which could threaten the very survival of bears in National Parks and other areas (e.g. Moment 1970). While no death due to the black bear has ever been recorded in the Great Smoky Mountains National Park and the danger posed by even larger species may be overstated (Herrero 1970), the chance of physical injury is ever present. This is especially true when the often foolhardy behaviour of Park visitors is considered.

Table 9 gives the reasons listed by visitors concerning why humans are injured by bears. Feeding bears was the most popular response with more of the above median group listing it than the below median group. Annoying or taunting bears was second in popularity, although mentioned more by the below median group. All other answers were mentioned much less frequently with some differences between groups. Many human injuries caused by bears involve a sow with cubs. Although particularly true of grizzlies, it is nonetheless surprising that less than one percent of the subjects mentioned this as a factor. That bears are naturally vicious or actively seek to hurt people was hardly ever mentioned.

TABLE 9. VISITOR ATTITUDE CONCERNING WHY PEOPLE ARE INJURED BY BLACK BEARS AS RELATED TO BEAR KNOWLEDGE (Percent)

Reason (in descending order)	Above Median	Below Median	All
Feeding bears	36.2	27.1	30.6
Annoying bears	23.5	29.5	26.2
People go too close	7.8	12.9	11.2
Disregard rules	12.7	18.8	11.0
Careless, foolish, ignorant	6.0	9.0	7.2
Their own fault	6.6	2.4	4.0
Playing with bears	2.4	3.8	3.6
Other responses, don't know	1.8	4.3	2.8
Bears look cute, gentle	1.2	1.4	1.6
Trying to take photographs	1.8	0	1.2
Involves sow with cubs	0	1.0	0.6

Why Do People Feed Black Bears?

Since feeding bears is responsible for most bear injury reports in the Great Smoky Mountains, a question as to why people do this was included in the survey. Table 10 lists why visitors feed black bears. The most popular answer is that people are ignorant or stupid, and it was more likely to be mentioned by the above median than the below median person. The second most popular answer was that it is human nature to break rules. Almost as popular were forgeting the warnings or that bears look tame, gentle or harmless.

What About Park Regulations?

Should the regulations be essentially as they are now? Should they be more strict? Should they be more lenient or even left to the discretion of the tourist? The latter response was quite unpopular as shown in Table 11. In fact, two-thirds of those interviewed felt that the rules and regulations as presently stated were adequate. However, over a quarter of the people were ready and willing for more strict regulations or enforcement. The above median people were more disposed to tightening up, indicating that as people learn more about wildlife, they are more prone to want it protected. The primary rule in question is the one posted on many signs throughout the Park stating that it is unlawful to feed bears.

Confrontation

Several questions in the survey deal with visitor attitude toward the seriousness of bear behavior and what one should do during an interaction with a bear. Only one of these questions will be discussed here, a hypothetical situation in which the visitor met a bear on a trail. The responses are listed in Table 12.

TABLE 10. VISITOR ATTITUDE CONCERNING WHY PEOPLE BREAK RULES AND FEED BLACK BEARS AS RELATED TO BEAR KNOWLEDGE (Percent)

Reason (in descending order)	Above Median	Below Median	All
People are ignorant, stupid	25.3	17.6	21.0
'Human nature' to do so	13.9	13.3	13.0
Forget the warnings	9.6	11.9	12.6
Bears look tame, gentle	10.3	12.4	11.6
To take pictures	12.1	5.7	8.4
Curiosity	4.2	11.0	8.2
Showing off, wanting something to brag about	3.0	8.6	6.0
To observe them	4.8	7.2	5.4
Excitement	7.2	1.4	3.8
Other reasons	6.0	5.2	5.4
Don't know	3.6	5.7	4.6

TABLE 11. ATTITUDE ABOUT RULES CONCERNING BEARS AS RELATED TO BEAR KNOWLEDGE (Percent)

Question		Above Median	Below Median	All
Rules concerning tourist behavior towards bears should be	left to tourist	3.0	4.3	3.6
	left as they are	60.2	70.5	66.4
	be more strict or better enforced	34.3	21.9	26.0
	Other responses	2.4	3.3	3.0

TABLE 12. ANSWERS OF VISITORS TO QUESTION CONCERNING WHAT THEY WOULD DO UPON MEETING A BLACK BEAR ON A TRAIL (Percent)

	Bear Knowledge		Sex		
Response (in descending order)	Above Median	Below Median	Male	Female	All
Walk slowly away	29.5	30.5	34.4	26.4	30.4
Stand motionless	24.7	22.9	26.0	24.0	25.0
Run away	14.5	20.9	10.4	23.6	17.0
Move aside, keep distance, avoid	22.9	10.9	22.0	11.2	16.6
Do nothing	1.2	2.9	1.6	2.0	1.8
Frighten or scare bear (shout, throw stones, etc.)	1.2	2.4	2.4	1.2	1.8
Try to hide	1.2	1.4	0.8	2.4	1.6
Climb a tree	1.2	1.4	0.4	2.0	1.2
Other responses	2.4	4.3	1.2	4.8	3.0
Don't know	1.2	2.4	0.8	2.4	1.6

The most popular response was to walk slowly away. This was mentioned by about 30 percent of all people. Whereas bear knowledge did not discriminate answers given to this response, males were more likely to mention it than females. The next most popular was to stand still, motionless, freeze, etc. The third most frequent response mentioned was to run away, certainly not too wise since running often stimulates chasing. Below median people were more likely to mention it than the above median, and females were more likely to list this as a response than were males. Since females are, on the whole, perhaps less adept at running than males, it would seem as if this was something of a panic response. A far less popular response of the same type was climbing a tree (black bears are good climbers), which was five times more likely to be mentioned by women than men. The fourth most popular alternative was to avoid, move aside, keep one's distance, etc. It was cited by more than twice as many above median than below median people and by males over females almost in the same ratio. All other responses were listed by only 3 percent or less of all visitors, but it is interesting that attempts to frighten, scare off or throw objects at the bear were listed by twice as many below median as above median persons and by twice as many males as females, indicating that ignorant bravado may be at work.

CONCLUSION

A large amount of data has been presented which, nonetheless, does not do justice to the survey as a whole. Certainly, many of the responses to given questions could have been analyzed by looking at other factors than those emphasized here. However, the main goal would seem to have been realized—a better understanding of the knowledge and attitudes toward bears by Park visitors.

We warn against too literal generalizations of our findings. The limitations of both the survey approach and our particular application of it should be emphasized. Certainly our overall findings are not based upon a random analysis of all Park visitors. Nonetheless, we are basically confident in the value and reliability of such an approach and believe ours and similar surveys can provide much objective and useful information concerning bear knowledge and attitudes. With the current resurgence of interest in the environment and the place in it of wildlife, a similar survey in the Great Smoky Mountains National Park five or ten years from now might be especially interesting and informative.

ACKNOWLEDGEMENTS

This study was supported in part by Research Grant MH-15707 from the United States Public Health Service and the Agricultural Experiment Station, Institute of Agriculture, University of Tennessee. We also thank the volunteer interviewers, the staff of the Great Smoky Mountains National Park who cooperated fully, Idonna Tillery for typing, and Lori S. Burghardt for editorial advice.

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Preservation and Management of Grizzly Bears in Yellowstone National Park[1]

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SUMMARY

The paper presents general information on grizzly bear (*Ursus arctos*) numbers, increases in park visitors, the extent of human developments (campgrounds, etc.), and garbage disposal facilities within Yellowstone Park. Data are also presented on grizzly relationships to developments, garbage disposal sites, humans, and the results of management. Conclusions are made on conditions which favored the preservation of a grizzly population, the desirability of eliminating artificial food sources, the effects of repeated transplants of bears, and management actions which could reduce the opportunites for injuries to humans and the need to control bears.

INTRODUCTION

The grizzly bear is part of the native fauna of Yellowstone National Park. The preservation of a representative grizzly population is integral to the park's basic purpose. This is to preserve natural environments and native biota as an integrated whole (i.e., ecosystem) for their scenic, educational, cultural and scientific values.

This paper was written to make unpublished information on the grizzly available for reference use. It shows that human influences which altered bear habits increased opportunites for injuries to visitors, conflicted with a stated objective to preserve the grizzly under natural conditions, and generally degraded the esthetic and scientific values of the grizzly. The desirability of maintaining grizzlies under natural conditions is shown by comparing the 3 injuries to humans from bears in the 'wild' over the past 40 years with the 60 injuries that were caused by bears which were attracted to high visitor use areas by natural food.

METHODS

Figures on grizzly numbers were compiled from park records. These were mainly in annual wildlife reports. Figures between 1930 and 1959 had been variously based upon yearly counts of up to 150 bears and/or estimates by park personnel. Those since 1959 had been based upon annual counts of 154-202 individually marked or unmarked bears, as reported by Hornocker

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[1] This Paper has been previously published in *BioScience* 21 (16): pp. 858-864; 1971.

(1962), Craighead & Craighead (1967), plus estimates. Counts were primarily of bears that were concentrated at or in the vicinity of garbage disposal sites during the summer. Estimates generally attempted to account for bears which remained in scattered distributions in the remote portions of the park.

Information on visitor numbers, developments, garbage disposal facilities, bear injuries to humans, and management activities was obtained from current park records or reviews of past correspondence and administrative reports. Interpretations were aided by the author's association with bear control and visitor protection activities, by interviews with park rangers who had carried out such activities since the 1930's, and coincident observations of grizzlies while carrying out research on wild ungulates in both the remote back-country and more accessible portions of Yellowstone Park since 1962. Grizzlies had been individually marked from 1959-1967 as reported by Craighead *et al.* (1960 and 1969).

RESULTS

Grizzly numbers

Population estimates for 10 years in the 1930's ranged from 160 to 310 and averaged about 240; 6 years in the 1940's, 200 to 320 with an average of 235; 4 years in the 1950's, 150 to 180 with a 170 average; 9 years in the 1960's, 200 to 250 with a 220 average. The reasons for the lower estimates in the 1950's were not apparent. The accuracy of population estimates between 1930 and 1959 could not be assessed. Those since 1959 could be conservative because the portion of the population which remained in the more remote areas of the park was underestimated.

A population of 200 grizzlies within Yellowstone's approximately 3,400 square miles would represent an average density of one bear per 17 square miles; 300 grizzlies, one bear per 11 square miles. Densities of one grizzly per 9 square miles have been reported for Glacier National Park by Martinka (1969), one per 15 square miles for Mount McKinley National Park by Dean (1958) and for a northwestern Montana area by Jonkel (1967). The density figures from these Rocky Mountain regions indicate that the general estimates of about 200-300 grizzlies for Yellowstone Park since the 1930's were reasonable.

Randall's (1961) accounts of hunting and trapping grizzlies outside Yellowstone Park boundaries suggest that bears which inhabited or ranged into these areas were either eliminated or greatly reduced in number during the early 1900's. Hunting ceased in Yellowstone Park after 1886. The park grizzly population has probably since occurred at 'carrying capacity' levels. Accounts and records of bears moving outside the park, that may reflect regular or periodic emigrations, are presented by Skinner (1925), McCracken (1955), Craighead *et al.* (1964), Craighead & Craighead (1967). The carrying capacity of the peak environment for grizzlies since the early 1900's could be lower than previously because of a reduced biomass of wild ungulates (possibly one of a limiting food source complex) and/or lowered habitat security levels (Errington 1946). The latter would occur where grizzly home ranges included areas outside park boundaries that became heavily hunted.

Park visitors

Numbers of yearly visitors to Yellowstone increased from about 1, 000 to 260, 000 between the establishment of the park in 1872 and 1929. The average number of visitors per year was about 0. 3 million during the 1930's, 0. 5 million during the 1940's, 1. 3 million during the 1950's, and almost 2 million during the 1960's.

From the late 1880's through the 1920's most visitors traveled to the park by train and stayed at inns or hotels. After 1930 most visitors came by car and increasing numbers camped outdoors. Eleven campgrounds with a total of 1,119 campsites were present in 1940; 14 campgrounds with 2, 253 sites in 1969. During 1969, about 16 percent of 2.1 million visitors stayed an average of 2. 6 nights in park campgrounds.

Developments

Approximately 95 percent of Yellowstone Park's 2. 25 million acres are wild lands. The remaining land is in roads or developments, such as campgrounds, hotel, inn and cabin sites, and miscellaneous other visitor or administrative facilities. Units which were a campground-other-facility complex, as well as those which were only campgrounds, are collectively called 'developed areas' or 'developments.' The locations of six major (with 200 or more campsites) and nine minor developments are shown on Figure 1. None were fenced to exclude bears.

Garbage disposal

Approximately 7 thousand tons of garbage were collected and disposed of within the park each year between June 1 and September 15 of 1968 and 1969. The location of dump and incinerator sites are also shown on Figure 1. Only the Mammoth area incinerator was completely enclosed within a bearproof fence. The two other incinerators near the Grant Village and Bridge Bay developments left sufficient unburned food to attract bears during periods of mechanical difficulty or when the volume of garbage was greater than their burning capacity. Garbage dumps were unfenced pits.

Grizzly relationships to developments

The number of campsites in different developed areas, the distances to the nearest garbage sources at dumps and incinerators, and the relative use of areas by grizzly bears (as reflected by control actions) are shown in Table 1.

Habitual use was considered to involve repeated intrusions into developed areas by individual bears between June and September, as well as seasonal intrusions between May and mid-July or September and October. Seasonal intrusions occurred from animals traveling through a developed area to some place else, from breeding season movements and associations of males with females, and from food-seeking by particular bears before garbage became available at disposal sites (usually in June) or after sites ceased to be used in the fall.

Five of the six major developed areas were 8 miles or less from garbage dumps. Table 1 shows these areas were habitually used by grizzly bears. Two incinerators that were within ¼ to 2 miles of three of these developments probably contributed to habitual use. Intrusions into the major Madison development and nine other areas with approximately 100 or less campsites were comparatively rare or not known to occur.

Relatively high numbers of grizzly control actions (numbers of bears transplanted or destroyed) have occurred in 1935, 1937, 1942, 1949, 1959, and during at least four years since 1963. Conditions that may have contributed to the

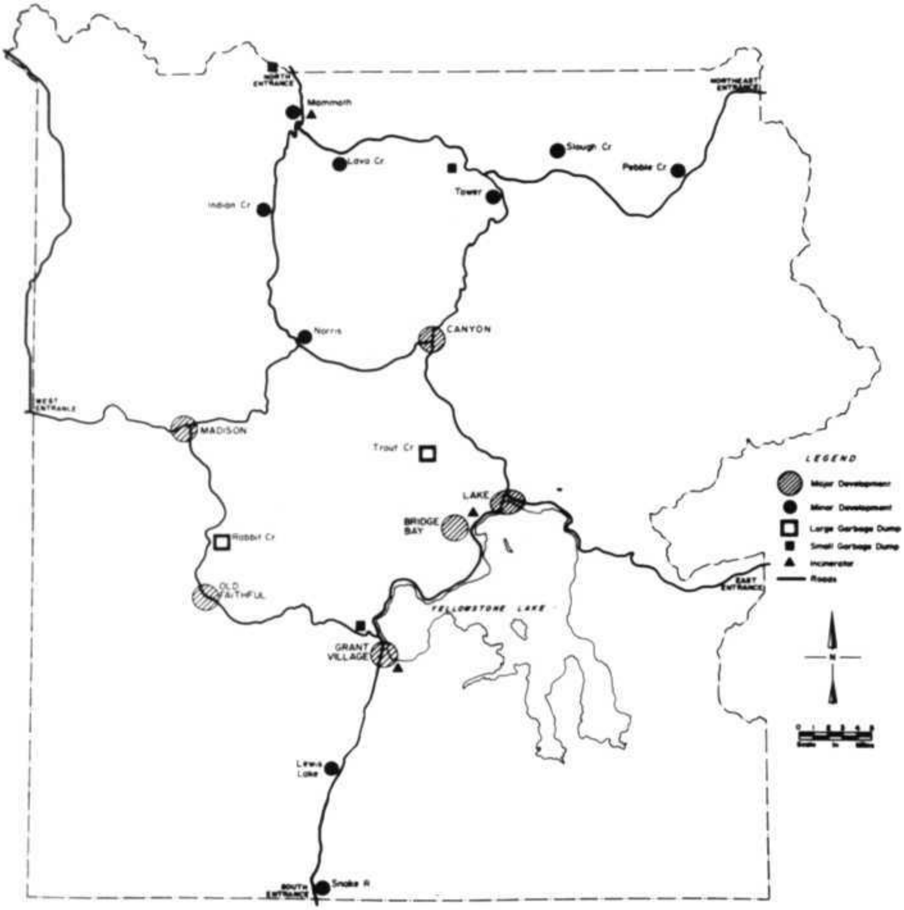

Fig. 1 Location of park developed areas and garbage disposal sites.

relatively high numbers of control actions during 1968 and 1969, were yearly carryovers of animals that repeatedly returned from transplant sites (discussed later), the presence of garbage in non-bearproof cans within some campgrounds, and an experimental 'phasing out' of artificial food sources that involved dumping separated 'edible' garbage for bears at the Trout Creek site. The latter may have contributed to some bears intruding into certain park developments by intensifying the behavioral interactions among the variously dominant and subordinate animals that fed at this dump.

About two-thirds of the grizzlies that were removed from the Canyon, Lake Outlet, and Bridge Bay developments in 1968 and 1969 were marked animals (discussed later). Data were not available, but it is suspected that most of these bears had been marked at or near the Trout Creek dump, or had a history of occurring at this dump area either prior to or in conjunction with their use of developed areas. During 1968 and 1969, only unmarked bears were observed or captured in the Grant Village development which was 18 miles from the Trout Creek dump. Some of these unmarked animals were believed to have come from the small dump about 4 miles from Grant Village. This dump was

TABLE 1. RELATIONSHIPS BETWEEN CAMPGROUND SIZE, DISTANCES TO GARBAGE DISPOSAL SITES WITH AVAILABLE FOOD, AND GRIZZLY BEAR USE DURING 1968 AND 1969.

Developments	No. campsites 1940	No. campsites 1969	Miles to nearest Dump	Miles to nearest Incin-erator	Control actions† 1968	Control actions† 1969	Habitual use by grizzlies
Old Faithful	300	Closed	4		1(1)‡	‡	Yes
Canyon	250	340	8		14	16(4)	Yes
Lake Outlet	300	428	7	2	16(3)	25(5)	Yes
Grant Village		433	4*	½	20(1)	5(1)	Yes
Bridge Bay		230	7	¼	8	9	Yes
Madison	35	292	9				No
Norris	20	116	13			1	No
Lewis Lake		100	11			1	No
Mammoth	100	91	5*				No
Indian Creek		78	10				No
Tower Fall	30	53	4				No
Four other units	84	92	8-20				No
Totals	1119	2253			59(5)	57(10)	

* Closed or garbage not available after 1967.
† Number of times bears removed by capturing for transplanting or destroyed with latter in parentheses.
‡ Repeated attempts to capture other grizzlies unsuccessful.

closed in 1968. The lower number of control actions in the Grant Village development in 1969 apparently resulted from partially successful transplants of grizzlies which first intruded into this area in 1968.

Other factors also influenced grizzly bear use. Bearproof garbage cans were not present in all portions of the Canyon and Lake Outlet campgrounds until the fall of 1968; nor Grant Village and Bridge Bay campgrounds until the spring of 1969. Such 'bear-proofing' reduced the amount of artificial food for bears within these campgrounds. During the summer of 1969, the only available food within park campgrounds was from visitors failing to put their edible camp supplies in the trunks of cars or a similarly secure place. Despite distributed and posted warnings that this would attract bears, enough camp food was available in larger campgrounds to attract some grizzlies.

The locations of the Canyon, Lake Outlet and Grant Village developments at the edge of physiographic barriers (rugged canyon or Yellowstone Lake) probably placed these areas in the path of grizzly travel routes. The locations of the first two on or adjacent to large unforested areas with fertile alluvial soils (with relatively high densities of rodents and bulbous plants) also placed these in what appeared to be superior spring and, in some years, fall habitat for the bears. The suggested overall relationships were that habitual grizzly use was influenced by the physiographic locations of developments, the distances developments were from garbage dumps or incinerators, and the quantity of garbage or edible camp supplies within larger campgrounds.

Grizzly relationships to garbage disposal sites

Hornocker (1962) reported from his studies in Yellowstone Park that grizzlies traveled long distances to concentration sites that centered around garbage dumps. Individual bears traveled from areas within as well as outside the park. The numbers using a dump progressively increased from June to a peak around August 1. Dispersals of bears from concentration sites occurred rapidly after about mid-August and while dumps were still operating. Hornocker concluded that garbage food sources affected bear distributions and movements, but were not a major factor in determining population numbers.

Craighead *et al.* (1969) considered the movements of grizzlies to use artificial food at refuse dumps during the summer 'a special type of migration.' Distances between the summer and autumn ranges of individual bears were reported to be 10-75 miles or more. The migrations of some grizzlies from distant areas to a garbage disposal site probably resulted from previous garbage feeding experience as a young animal. Jonkel (1967) postulated such relationships for black bears (*Ursus americanus*). Some adult males may have initially encountered garbage food sources during the course of breeding season movements or mid-May to mid-July mating associations with females (Craighead *et al.* 1969) and not have been 'garbage-raised' as young animals.

Jonkel (1967) reported that most black bears that used natural food either lost or maintained their weight during the period after they emerged from hibernation to mid-July. Studies by Murie (1954), Martinka (1969) and Tisch (1961) indicate that the natural summer foods of grizzlies and black bears are primarily herbaceous plants. Apparently garbage or camp groceries are a highly palatable supplement to natural summer diets which do not result in weight gains.

Murie (1961) reported that the behavior of grizzlies was one factor in keeping animals widely distributed in McKinley National Park. The home ranges of single adults, family groups and weaned young overlapped broadly, but spacing (between individuals and social groups) was usually maintained by what could be considered avoidance behavior. The agonistic behavior of female grizzlies was pronounced in the defense of young. Dispersals of weaned young from family associations were gradual or occurred abruptly as a result of the agonistic behavior of maternal females. Murie considered the close association of 30 grizzlies he observed on a Yellowstone Park dump as an apparent loss of 'wild natural habits.' Aggregations of about 20-30 bears were known to occur at the Trout Creek and Rabbit Creek dumps during the summer of 1969. Craighead *et al.* (1969) reported that between 98 and 132 grizzlies were annually attracted in summer to the Trout Creek area.

The concentration of grizzlies at garbage disposal sites, in combination with the behavior of adult animals, may have contributed to greater intrusions of young bears into park developments, i.e., as compared to young animals remaining on or dispersing from more scattered summer home ranges. Hornocker (1962) reported a definite peck order and what could be considered high levels of agonistic behavior among variously dominant and subordinate animals that fed at a dump. Weaned young, separated from females, and young adults ranked as the most subordinate animals.

Some grizzlies that fed at garbage dumps became conditioned to accept (i.e. not avoid) the presence of humans and/or to respond positively to the appearance of garbage-hauling equipment. Young bears, females with young and some adults may have made such behavior adjustments to obtain food before it was appropriated by other dominant, but more wary (of humans) animals. The indicated overall relationships were that garbage food sources altered the natural summer distributions of a substantial portion of the park grizzly population and placed concentrations of interacting bears within comparatively short distances of certain park developments.

Grizzly-human relationships

Two grizzly-caused fatalities have occurred within Yellowstone Park over the past 97 years. One in 1907 involved a visitor who chased a cub up a tree, prodded it with an umbrella, and was fatally injured by the responding female bear. The other fatality occurred in 1916 when a Government employee attempted to chase a large grizzly from a freight wagon containing edible camp supplies.

Sixty-three known and probable grizzly-caused injuries to humans have occurred within the park over the 40 years since 1930 (Table 2). The data show that less than proportionate increases in injury rates occurred with increases in visitor numbers during all but the 1950's. As will be discussed later, the decrease in injury rates during the 1950's mainly resulted from differences in bear control procedures.

TABLE 2. VISITOR NUMBERS, INJURY RECORDS AND NUMBER OF BEARS KILLED FOR CONTROL IN YELLOWSTONE NATIONAL PARK, 1930-1969.

Period	Average No. visitors (millions)	No. known and probable injuries*		Injury rates per visitor	No. grizzlies killed for control
		Visitor	Employee		
1930's	3.2	4(1)	2	1: 800, 000	23
1940's	5.5	9	3(1)	1: 610, 000	42
1950's	13.6	5(4)	1	1: 2, 720, 000	25
1960's	19.5	38(12)	1	1: 510, 000	37
Totals	41.8	56(17)	7(1)	1: 746, 000	127

* Number circumstantially probable in parentheses.

Table 2 also shows that consistent relationships did not exist between increases in visitors and the numbers of grizzlies killed for control. Some direct relationships between higher injury rates to humans and bear kills were indicated, but this was additionally influenced by control procedures.

About 75 percent of the 63 grizzly-caused injuries to humans were minor to the extent that they required only first aid, sutures, or lesser treatment on an out-patient basis (Table 3). The other 16 injuries (25 percent) entailed overnight or longer periods of hospitalization for treatment of shock and/or injuries.

Grizzly-caused injuries occurred predominantly in park campgrounds and to visitors (Table 3). Of the 60 known and probable injuries in such areas since 1930, 43 occurred while persons were in sleeping bags or bedrolls either in the open or in tents; 4 resulted from walking confrontations in areas where bears had been fed for tourist viewing; 7 were walking confrontations in campgrounds (6 during daylight and 1 at night); 3 resulted from attempts to chase bears away from camp food; 1 from an attempt to pet a bear in a culvert trap; and 2 from unknown circumstances.

Only three persons are known to have been injured while hiking in park backcountry areas between 1930 and 1969. Two of the injuries occurred in 1966; one in 1960. All were caused by female bears with young. Martinka (pers. comm.. 1969) reported that 8 and possibly 9 of the 10 injuries that occurred while persons were hiking (one photography attempt) in Glacier National Park over the past 20 years resulted from natural defensive actions of female bears with young. The two fatalities and three other injuries to humans within Glacier Park during this period were caused by animals that habitually frequented developed areas to obtain garbage or camp food.

The suggested relationships in Yellowstone Park were that human influences in the form of artificial food were basically responsible for most (95 percent) of the grizzly-caused injuries over the past 40 years. The three injuries that occurred in the 'wild' resulted from the natural defensive behavior of females with young.

Management

Park objectives to preserve a grizzly population under natural conditions and provide for the safety of visitors appear to have been formalized during the 1930's. Management to accomplish these objectives has involved removing bears which come into developed areas and regulating human activities or influences to decrease the opportunities for bear-caused property damage or injury to humans. Grizzlies were removed from developed areas by capturing them with culvert live traps or immobilization drugs (after 1962) and by shooting.

The removal or control of bears by shooting during years between 1930 and 1962 appeared to be variously *responsive* and *preventive* in relation to the incidence of injuries (Figure 2). Removals during years without injuries or prior to the occurrence of injuries were considered preventive. Removals by shooting between 1963 and 1965 were apparently deferred despite high injuries. Those since 1966 reflect a progressively increasing response to a somewhat sustained occurrence of injuries.

Changes in removal procedures after 1962 were influenced by increased concern for the grizzly as a rare species. Bears that had become trap-shy from previous experiences with culvert live traps and would have been destroyed in previous years were repeatedly captured and transplanted by the use of immobilizing drugs. Additional deferments from destroying particular bears were made because marked animals were important to research studies and critical public reactions to 'destroying too many bears.' These deferments

TABLE 3. RECORDS ON GRIZZLY-CAUSED INJURIES TO HUMANS IN YELLOWSTONE NATIONAL PARK, 1930 TO 1969.

	No. of injuries*	Conditions							
			Sleeping in			Treatment		Persons	
Periods	Developed areas	Back-country areas	Bag†	Tent	Other	Out-patient	Hospitalized	Visitor	Employee
1930's	6(1)	0	1	1	4	3	3	4	2
1940's	12(1)	0	3	5	4	12	0	9	3
1950's	6(4)	0	4	1	1	4	2	5	1
1960's	36(12)	3	7	21	11	28	11	38	1
Totals	60(18)	3	15	28	20	47	16	56	7

* Number attributed to grizzly by circumstantial evidence shown in parentheses.
† Sleeping bag or bedroll on ground.

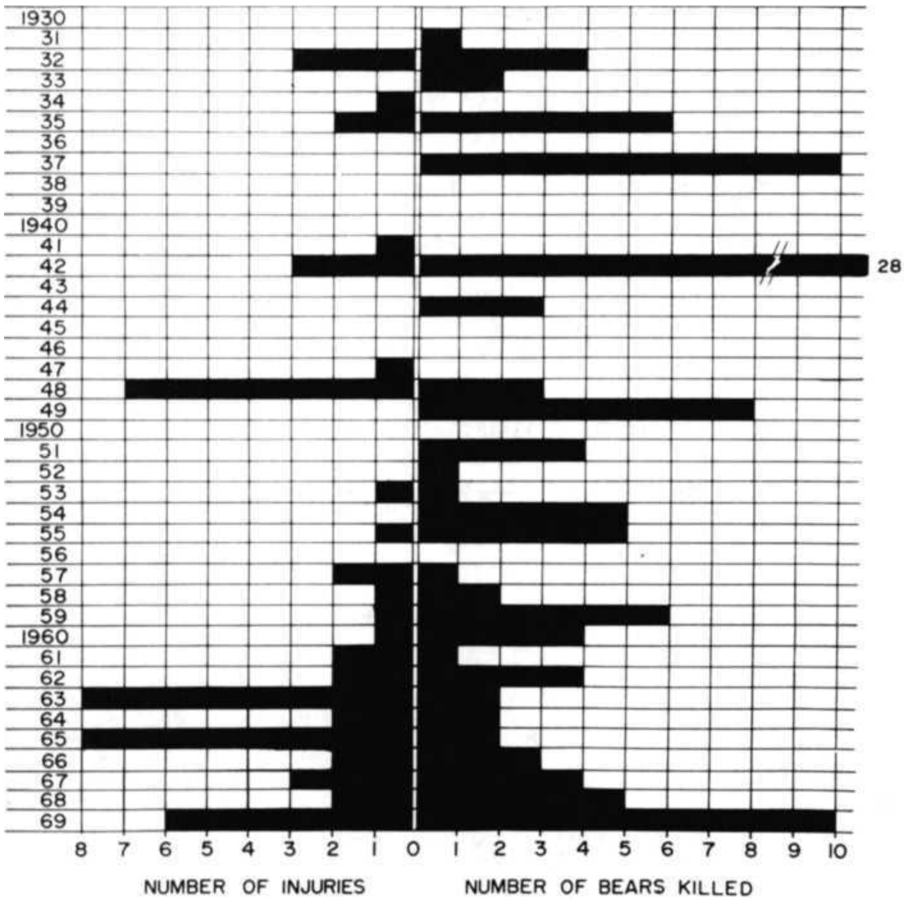

Fig. 2 Grizzly-caused injuries in developed areas in relation to grizzlies killed for control, 1930-1969, Yellowstone National Park.

resulted in individual bears, mating animals and, finally, family units habitually frequenting certain developed areas.

Figure 2 shows an average of three grizzlies was destroyed and about one injury occurred each year over the 1930 through 1962 period of both responsive and preventive control. An average of 2. 5 grizzlies was destroyed and 0. 6 injuries occurred each year during the 1950's. Preventive control was most continuous during this period. From 1963 through 1969 an average of four grizzlies was killed and 4. 5 injuries occurred per year in park developed areas. These values are not without influence from increases in visitor numbers, but they indicate that the attempts to substitute repeated transplanting within the park for the destruction of bears that habitually frequented developed areas contributed to increased injuries to humans and, ultimately, the number of bears destroyed.

The relatively high control kill of 28 grizzlies in 1942 may have been partially due to the 1941 closure of the bear feeding and viewing site within 3 miles of

Canyon. Other coinciding circumstances were an apparent deficiency in natural food which increased intrusions of both black and grizzly bears into park developed areas, and a greatly reduced ranger force for trapping and transplanting bears as a result of World War II.

Unmarked grizzly bears that were captured in or near park developments were transplanted a total of 47 times during 1968 and 1969. Twenty individually marked grizzlies and one recognizable grizzly were transplanted a total of 54 times during the same period. Eleven of these identifiable bears returned from transplant-release sites to the same development a total of 32 times, or to another development a total of 4 times. The distances these transplanted grizzlies returned are shown in Table 4. Five of the 10 marked bears that did not return were transplanted 8 miles from capture sites. The other five were transplanted 18-26 miles from capture sites.

TABLE 4. NUMBER OF TIMES AND DISTANCES IN MILES THAT MARKED GRIZZLIES RETURNED FROM TRANSPLANT SITES IN 1968 AND 1969.

Bear No.	No. times returned	Distances returned: (airline miles)
1	6	8, 8, 7, 28, 27, 8
2	6	7, 16, 16, 20, 20, 17
3*	4	8, 20, 26, 15
4*	3	8, 20, 15
5	4	8, 8, 26, 20
6	4	8, 26, 15, 26
7	3	8, 8, 8
8	2	25, 26
9	1	7, 7
10	1	16
11	1	7

* In campground as cub and as yearling with first two returns in association with adult female.

The shorter return distances of 7-8 miles shown in Table 4 were between the Canyon, Lake Outlet and Bridge Bay developments and the Trout Creek dump. Apparently neither the use of this dump nor more distant release sites prevented certain bears from returning to these developed areas. Most marked bears were adults, but four independent returns by two yearlings to the same area from transplant distances of 15-26 miles indicate this age class has homing capabilities. The greatest airline distance a bear could be transplanted by vehicle from any centrally located park development without placing animals near other developments was about 36 miles. This distance may not be great enough to overcome the homing capabilities of most adult grizzlies. Transplants of adult animals into areas where population units already occurred at equilibrium densities could have adverse population consequences (Davis 1949).

Three sites where bears had been purposefully fed garbage to facilitate tourist viewing were closed between 1930 and 1941. Two were in the immediate vicinity of the Old Faithful and Canyon developments; one was within 3 miles of Canyon. Four open pit garbage dumps were also closed between 1950 and 1969. These were closed to disperse concentrations of bears that either contributed to intrusions into developed areas or caused injuries. Injuries mainly resulted from persons attempting to view or photograph grizzlies at close range.

Other controls on human influences or activities have involved installing bear-proof garbage cans in campgrounds, limiting access to existing dumps or incinerator sites to authorized personnel, regulating the use of certain campgrounds to avoid May and June or fall intrusions by bears, and distributing and posting informational literature on how to travel and camp in bear country. A monitoring system maintains daily records of grizzly sightings, incidents of property damage or personal injuries, and bear control actions. Records on the location of female grizzlies with young or particularly high densities of bears are used to advise appropriate precautions to hikers and restrict foot travel or camping in certain areas.

CONCLUSIONS

A representative grizzly population has been preserved within Yellowstone Park. This was primarily due to the park being sufficiently large and ecologically intact to sustain a population and the existence of large blocks of wild land without conflicting human uses or developments. Except for limited mortality from control operations that averaged about three animals annually, and occasional scientific collections or shipments of animals to zoos, the resident grizzly population was essentially naturally regulated. Emigrations or movements of animals from the park population contributed to sport hunting and intrusions into settled areas outside park boundaries. The latter was mainly in response to available artificial food.

Management actions to remove all artificial food which alters grizzly bear habits and directly or indirectly causes some animals to intrude into developed areas could restore conditions more appropriate to the park's basic purpose and the objective of preserving a grizzly population under natural conditions. These actions, in conjunction with consistent preventive removals of bears from developed areas, could be expected to reduce the opportunity for injuries to visitors and, ultimately, the need to control bears. Repeated transplants of grizzlies which habitually frequent developed areas maintain these animals in the population, but eventually increase injuries and place bear control on a 'sustained yield' basis. The abnormally high incidence of injuries from such bears tends to make the park's attempts to preserve a wild grizzly population controversial.

Fencing existing incinerators and relocated land-fill dumps or hauling garbage outside the park would abruptly terminate garbage-influenced aggregations of bears in the vicinity (within 8 miles) of park developed areas. This would also preclude young bears from acquiring garbage-influenced habits. Abrupt exclusions of bears from garbage food sources could result in an initially greater number of intrusions into park developed areas than a gradual withdrawal of such food. Gradual withdrawals could result in a greater total number of intrusions over time because young animals would continue to learn to use artificial food sources and concentrations of interacting bears would continue to occur on decreasing amounts of garbage.

Consistent preventive removals of grizzly bears from park developed areas could reduce the opportunites for injuries to visitors, with either abrupt or gradual exclusions of the animals from garbage food sources. Distant transplants to reestablish grizzly populations in suitable remote wilderness areas in the Rocky Mountain region would serve as an alternative to destroying animals that could not be transplanted sufficient distances within the park to overcome their homing capabilities. Animals destroyed for control purposes within the park can be salvaged as scientific specimens and donated to educational institutions.

The total number of grizzlies that would need to be removed from the park by distant transplanting or shooting could be greater with gradual reductions in artificial food. It is unlikely, however, that these or any subsequent removals that were confined to bears which came into developed areas, would be of sufficient magnitude to have lasting consequences on the park's grizzly population (i.e. prevent the reestablishment of environmental and behavior-influenced densities). The opportunities for injuries to visitors and the need to control bears within developed areas could be additionally reduced by imposing and publicizing fines for allowing the animals to feed in campgrounds (as a result of not properly storing food), and either converting campgrounds within superior grizzly habitat to day-use picnic areas or enclosing them within bear-proof fences.

POSTSCRIPT

Following reviews of data and recommendations from a Scientific Advisory Committee,[1] park administrators directed that a program be implemented which would reduce injuries to visitors and restore a natural grizzly population. An outline of this program, the general design for evaluation studies, and a report on first-year results have been presented by Cole in the foregoing paper. The program mainly lists steps for removing all artificial foods that attract bears into park developed areas, procedures for controlling bears and protecting visitors, and an open-ended schedule for closing two large garbage dumps that were used by grizzlies. Evaluation studies involve testing hypotheses that relate to injury rates, bear control actions, and indices of 'naturalness' in the grizzly population.

The following is a brief summary of 1970 results. One of the two large open-pit dumps in the park was closed. Some portion of 30 control actions that involved 18 different grizzlies could be attributed to closing this dump and the presence of garbage cans without bearproof lids in one hotel and cabin complex. The remaining 40 control actions that involved 32 different bears were mainly due to intensified efforts to promptly remove grizzlies from campgrounds.

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[1] 'A bear management policy and program for Yellowstone National Park.' Report to the Director by the Natural Sciences Advisory Committee of the National Park Service, 1969, 7 pp., typewritten.

Thirty-nine different bears were transplanted within the park a total of 50 times. Sixty percent of these transplants were successful in preventing subsequent returns to developed areas. Six bears that returned from transplants and one injured animal were intentionally destroyed. Eight bears were donated to zoos. Five other bears were unintentionally removed from the population because of drug malfunctions, or the animals charging personnel who were attempting immobilizations. Attempts to donate grizzlies to states to reestablish populations in suitable historical habitats were unsuccessful. Destroyed animals were processed as scientific specimens for educational institutions.

Two persons were injured in a campground by one grizzly bear in 1970. This is lower than average incidence of injuries for the previous 10 years (Figure 2), but valid tests for differences will require data from a series of years. One additional injury occurred in a backcountry area when a hiker approached too close to a female grizzly with a cub. This was the fourth such incident over a 41-year period.

The scheduled closure of the last open-pit dump for 1971 or 'the earliest possible later date' could result in some bears visiting developed areas that do not already do so. Fewer such 'new' visits may be expected to the extent that (1) successive generations of young bears do not become habitually linked to food supplied by humans, and (2) the interactions between the variously dominant and subordinate animals that use this dump are not intensified or prolonged by gradually reducing the amount of garbage that is hauled to the dump.

Contingencies listed in the park's program if bear visits to developed areas 'exceed control capabilities or lead to excessive numbers of animals being destroyed' are: continue to use the dump beyond the scheduled closure; manipulate campground opening or closing dates; restrict camping to trailer or pickup units; temporarily close campgrounds, if necessary.

Removals of incorrigible bears are expected to not exceed 10 percent of the population during 1971, and to decline to negligible levels in subsequent years. Only a temporary minor depression of grizzly population numbers seems possible, because the annual production of cubs exceeds any envisioned removals of bears, and an increase in the survival rate for young animals appears imminent. Martinka's (1969) comparisons of data from his studies with that from Yellowstone Park and other areas indicate that a high first-year mortality of young grizzlies (35 to 40 percent) occurs in population segments that concentrate at garbage dumps. Comparative mortality rates from the cub to yearling class in two naturally distributed bear populations were about 5 and 7 percent.

ACKNOWLEDGMENTS

I wish to thank Dr. Adolph Murie, Moose, Wyoming, Dr. A. Starker Leopold, University of California, and Mr. Clifford J. Martinka, National Park Service, for reviewing the manuscript. Yellowstone Park Rangers Dale H. Nuss, Gary N. Brown and Gerald E. Mernin provided information and reviews of manuscript sections on bear control and visitor protection activities that greatly aided interpretations of management results. Administrative reports and file records had been maintained by the Ranger Division of Yellowstone National Park. The paper is a contribution from the National Park Service's Office of Natural Science Studies, Project YELL-N-38.

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Bears and Man in Glacier National Park, British Columbia, 1880-1980

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INTRODUCTION

Work on the topic discussed in this paper stems from more general research on recreation development and planning in Glacier National Park, [1] but I think it is independently justified in several ways. First, Glacier Park is an increasingly valuable ecological resource that continues to be a stronghold of the grizzly bear, a species markedly diminished over much of its former range. Secondly, Glacier is also an increasingly important national recreation area. Sound management of the park as an ecological and recreational resource can only be achieved if the bear/man relationship pertaining there is fully understood. Thirdly, the time period 1880-1980 provides a considerable time perspective on the problem. The white man's invasion of the area began in 1881; hence by starting then one can assess the nature and degree of man's impact on the primeval landscape and its components, such as bears, in the cumulative long term. The work is projected to 1980 because it is felt that certain positive actions can, and should, be implemented very soon if the resource values outlined are to be safeguarded. Finally, there is a dearth of information available for interpretive and educational programmes in the park.

FOCUS OF INTEREST

In my work on the man/bear relationship in Glacier Park I am concentrating on three main areas of interest. First, park visitor behavior and attitudes regarding bears; second, park resident behavior and attitudes; and third, Parks Branch policies and actions. The current stage of research necessitates that in this paper I concentrate on the first area—the history of visitor behavior and attitudes regarding bears in Glacier Park. The information available for research includes visitor accounts, log books of hotels and mountain huts, Parks Branch reports, ecological studies and public opinion surveys. [2] The material thus varies considerably in accuracy, and in temporal and spatial coverage, but cross checking and evaluation of sources serve to minimise errors. Before proceeding to a chronological survey of the bear/man relationship in Glacier Park a brief description of the study area is in order.

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1 Undertaken in connection with the author's Ph. D. thesis, entitled: *Man, Landscape and Recreation, Glacier National Park, British Columbia, 1880 to Present.*

2 The assistance of the National and Historic Parks Branch and the Alpine Club of Canada in making information available is gratefully acknowledged.

Glacier National Park

Glacier National Park, founded as a small reserve in 1886, now encompasses 521 square miles of the rugged, glaciated, central Selkirk Mountains, centred on Rogers Pass. The area, lying within the bend of the Columbia River, is drained by four main streams, the Beaver, Mountain Creek, Illecillewaet and Flat Creek. The topography ranges in height from 3,000 to 11,000 feet, and the climate is marked by short summers and high precipitation, averaging 65 inches, the bulk being snow. The vegetation ranges from dense, virgin stands of cedar, hemlock, spruce and fir at the lower elevations to alpine meadows above 8,000 feet. There are also areas of swamp, cottonwood, alder and berry patches that are of special importance to bears.

The first major impact on man on this environment resulted from the construction of the Canadian Pacific Railway via Rogers Pass in 1885. The following year a small area around the pass was set aside as the Glacier Park Reserve. Within this area a hotel, the Glacier House, and other recreational facilities were quickly provided by the railway company and a flourishing tourist trade established. Despite avalanche damage a railway town continued to exist at Rogers Pass until the track was relocated via the Connaught Tunnel in 1916. The tourist business was curtailed abruptly in 1925 with the closure of the hotel and for the next thirty years there was little development or use of the park, which by 1930 had acquired its current boundaries and size. Renewed development, mass visitation and new bear problems have occurred since the opening of the Trans-Canada Highway via the park in 1962.

EARLY VISITORS AND BEARS

Some of the names in the park indicate the early recognition given to bears in the area, thus, we find: Bear and Grizzly Creeks, and the mountains, Ursus Major and Minor. The first known white explorer in the area, Major Rogers, said little about bears other than noting that his party had shot them while travelling up the Illecillewaet River. However, subsequent explorers of the region all comment on the numbers of bears found there. Fleming (1884), noted that the surveying party before him in the Beaver Valley had seen as many as fifty. A later report (Anon. 1885, p. 887), assures sportsmen that in the area surrounding the railway construction camp in Bear Creek:

> the bears are still there for the engineers were too busy to do much hunting.

The eminent naturalist, John Macoun (1922, p. 230) recalls time spent near Rogers Pass in 1885, and notes when climbing Avalanche Mountain:

> By good luck we never saw a bear but smelt them very often. The day before we reached the mountains a wounded grizzly had attacked two men when one of them was drinking at a little creek.

This appears to be the first of very few attack on humans recorded in the Glacier Park area. During the first thirty years of tourism in Glacier visitors apparently regarded bears with a mixture of fear and sportsmanship. Thus, a painter vacationing at Glacier House was said (Cumberland, 1887, p. 160) to be:

> in raptures over the scenery, but he appeared to be highly regretful at not having brought his rifle with him as bears were in sufficient numbers to cause him uneasiness, when going out on a lonely sketching expedition.

Such attitudes were fostered in the literature of the Canadian Pacific Railway (Canadian Pacific Railway, 1888, p. 26, 1889, p. 58), which, while declaring that at Glacier:

> bears can always be obtained

also stated that:

> the grizzly... is always looking for trouble and when he digs up the hatchet, look out for squalls.
>
> Things have changed with time, the rifle has supplanted the bow, but nothing has supplanted the grizzly; he is there yet and king of the wilds...

It is little wonder that while most visitors probably only saw tracks, and although virtually no one was injured, many people carried rifles or revolvers in the backcountry.

To ensure the satisfaction of all Glacier's visitors, the C.P.R. had one and later two bears chained to posts next to the station and Glacier House hotel. Rev. Green (1890, p. 65) described one as:

> a black bear cub, which at first made night horrible by squealing for its mother, but, nevertheless, was a most intelligent, playful and amusing little animal.

At least one of the bears escaped, its collar later being found on the top of one of the snowsheds. The practice of exhibiting animals, often exotics, in the national parks was continued for a long time, there being a zoo at Banff and, even today, a buffalo paddock in that park. Perhaps even more grotesque and inappropriate was the exhibition of dancing French bears at Glacier in 1895. They had given displays all across Canada, but at least one bear got his revenge on man by hugging a spectator to death in Winnipeg.

HUNTING

For a long time the hunting of bears in the park was encouraged by the C.P.R.'s promotional literature, and there are numerous examples of hunts quoted in the literature. Most were unsuccessful there being many difficulties, as noted by Stutfield (1903, p. 148):

> Bears, black, brown and grizzly are by no means uncommon in the Selkirks, but hunting for them in those vast, dense and trackless forests is like looking for the proverbial needle in the haystack.

Some bears were shot in the backcountry of the park but most were killed near the railway. Thus,Sladen (1895, p. 296) notes:

> We never saw or heard any grizzlies while we were at the hotel; but that they do exist is certain, for they get killed in the immediate vicinity when there are not too many tourists about to frighten them. There was one killed just before we went there that weighed over twelve hundredweight.

According to Feuz, one of the Swiss Guides, later at the Glacier House, the hotel garbage was quite an attraction. This may well have contributed to an incident, noted by Wilcox (1897, p. 131) in which:

> One gentleman had the good fortune to shoot a black bear from a window of the hotel

Bears were also reported attracted to explorers supply camps and the railway settlements in the park. Arthur Wheeler, the surveyor, reports (1905, p. 91) that in the Asulkan valley:

> On the way up, the tracks of a huge bear had been noticed along the path worn by our ponies and investigation showed the same tracks all around the tent... .the bear hung around for some days and was seen by the packers on the trail lower down, at which time they were within fifty feet of him but without a rifle.

Later, Wheeler recalls:

> We had three visits of this sort at main cap at Rogers Pass. As a rule (the bears) bore charmed lives, or else the local sportsmen were very bad shots.

Of all the characters associated with bears in Glacier, one, Charles Deutschman, otherwise known as 'Old Grizzly' was the most prominent. He prospected and hunted throughout the Selkirks and while doing so in Glacier Park discovered the Nakimu Caves, in 1904. The caves are located in the Cougar valley and Deutschman doubtless shot a number of bears in this area. Wheeler (National Parks, 1914, p. 6) states that:

> During one of our visits a grizzly bear (Ursus ferox) was killed by Deutschman. The black bear (Ursus americana) is plentiful at the head of Bear Creek across Balu Pass, and it may be safely assumed that he does not fail to visit Cougar valley.

A later caretaker at the caves did, however, note that grizzlies were quite infrequent in the Cougar valley. Hopefully Deutschman's memoirs will be published, thus providing much new information on his activities and the history of bears in the Selkirk Mountains.

1910-1960

The explorer, Howard Palmer, having seen a bear in the southern backcountry of the park, in 1910, was the first to express, in writing (Palmer 1910, p. 482), an interest in photographing rather than shooting bears. However, most people doubtless still hunted with a gun, some on a grand scale, as is indicated by the comments of one of Palmer's men, who, near Beavermouth (Palmer 1914, p. 242)

> had met a bear hunter on the river going back with the fruits of his seasons trapping, consisting of twenty-seven black and brown bearskins.

While the C.P.R. apparently discouraged hunting in the parks after 1904, it was not until 1919 that the federal government gained control of wildlife in the parks. Even then, with better law enforcement, hunting and poaching continued, at least until 1930. The last recorded big bear hunt in the area took place on the eastern edge of the park, in 1926.

While the emphasis in this paper is on park visitor relationships with bears, some comments on the attitudes of park residents in the 1920's are of interest. It was in the 1920's that resident complaints about bears came to be heard. A bear that had become a nuisance around the settlement of Glacier was shot in 1921. In 1925 the bear problem was so bad that the residents submitted a petition to the Park Superintendent (National Parks, 1925). It read:

> Now that the snows have gone the bears are beginning to roam around as in former years. Apparently they seem to be more numerous and going

> round in three's and four's. Now that Junkin's camp is closed down, where the bears used to be fed often and frequently, they are getting to be a bother and very destructive. We suggest if you would allow six or seven of these bears to be shot and ammunition let off around here it would scare the rest away and then we would not have this worry and trouble over them.

This statement indicates the prevailing attitude to bear control and further shows the continuing problem resulting from artificial feeding of bears and the withdrawal of such food supplies. The suggestion that bears had increased in number around 1925 is backed by the recollections of Warden Mann (pers. comm. 1969). Such a change in population or distribution might have been influenced by the decline in hunting, the closure of the hotel and fewer visitors, as well as by the closure of other park settlements. An estimate of animal numbers in the park, the first census of its kind in Glacier, gave the number of park bears in 1925 as: 10 grizzly and 100 others (National Parks, 1925a).

In 1942 (Munro 1945) a second, more substantial, inventory of the park's fauna was undertaken. It was estimated that there were then about 60 black and 35 grizzly bears, mainly along the railway route, in the park. While Munro knew of only one bear attack on a human in Glacier, he did note (Munro 1945, p. 185):

> Nevertheless people admit an uneasiness and dislike of the animal. It is met often enough to cause apprehension and there seems little doubt that its presence deters some people from visiting the park.

Park residents, likewise, were still concerned about the bears to the point where they were said to be afraid of going out on the trails for fear of meeting grizzly bears. Not surprisingly a National Parks report (1943) reads:

> The Grizzly Bear menace in the National Parks is largely confined to Glacier Park. . . . In Glacier Park there were six or seven grizzlies which came in very close to the townsite at Glacier Station. Three of these animals were killed by the wardens a few months ago.

Thus, in the 1940's, public attitudes and park policy were such that a number of bears considered a nuisance were shot, though by this time hunting them for sport had been terminated. By 1960 we have on record a minimum of four maulings and fifteen bears shot, with an unknown number killed by trains, in Glacier Park. In the 1960's both attitudes and action were to change.

The 1960's

In 1962, when the Trans-Canada Highway was opened via Glacier Park, the bear population was estimated (Mundy 1963) as 100. A compilation (Francis 1958) indicates that many of the park's bears were located along the line of the railway. It was along this route that the highway was built, hence many of the animals were affected by this development. Of 18 grizzlies handled by Mundy in 1961 and 1962, only three were trapped away from garbage dumps, mostly in association with construction camps. Apart from garbage, some bears even ate dynamite being used for avalanche research. One bear that 'bothered' a trail crew was blinded by a dynamite blast used as a bear repellent, and subsequently had to be destroyed.

To obtain data on current visitor attitudes and behavior regarding bears in Glacier Park an interview survey was conducted in the park in the summer of 1969. The results of this study have been reported elsewhere (Marsh 1970) but will be summarised here to provide comparison with the historic evidence cited. Furthermore, the results of the survey provide a background to some current problems and possible solutions.

Most of the 114 park visitors interviewed had seen bears in the wild but under 10% claimed to have seen a grizzly, and virtually no one reported having been bothered by bears. Under 20% of those interviewed said bears discouraged them from hiking, and under 10% said bears discouraged them from camping. As regards management, only 2% wanted all bears removed from the parks, though 19% thought all grizzlies should be eliminated in the park. Hunting of bears and the carrying of firearms for protection in the parks were disapproved of by the majority. Most of those interviewed considered the present practice of removing noxious bears away from people to be the most appropriate course of action. While few people displayed any detailed knowledge of bears most had read something, usually non-technical, and seen films about bears.

SUMMARY AND CONCLUSIONS

Since the 1880's there have been marked changes in the Glacier Park environment and consequently changes in the behavior of both man and bear. Likewise, the relationship between the two species has changed during this period. Today, we find, at least amongst that segment of the public that stops in Glacier Park, an interest in, and appreciation of, bears that results in high toleration of them despite the occasional human injury and inconvenience. It would appear that the fear and ignorance of bears, expressed by park visitors and residents alike at the turn of the century, have declined. The aggressive sporting interest in bears has given way, in the park, to a more passive, observational and photographic enthusiasm.

Such changes in human behavior and attitudes have not, unfortunately, eliminated long standing problems due to man/bear interaction. Thus National Park managers, in Glacier and elsewhere, still have to tackle the problem of trying to maintain bears as natural components of the park habitat while ensuring the safety and satisfaction of park visitors and residents. In the past there has been a failure to anticipate, and cope adequately with, problem situations; the blame falling on both park managers and visitors alike. Furthermore, the tendency has been to divert problems for a short period rather than provide long term solutions. For example, relocation of noxious bears has often failed to solve problems, as has the substitution of one garbage source for another.

Given this continuing unsatisfactory situation a brief look at the future, at least to 1980, and some positive suggestions seem in order.

THE FUTURE

Unless there are improvements in the knowledge and management of bears, and in the education and behavior of visitors, there seems every reason to believe that man/bear relationships in the park will deteriorate further causing undesirable stress and danger to both species. The situations in other parks in Canada and the U.S.A. can serve as warnings and guides on which to base action. Technical solutions to many of the problems are available but implementation has been tardy. To ensure the optimum use of Glacier Park's resource potential, as outlined at the start of the paper, requires that some action be taken within the next ten years. More specifically, it is suggested that the following points relating to man/bear management in Glacier Park be considered and acted upon as soon as possible.

Further research on bear ecology and visitor recreation behavior and attitudes should be undertaken in the park to provide sound facts on which to tackle the individual problems. Such research should be on a continuing basis so as to provide management with up to date information on a changing situation.

Full advantage should be taken of practical and theoretical knowledge obtained elsewhere, by exchange of research reports and park personnel, and participation in conferences such as this.

In Glacier, garbage equipment, collection and disposal needs improvement. Burning garbage is no use if bears get to it at campgrounds prior to this. Furthermore, even incinerated garbage, as is found near Rogers Pass, attracts bears, unless the area is effectively fenced.

Visitor facilities, especially campgrounds, like those at Mountain Creek, need to be better designed and located to minimise the chance of bears feeding in them and subsequently becoming troublesome.

Noxious bears need to be dealt with more effectively. This means quick recognition of a problem situation and immediate, long-term effective action. Lack of access roads in Glacier prohibits the trucking of noxious bears to remote areas of the park, like Flat Creek or Mountain Creek. In the past many bears removed have returned and caused further trouble and expense. Consideration should be given to helicopter removal.

In view of the fact that Glacier Park is considered a prime refuge of the grizzly it may be desirable to zone part of the park, say Mountain Creek, specifically for this purpose, and manage bears and visitors accordingly.

On the human side many improvements should be made or initiated immediately. Laws regarding the feeding or intimidating of bears should be adequately publicised and zealously enforced, with press coverage given to such enforcement.

A more extensive and intensive educational campaign concerning bears in the parks should be undertaken. This survey has indicated that attitudes and behavior of visitors have changed, so why not further change—for the better? Education and interpretation regarding parks and bears should be extended into the cities, for this is where most park visitors are from, and this is where the media and public, during their weekday leisure time, are available. Park literature on bears needs to be more detailed and specific to each park and should be based on more thorough ecological research as outlined previously.

Finally, park personnel at all levels should be more familiar with bear ecology and problems. This applies especially to those meeting the public in the campgrounds and at interpretive talks, when advice and information on bears is often requested. This calls for greater training of such personnel and their improved availability to the public.

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Conservation of the Grizzly—Ecologic and Cultural Considerations

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The idea that before settlement the grizzly occurred far across the prairie eastward of the Rocky Mountains has prevailed for a long time (Seton 1929; Hall & Kelson 1959). Since the geographic distribution of a species is a matter of ecologic significance, it may be worthwhile to examine this information. It is recognized, of course, that a line on a map demarking the outer limit of a distribution in any direction does not represent necessarily either a continuous or static situation. The distribution of a species not only will be in accordance with its habitat, but also the extremistics of this will vary time—and—place-wise according to prevailing conditions. These often are most variable at a range periphery.

My concern in this paper is with the distribution of the grizzly bear on the prairie east of the rocky Mountains from Canada's Saskatchewan River southward to the Arkansas River in the United States. For information bearing on this matter, recourse was taken to a part of our heritage of historical literature, which is the source of an abundance of little used natural history information.

Henry Kelsey (1929) seems to have been the first European adventurer to leave a record concerning the grizzly in the mid-continent region. In his journal entry for 20 August 1691, he provides a description of this bear which is surprisingly brief considering it was doubtless a new experience. At that time, he seems to have been some 400 miles west of a place he called 'Deerings Point.' This locality is thought, by some, to be The Pas of the present Manitoba. Some 400 miles west of here by river channel would have placed Kelsey in the prairie region of what is now the Province of Saskatchewan.

Approximately one hundred years later, in 1789, Alexander Mackenzie traversed the country from Lake Superior to Fort Chipewyan on Lake Athabasca by way of Lake of the Woods, Lake Winnepeg, and the Saskatchewan, Beaver and Athabasca Rivers. Whether or not he saw any grizzlies in making this travel is unknown. At least he did not report seeing any until making his way up the Peace River from Fort Chipewyan in 1793 (Mackenzie 1927).

Paul Kane, the Canadian artist, made a similar traverse from Lake Superior to the Saskatchewan River and on westward. He did not report having seen any grizzlies until he reached the Saskatchewan River above 'Long Grass Prairie' (Kane 1968).

In the Red River region in 1800, Alexander Henry reported the grizzly as uncommon (Coues 1965a). Whether or not he actually saw any grizzlies in this region is not clear from the record he left.

According to Brackenridge (1814), this bear usually did not occur below the Mandan villages along the Missouri River. These villages were in the vicinity of present day Bismark, North Dakota.

Much later, in 1875, George Bird Grinnell seems to have regarded the grizzly as common in the Black Hills. The most easterly point at which he saw the species, however, was about the headwaters of the Heart River, some thirty miles east of the Little Missouri in the present State of North Dakota (Grinnell 1876). It was at the mouth of this river that Lewis & Clark first encountered and wounded a grizzly seventy-one years earlier on 20 October 1804 (Coues 1965b); two weeks earlier, they had seen the tracks of a large bear, taken to be of a grizzly, near the mouth of the Moreau.

Wilson Price Hunt, in 1811, left the Arikara villages near the confluence of the Grand River with the Missouri on an overland expedition to Astoria. He reported no information concerning the grizzly east of the Continental Divide except for one taken in the Big Horn Mountains in the headwaters area of Crazy Woman Creek (Rollins 1935).

Further to the southward, two great travel ways had become well established by the mid-nineteenth century. Robert Stuart is credited with being the founder of one of these—the Oregon Trail—in 1812. The only grizzly he reported for the region east of the Continental Divide along this route was one shot by his party in the Casper Mountains adjacent to the North Platte River (Rollins 1935). This would not be far from the present city of Casper, Wyoming.

Less than a decade later, Major Stephen H. Long led an army expedition up the Platte River to the Rocky Mountains, which returned by way of the Arkansas and the South Canadian Rivers to St. Louis. No sign of the grizzly was reported until they reached the place where the South Platte River issues from the Rocky Mountains. Here a grizzly was shot at without making a kill. This species also was observed by this party in the vicinity of the present city of Colorado Springs and of the presently named Beaver Creek in eastern Fremont County (James 1966).

A prairie traveler, whose name has become intimately associated with the Oregon Trail, is Francis Parkman. His route up the Platte River, down the Rocky Mountain front and back along the Arkansas River, closely followed that of the Major Long expedition. In his journal of his tour, he reported the presence of the grizzly in the Chugwater Creek and Goshen Hole areas of present day Wyoming; and he also told of seeing a man who had been injured by a grizzly along the Arkansas River near the Pueblo, now the city of that name in Colorado (Wade 1947).

In 1849-50, an army expedition made the trip to the Great Salt Lake Valley and back over the Oregon Trail. The official report of this expedition, while it is replete with natural history observations including a few regarding bear, carries no information about these animals for the country east of the Continental Divide in Wyoming (Stansbury 1853).

Many of the travelers over the Santa Fe Trail, further to the southward, left accounts of their experiences in crossing the prairie. Jacob Fowler was one of these. According to him, a member of his party was so injured by a grizzly that death ensued three days later. This incident took place near the confluence of the Purgatoire River with the Arkansas in November of 1821 (Coues 1965c). The location of this incident would be near the present town of Las Animas, Colorado.

Josiah Gregg's 'Commerce of the Prairies' stands out as a classic concerning the natural history of the Santa Fe Trail region. In the high country above the city of Santa Fe, where the grizzly was known to occur, Gregg reported having seen the tracks of a large bear, presumably a grizzly. For the prairie country to the eastward, he noted only the black bear, which he said was found in thickets along streams (Gregg 1954).

This review, while by no means exhaustive, helps to establish at least two points concerning the distribution of the grizzly eastward from the Rocky Mountain front. First, in the region of the northern International Boundary, it does show the grizzlies' range to have extended eastward to the great bend of the Missouri River in the present North Dakota, southward at least as far as the Moreau in the present South Dakota, and possibly eastward to the Red River region. This information, of course, is not new. Secondly, southward from this region to the Arkansas River country the prairie does not appear to have been habitat for the grizzly. Two locality records, one for Kansas and the other for Minnesota, both recognized as marginal by Hall & Kelson (1959), can be considered aberrant occurrences. This interpretation of the distributional information brought together here is consistent with that of Brackenridge (1814). He did not consider the grizzly an animal of the prairie as such; and he did point out that (in the northern prairie region) usually it was associated with woods adjacent to large streams.

Implicit in this information is the suggestion that from the first decade to the final quarter of the last century, the margin of the grizzlies' range receded westward from the Red River region rather quickly as settlement developed. It suggests, further, a likelihood of a scant population for this species at the outset of the historical era.

The grizzly, nevertheless, continues to be a wide-ranging species. At the beginning of North America's historic period, it was found in the mountainous West all the way from Mexico to the Arctic. With settlement, in addition to possible range lost in the Red River region, it has lost also the southern part of its range in the Rockies, as well as most of its former range in the Sierra-Cascade cordilleran system further west.

The broad geographic distribution of the grizzly suggests also a broad base of adaptation. This is reflected clearly in its feeding habits, which are thoroughly omnivorous but preeminently herbivorous. Adaptation in this direction is so complete that its sectorial teeth have lost their trenchant character as shearing carnassials, and have instead become tuberculate (Scott 1937). All the cheek teeth, in fact, have broad, tuberculate crowns. In this respect, their teeth are remarkably similar to those of man and of the swine, and atypical for a carnivore.

Studies show clearly that vegetation forms the foundation of the grizzly's diet (Palmer 1939; Chatelain 1950; Clark 1957; & Martinka 1970). Flesh and insects also are included among the materials it eats. Some of this is acquired through scavenging activity. Its diet would include more meat if this were easier to get, because this bear shows a strong fondness for meat whether it is fresh or carrion (Murie 1944).

In its feeding habits, therefore, the grizzly is not a specialist, but rather a generalist. Its ecologic niche is broad, since in the trophic system of which it is a part, it functions as a grazer, as a predator, and as a decomposer. Each of these functions also is performed by food specialists at each trophic level. The integrity and the survivability of the natural community is maintained and fairly assured owing to this trophic overlap.

Thus it is that a major community, like a biome for example, can loose a species or so and still not loose its essential ecologic identity or functioning. The presence of the grizzly appears not to be essential to the maintenance of its community. In other words, its ecologic value apparently is not a critical one. The structuring of a staunch case for the conservation of the grizzly based only upon ecologic value, as presently understood, therefore, appears foredoomed.

Upon what grounds, then, can conservation of the grizzly be justified? Among other values which might be recognized, it should be appropriate to give weight to values culturally derived, that is to say man-conferred. The more primitive societies of mankind commonly hold more or less in reverence certain wildlife species. Parkman (1946) in 'The Oregon Trail,' stated that the Dakotas regarded the grizzly as 'the divinity of war.' A reverence for the bear was common among the north American Indians according to Grinnell (1962). In our culture, by way of contrast, we seem not to reverence any animal unless it be the golden calf or the Wall Street bull.

Some of the grizzly's activities, to be sure, are clearly inimical to man's interests. There should be no need to review these here, since they are already largely a matter of common knowledge.

Nature adventuring, whether it be hunting, fishing, birdwatching, wild-flowering, rock-hounding or scenery enjoyment, is a well established tradition among Americans. With the increased affluence of the last score or so of years, there has been a spectacular growth in the number of persons seeking this sort of satisfaction. But one can wonder whether this seeking may be a fad of the times or whether it truly is demonstrative of a deep-seated sense of nature appreciation—a sense released largely by recently acquired affluence.

The results of a survey issued by the National Wildlife Federation (1969) provide grounds for this wondering. In this survey, people were asked what they thought to be 'the most pressing problem connected with our natural surroundings.' There was a choice of one answer out of seven possibilities. Three of these concerned pollution, and one concerned wildlife preservation. Seventy-five per cent of the respondents chose pollution against five per cent for wildlife preservation.

Owing to the current general concern about pollution, this result really was not surprising. What was surprising perhaps was that primary school children, the less affluent, and the residents of small towns all expressed more concern about wildlife than other groups. Does wildlife truly mean comparatively little to the big city resident? The more affluent? Or the better educated? Is this apparent indifference toward wildlife reflective of a higher level of humanization among these latter groups?

Eric Hoffer (1969) has, in fact, equated the humanization of man with the conquest of nature. According to him: '... the overcoming of nature, so crucial in the ascent of man, can be a most effective agency of humanization in the decades ahead. One would like to see mankind spend the balance of the century in a total effort to clean up and groom the surface of the globe—wipe out the jungles, turn the deserts and swamps into arable land, terrace barren mountains, regulate rivers, eradicate all pests, control the weather, and make the whole land a fit habitation for man. The globe should be our and not nature's home, and we no longer nature's guests.'

Hoffer's ideas are patently anti-ecologic. Complete fulfulment of them would mean the *Gotterdämerung* of the nature treasured by many persons the world over, and held in reverence by many others, including those we consider less civilized than ourselves. Civility, which itself is a mark of humanization, does not equate itself necessarily with 'advanced civilization.' Is there an implication of Hofferism, either conscious or non-conscious, in the ever growing urban-technological sophistication?

There are, it is reassuring to observe, other winds blowing. Increasingly one feels the press of concern for change. Long established institutions are being criticized and even challenged. The hand which feeds is being bitten. One result has been the arousal of a nation-wide concern for great improvement in the quality of our environment. No longer is destruction of environment together with the life dependent upon it being passively accepted as the price of economic development. Destructive forces have been rampant far too long in our society. Long standing apathy toward them has cultivated much indifference or even callousness toward nature—toward environment and life alike.

The time is ripe to cultivate and promote constructive influences. Endeavour in nature conservation certainly is one of these. It manifests a civil rather than a barbaric attitude toward our world; and on man its effect is humanizing—an effect greatly to be desired at any time, but especially so today. Man's attitude toward the world of wild nature, that is, toward wildlife and its habitat, may well portend the quality of living he destines for his future. In a recent work, Clark (1969) admonishes us to remember that we are but part of a great whole we know as nature—'All living things are our brothers and sisters.' In part, he was echoing what Pope (1951) had said more than two hundred years earlier with the lines:

> 'All are but parts of one stupendous whole,
> Whose body nature is, and God the soul. '

Nature appreciation, already present in our society, needs greatly to be reinforced. How can this be accomplished? How is an attitude of appreciation, of love, for nature to be cultivated until it becomes an indelible part of the American ethos? Persons tend not to harm that which they love. It seems to me that the conservation of the grizzly bear is intimately associated with these questions. Of what meaning to our society is the grizzly, for example? The conservation of this bear must come to be viewed not only in the usual foremat concerning a wildlife species, but also in terms of its humanistic significance as well. To achieve enduringly the grizzly's conservation, the whole man must be reached—his body and his soul.

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Grizzly Bear—Man Relationships in Yellowstone National Park[1]

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INTRODUCTION

The grizzly bear, *Ursus arctos horribilis*, is an intelligent, extremely efficient omnivore and a relatively inefficient carnivore. This large bear feeds on grasses, sedges, tubers, berries, nuts, carrion, meat caches, rodents, big game, livestock, garbage, and even modern packaged foods. The propensity to seek and utilize a wide range of edibles has brought the grizzly into frequent contact with man. This ecological relationship of the omnivorous grizzly associating with omnivorous man and the predatory bear competing with the predatory human has led and will continue to lead to confrontations, property damage, and occasional conflict and injury. The grizzly has a long history of seeking and taking the food it wants with little opposition. The erratic, aggressive, and frequently unpredictable behavior of both grizzly and man increases the probability of conflict. The opportunity for confrontation and for injury to humans is small, but it is greater in national parks than elsewhere.

To understand grizzly bear—man relationships in Yellowstone National Park, we must first recognize that the ecology of bear and man has always overlapped. Within recent geological time, wherever the species existed, the grizzly bear was at or near the top of the North American food pyramid.

The North American Indian and the grizzly bear coexisted in a spacious environment. Two questions we wish to explore are—can the grizzly bear and man coexist in the congested environments of our large national parks ? Specifically, can man and grizzly live together in Yellowstone ? Secondly, if they can coexist, how should man achieve this? Both questions require more than theoretical or philosophical answers, ethological extrapolation, administrative decrees, or generalized guidelines.

We, our colleagues, and our graduate students sought to answer these questions 12 years ago when we began a long-term study of the grizzly bear within the 7, 700 square miles of Yellowstone National Park and adjacent national forests (Craighead *et al.* 1960). Since 1959 we have captured, examined and released over 550 grizzlies, immobilized and individually color-marked 256 and logged over 40, 000 man hours observing and recording their activities and behavior.

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[1]This paper has been previously published in *BioScience* 21 (16): pp. 845-857; 1971.

In addition, 24 individual grizzlies have been fitted with radios and radio-monitored for approximately 30, 000 hours in order to obtain data on movements, home ranges, food habits social and denning behavior, and an understanding of bear-man relationships (Craighead & Craighead 1965, 1969, 1970).

SOME BIOLOGICAL FACTS

Using data from 324 censuses totaling 11, 340 hours and from an intensive trapping, re-trapping and marking program, we have calculated a minimum of 175 grizzly bears in Yellowstone area. One-third of the adult females (about 15) breed each year and produce an average of 33 cubs or a 19% annual increment. The females first breed successfully at 4½ years though many may not produce cubs until they are 8 or 9 years old (Craighead *et al.* 1969). The annual increment slightly exceeds the mortality rate; thus, the population grew at an average annual rate of approximately six grizzlies per year from 1959 through 1966 (Craighead &Craighead 1967). An increase in the death rate, especially of adult females, could jeopardize the population.

In the summer months, grizzlies gradually, but steadily, congregate at Trout Creek (Figure 1) and at other major open-pit dumps in and outside of Yellowstone. Grizzlies are attracted to these dumps from all portions of the Park and from the adjoining national forests. Peak densities are reached in August. Our observations indicate that there are few grizzlies in the Yellowstone backcountry during this time. Mullen & Booth (1969) also found fewer grizzlies on the Shoshone National Forest adjacent to Yellowstone during August than prior

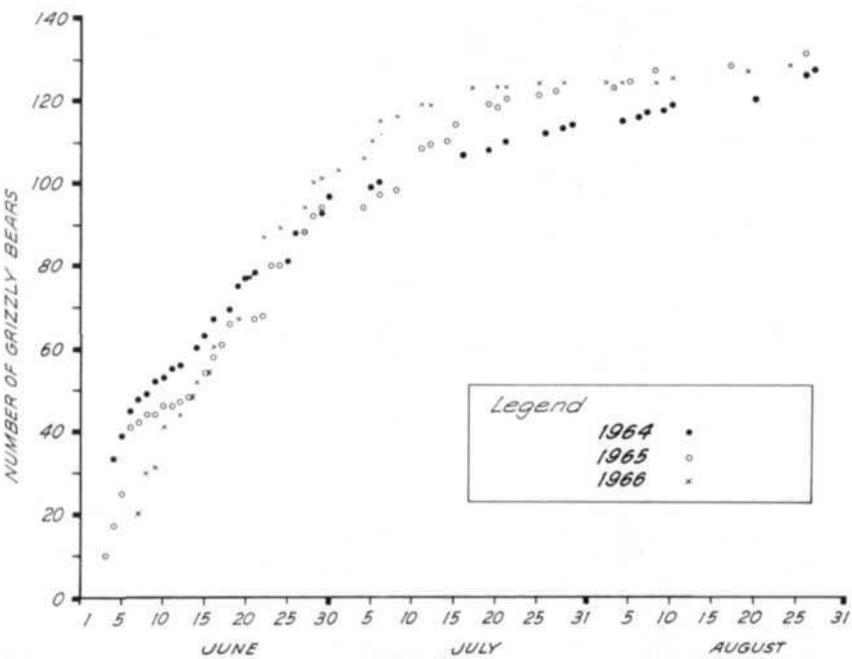

Fig. 1 Seasonal coalescence of grizzly bears at Trout Creek Dump. Each data point represents a 3½ hour census.

to and after this month. Our census and movement data (Craighead & Craighead 1967) show that Yellowstone National Park serves as a summer refuge for many grizzly bears whose home ranges extend beyond the Park boundaries. We have computed that a 5, 000 square mile area including Yellowstone National Park and an adjacent 10-mile corridor of national forest land supports an average of about one grizzly bear to every 29 square miles. Some grizzlies spend their lives entirely within the Park; others do not. Those that move outside the Park boundaries are hunted. Forty-eight percent of the grizzlies shot outside the Park from 1959-1968 were adult animals and 52% were sub-adults ranging from yearlings to four-year-olds, showing that outward movement from within the Park is not confined to young animals. These data suggest that movements of grizzlies out of the Park result from the species' natural mobility and should not be interpreted as evidence that grizzlies have exceeded the carrying capacity of their environment in Yellowstone National Park.

Studies have been made of the movements and home ranges of grizzlies inhabiting Yellowstone and adjacent portions of four national forests. Data from color-marked and radio-tagged bears show that most, perhaps all, of the grizzlies in this population feed at one or more of the earth-filled garbage dumps (Figure 2) at sometime during the course of their lives; some visit the dumps frequently, others infrequently. Thus, it is doubtful if the term 'wilderness grizzly' is useful if we mean an animal having no contact with 'artificial' food sources. For example, 114 marked grizzlies were identified at the Trout Creek Dump during the summers of 1966 through 1968. Table 1 lists the number of these marked animals identified at the dump and also in the backcountry.

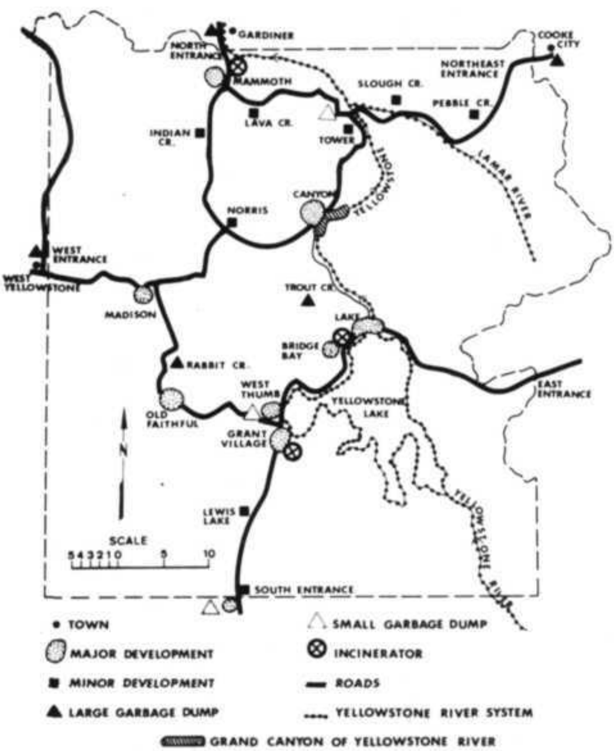

Fig. 2 Map of Yellowstone National Park showing developed areas, garbage dumps, and incinerators.

TABLE 1. COLOR-MARKED GRIZZLIES OBSERVED AT TROUT CREEK DUMP AND RE-OBSERVED IN WILDERNESS AREAS* OF YELLOWSTONE NATIONAL PARK FROM 1966-1968.

Cubs	1-year olds	2-year olds	3-year olds	4-year olds	Adults Males	Females	Total
229	218	183	158	141	30	39	
230	219	202	177	144	207	40	
236	220	216	185	147	217	101	
240	221	227	211	165		112	
241	233		228	183		128	
256				188		132	
				208		141	
						163	
						172	
						173	
						187	
						228	
6	5	4	5	7	3	12	42

*Wilderness and backcountry are used synonymously in the text. They are undeveloped, roadless areas retaining their primeval character without permanent improvements or human habitation. In these areas, the earth and its community of life are untrammeled by man, and man himself is a visitor.

During a 3-year period, 37% of all the marked grizzlies that visited the Trout Creek Dump were also observed in the backcountry. Because of the pattern of human use in Yellowstone National Park, areas a mile or more from roads and developed areas conform to the definition of wilderness as it is stated in the National Wilderness Preservation Act. Approximately 95% of the 3, 400 square miles in Yellowstone, National Park can be considered backcountry. Most backcountry observations were made in spring and fall when the grizzlies were dispersed. As Table 1 shows, all age classes disperse throughout the Yellowstone backcountry.

Additional observations in the backcountry and at other garbage dumps during other years also show that, in the spring and fall months, the grizzlies that feed in summer at these garbage disposal areas also frequent the Yellowstone wilderness.

All Yellowstone grizzlies, regardless of their feeding habits or degree of association with man, inhabit wilderness portions of the Park and adjoining . national forests from October through April. Thus, management of grizzly bears in Yellowstone Park affects not only resident animals in the Park but also grizzlies inhabiting four national forests in three states.

Food disposal areas (Figure 2) have attracted grizzlies for over 80 years.

They have shaped and are integrally meshed with grizzly bear ecology in Yellowstone. Except for the nature of the food, they are ecological equivalents of the spawning salmon runs that attract and concentrate Alaskan brown bear (*Ursus arctos middendorffi*) during the summer months. Yellowstone garbage sites concentrate the grizzly bears during a 3-month period from June through August.

Key questions posed are: Have the garbage dumps basically altered the grizzly's relationship to man? Have they increased or decreased grizzly-man conflicts in Yellowstone ? Should they be eliminated and, if so, how ? To answer these questions we must understand bear-man relationships and the nature of bear-man conflicts.

BEAR-MAN RELATIONSHIPS

We can classify grizzly bears inhabiting the Yellowstone area into four types based on their feeding behavior as related to humans. These are: (1) bears which forage at the garbage disposal areas during summer months; (2) those that either occasionally or habitually visit campgrounds or developed areas; (3) bears man-conditioned by food handouts at lodges and construction camps; and (4) grizzlies which reside throughout most of the year in the backcountry and rarely visit a garbage dump, campground, or other developed areas. Overlapping of types occurs, yet the four categories are quite distinct. The majority of bears fall into the first category. Those in the second and third categories, though few, are the most troublesome. Practically no Yellowstone grizzlies qualify for the fourth category

Behavior of grizzlies frequenting garbage dumps:

We have obtained no evidence that the Yellowstone area has two distinct populations of grizzlies—'wild living' animals inhabiting the wilderness country and 'garbage-addicted' grizzlies inhabiting the dumps and developed areas of the Park. On the contrary, thousands of man-hours spent observing grizzlies at open-pit dumps and hundreds spent observing these same color-marked animals and monitoring radio-instrumented bears in wilderness country divulged not two distinct populations but two distinct behavioral patterns. Many of the grizzlies that feed at the isolated, open-pit, garbage dumps exhibit less fear, and greater tolerance of man at these areas than at other areas. The same animals that ignore human scent at the dumps are quickly alerted by it in the backcountry. From hundreds of encounters that we made with grizzlies when they were half a mile or more from the dumps, we observed that in most instances, they were alert and wary and would generally flee when they heard us or got a scent. Tolerance of man while feeding on artificial food at the dumps is definitely linked with specific sites. It is not a general toleration of humans or of human scent, although in rare instances the on-site conditioning may alter behavior in other locations. Animals that feed at garbage dumps, presumably where the human scent is strong, ignore it there but not elsewhere. We have little evidence that garbage feeding changes their human avoidance behavior. Troublesome grizzlies normally develop their behavioral patterns toward humans under quite different circumstances.

The Yellowstone garbage dumps provide grizzlies with an abundance of palatable food, congregate them for an unnaturally long period of time and alter some of their behavioral patterns. Feeding at these dumps does not normally develop grizzlies into garbage-seeking animals, make them dependent on humans (Leopold 1970) or create incorrigible animals. This does not imply that the garbage dumps are beneficial and should be kept open: it does mean that eating 'unnatural' versus 'natural' food does not, in itself, significantly alter the behavior of Yellowstone's grizzlies toward human beings.

Behavior of grizzlies frequenting campgrounds:

Of 36 grizzly bears captured and initially marked in campgrounds, 64% re-entered a campground or developed area following their release; 28% re-entered two or more times. Among 221 grizzlies initially captured and marked at garbage disposal sites or in the backcountry, 36, or 16% were later captured in a campground or developed area. Only 9.5% re-entered two or more times (Table 2). Thus, many grizzlies initially captured and marked in campgrounds had already developed chronic campground feeding habits and they became problem animals more often than grizzlies captured and marked elsewhere.

TABLE 2. NUMBER AND PERCENT OF 257 COLOR-MARKED GRIZZLIES CAPTURED OR RECAPTURED IN A CAMPGROUND OR ADJACENT DEVELOPED AREA, 1959-1969.

	Grizzlies initially marked inside campgrounds	Grizzlies initially marked outside campgrounds	Total
Number marked	36	221	257
Percent of marked population	14.0	86.0	100
Entering campground or developed area once *as a marked bear*			
Number	23	36	59
Percent	63.9	16.3	23
Entering campground or developed area two or more times *as a marked bear*			
Number	10	21	31
Percent	28.0	9.5	12

The data in Table 2 also suggest that capturing and marking grizzlies, which was essential to document that animals' behavior and movements, did not condition them to man or convert them into troublesome bears. Had this occurred, a much higher percentage of those captured and marked outside of campgrounds would have become 'campground foragers.' Evidence indicates that most of the troublesome grizzlies were developing or had already developed into problem animals before they were captured and marked in campgrounds.

The large number of animals marked (over 60% of the population at one time), as well as the unmarked grizzlies, exhibited a normal range of bear behavior. However, only bear-man relationships involving marked grizzlies could be individually and quantitatively documented. Therefore, few objective or legitimate comparisons can be made between avoidance or confrontation behavior of marked versus unmarked animals. Since we have no evidence that capturing and marking grizzlies altered their behavior toward humans, information obtained from marked animals is considered representative of both marked and unmarked ones.

From observations of marked bears and from records of radio-tagged ones, we learned that grizzlies become accustomed to campground foraging during spring and fall migratory movements when their travel routes intercept campgrounds. During this same period, grizzlies extend their home ranges searching for food. This pattern has been especially evident at the Lake and Canyon Village Campgrounds. Yearlings and 2-year-olds may wander into campgrounds following weaning, a time when they normally begin to disperse and establish home ranges of their own. For this wide-ranging, inquisitive animal, chance alone, no doubt, accounts for the discovery of and addiction to the food available in campgrounds. Those that learn to frequent campgrounds become conditioned to the near presence of humans. Those that enter infrequently remain shy and secretive. Habitual campground foragers normally develop behavioral patterns in response to the presence of man that are markedly different from those of grizzlies that feed at the isolated, open-pit dumps.

Any grizzly which frequents a campground is a potential hazard because humans may startle it at close range and be attacked. However, it is important to discriminate between habitual offenders and those that enter campgrounds for short periods of time, then move on and do not repeat the offense except infrequently over a period of years. It is difficult to define precisely the habitual offenders or incorrigible animals on a basis of frequency of visitation or frequency of recapture in campgrounds. However, until better criteria can be formulated, we have defined habitual offenders as those recaptured four or more times. Table 3 shows that among 72 grizzlies of both sexes, 69% were either never recaptured or were recaptured only once; 87% were not recaptured or were recaptured one to three times. Only 13% were recaptured four, five, or six times. These individuals constitute the habitual offenders.

Table 4 shows that 28 of the 72 bears captured in campgrounds or developed areas between 1959 and 1969, were killed or sent to zoos; 61% of these had

TABLE 3. RECAPTURE RECORD OF GRIZZLIES CAPTURED IN CAMPGROUNDS—1959-1969.

	Number of times recaptured in a campground							
	None*	One	Two	Three	Four	Five	Six	Total
Males	13	16	4	4	2	1	1	41 (57%)
Females	13	8	2	3	1	3	1	31 (43%)
Total	26	24	6	7	3	4	2	72 (100%)
Per cent	36	33	8	10	4	6	3	
	69		18			13		
		87				13		(100%)

* None = captured in a campground and never recaptured.

TABLE 4. HISTORY OF THE 28 GRIZZLIES ELIMINATED FOLLOWING INITIAL CAPTURE OR RECAPTURE IN CAMPGROUNDS-1959-1969.

Times recaptured in campgrounds	None*	One	Two	Three	Four	Five	Total
Number of males eliminated	4	7	2	0	1	1	15
Number of females eliminated	3	3	2	3	0	2	13
Total grizzlies eliminated in control measures	7	10	4	3	1	3	28
Percent eliminated	25	36	14	11	3	11	
	61		25		14		
	86				14		100%

*None = captured once in a campground and eliminated.

recapture records of zero or one, and 86% had recapture records ranging from zero through three. Thus, 86% of the campground grizzlies which were eliminated had not become habitual offenders. Obviously, the percentage of habitual offenders would have been greater had bears, which were initially captured or had three or less recaptures, not been dispatched. On the other hand, 51.4% of the 72 grizzlies captured in campgrounds and released had recapture records of less than four and these were not recaptured again. This suggests that grizzlies entering campgrounds should be transplanted long distances into the adjacent National Forest wilderness country following a first capture rather than dispatched. Cooperative agreements could accomplish this. Such a procedure would tend to break the reward pattern that may develop when grizzlies return frequently to campgrounds and find food. Eight grizzlies handled in this way were eventually taken as trophies by hunters outside the Park.

In general, frequency of recapture of individual grizzlies is directly related to the time a bear occupied a campground because it was routine procedure to keep traps set whenever grizzlies were observed. The incorrigible bears can be recognized because they will seek food in defiance of visitors and ranger patrols, make repeated bluffing charges at humans, and break and enter tents and trailers. Generally, such bears have a long history of campground tenancy. There is no question about the necessity of eliminating such animals. The problem is what to do with infrequent offenders. We believe great discrimination should be practiced in eliminating grizzlies after the first capture or with recapture records of one through three.

Behavior of grizzlies conditioned by food handouts:

By radio-tracking grizzlies that had been regularly fed in the presence of humans or that had developed foraging habits bringing them into frequent and close association with man, we learned that such animals developed behavioral patterns that made them extremely dangerous. They learn to associate food-getting with humans and soon lose their fear of man and human scent. They become thoroughly conditioned to man. This conditioning is not associated with a particular feeding area, as is the case with grizzlies that feed at remote garbage dumps, but is a general conditioning to man wherever he is encountered. Such animals may coexist with people for extended periods of time but, sooner or later, these man-conditioned animals are startled by humans at close range, defy interference at a food source, or completely disregard humans in their attempts to get food. This may occur in a campground, on a trail, or in the backcountry. The result may be a bear-man encounter ending in human injury or death.

For a grizzly to lose its shyness or fear of man requires cooperation and encouragement, and the initiative is usually with man. One male grizzly, No. 202, was radio-tracked for 2 consecutive years during the summer and autumn. Yearling No. 202 was instrumented and radio-monitored for 56 days in 1965. During that time, he established a 27 square mile home range that encompassed Canyon Village, but he did not visit the campgrounds arid caused no trouble. However, the following spring when he emerged from winter sleep, he swam the river and traveled the north rim of the canyon which led him directly into the Canyon Village Campground with its food supply.

As a 2-year-old, he was radio-monitored for 118 days of 1966. Though frequenting the campground, he gave no serious trouble until fall when he began visiting two construction camps in the area. He received food handouts and soon became bold enough to attempt to enter trailers and to feed fearlessly in the presence of humans. During 1966, this animal established a home range of 125 square miles with Canyon Village Campground as his center of activity.

Emerging from winter sleep as a 3½ year old animal, he returned to his old haunts in the campground. No. 202 was not an aggressive bear, had inflicted no injury and had caused little or no property damage, but he had been conditioned by food handouts, had lost his normal respect for man and, thus, became a potential menace to the safety of visitors. He was shot as a precautionary measure at the age of 3½.

Fortunately, grizzlies conditioned by food handouts at concessionaires or work camps have been rare in Yellowstone National Park. They have been more numerous in Glacier National Park. On the evening of August 13, 1967, at two widely separated locations in Glacier, grizzly attacks resulted in the deaths of two 19-year old concessionaire employees and serious injury to an 18-year old boy. Both attacks can be linked to food handouts and man-conditioned bears (Olsen 1969; National Park Service 1967; Leopold 1970; and personal communications, Gerry Atwell 1967 and Frank Evans 1867). Once man-conditioned by food handouts, the grizzly must be destroyed. The solution to such conditions is campground sanitation, frequent ranger patrols and thorough enforcement of the National Park Service regulations pertaining to the feeding of bears.

Behavior of grizzlies in the backcountry:

Grizzlies, living under wilderness conditions, utilize natural food but may be attracted to food made available by humans, and may become man-conditioned. For example, in 1961, a crew working on the control of blister rust experienced frequent confrontations and attacks from a 3-year-old, male grizzly in the Washburn Range, miles from a developed area. At first the bear was shy and avoided the men. Over a period of several weeks, he gradually lost his shyness. He excavated buried lunch trash and then accepted lunch scraps thrown to him. Eventually he approached boldly for food and made bluffing charges. On five occasions, he treed members of the crew and then rifled their packs and lunch

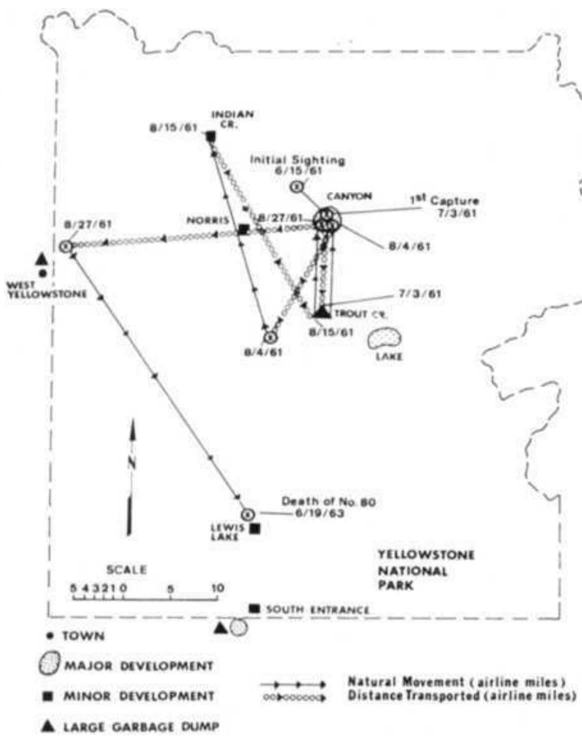

Fig. 3 Movements of Grizzly No. 80

pails. We later captured, color-marked and numbered this animal. He became No. 80; his movements to and from campgrounds are shown in Figure 3. This thoroughly man-conditioned grizzly was shot in June 1963 by Park rangers after molesting visitors camped in wilderness country near Lewis Lake. This documented account illustrates the role of food handouts in developing incorrigible bears. Generally, conditioning to man evolves in developed areas, but it is not necessarily limited to them.

BEAR-MAN CONFLICTS

The probability of being injured or killed by a grizzly bear in Yellowstone National Park is very small. From 1900 to 1970 there have been two fatalities from grizzlies (National Park Service, 1880-1970). Both occurred in the early 1900's. From 1931 to 1970, when more detailed records were kept, official National Park Service records show 63 injuries and no fatalities. During these 39 years, an average of a million people per year visited the Park. Thus, the injury rate from grizzlies has been one person per 600, 000 visitors.

Although grizzly bear attacks on man are rare, they provide exciting news copy and generate apprehensive public response. This, in turn, has initiated control action often with over-reactionary measures that have been harmful to the coexistence of the grizzly and man. Following the 1967 fatal incidents in Glacier National Park, four female grizzlies were shot and a cub was wounded. Only one of these animals was conclusively linked with the attacks. The

National Park Service Report, 'Grizzly Bear Attacks at Granite Park and Trout Lake in Glacier National Park, August 13, 1967', suggested garbage feeding as a conditioning factor, but did not mention the frequent feeding of grizzlies on garbage and food handouts in the presence of human viewers. This conditioned the bears at Granite Park to lose their normal respect for humans and may have man-conditioned the particular animal responsible for the tragedy.

Lightning storms, age and physical ailments of the bears, and unknown reasons, were listed as possible causes of the Trout Lake fatality. Cosmetics, hair sprays and menstrual odors were cited as the probable causes for this particular attack. Subsequently signs were erected at trail heads, warning—'Women—Do not travel in the backcountry during menstruation.'. This presumed cause for the attack—to our knowledge unsubstantiated—was widely publicized and probably deterred many women from making wilderness hikes.

Personal injury records:

Personal injuries caused by grizzly bears have been recorded in Yellowstone National Park for the past 40 years (1931-1970). We have found it difficult to evaluate these records because the injuries have varied in severity from bruises and minor wounds, requiring no professional medical attention, to those that required hospitalization. Also, there has been doubt whether some injuries were inflicted by grizzlies or by black bears. We have accepted with reservations the data which show 62 known and probable injuries from grizzlies, or 1. 55 per year.

From 1959 through September 1970, we worked closely with Park rangers to keep more accurate records of personal injuries inflicted by grizzlies (Table 5). Injuries during this period averaged two per year or approximately one injury for every 900, 000 visitors. This is hardly a record that would support the removal of all grizzlies from Yellowstone (Moment 1968) or a drastic control program within the Park. However, during 3 years of the Park Service's present program of bear management (1968-1970), injuries averaged 3. 33 per year. In comparison, injuries were only half as numerous from 1959-1967—averaging 1. 67 per year. We believe that the increase is due largely to the present management practices that have forced grizzly bears into campgrounds and developed areas of the Park (Figure 4).

Control measures:

Control of grizzlies within the Park is performed by the ranger staff. Troublesome animals are either killed of shipped to zoos. The term 'dispatch' includes both of these control measures. From 1931-1970, 140 grizzlies have been killed; this is a 40 year average of 3. 50. The exact number shipped to zoos during this period is unknown.

Seventy-four grizzlies have been dispatched by the Yellowstone administration during our 12-year period of research. This averages 6.17 grizzlies per year (Table 5). During 9 years of this period (1959-1967), prior to the enactment of the Park Service's present program of bear management, control averaged 4.1 per year. During 3 years of revised management (1968-1970), control averaged 12.3 grizzlies per year. Twenty-two grizzlies were eliminated from the Yellowstone population in control measures in 1970. Information on the number of deaths occurring from other causes during 1970 is not yet available. However, there was an average of 11 such deaths per year from 1959 through 1966. These represent only those deaths where the causes of death were known. If we assume that 11 grizzly bears will die in addition to those eliminated by control, the total loss from the population during 1970 will be 33.

TABLE 5. INJURIES FROM GRIZZLY BEARS, AND CONTROL MEASURES IN YELLOWSTONE NATIONAL PARK, 1959-1970.

Year	Park visitors*	Personal injuries	Control measures		
			Grizzlies killed	Grizzlies sent to zoos	Total
1959	1, 408, 667	0	6	1	7
1960	1,443,288	0	4	0	4
1961	1, 528, 088	1	1	2	3
1962	1, 925, 227	2	4	0	4
1963	1,872,417	6	2	4	6
1964	1,929,316	1	2	1	3
1965	2, 062, 476	4	2	0	2
1966	1, 130,313	1	3	0	3
1967	2,210,023	0	3	2	5
1968	2, 229, 657	1	5	0	5
1969	2, 193, 814	6	10	0	10
1970†	2, 200, 000	3	14	8	22
Total	22, 133, 286	25	56	18	74

*Data obtained from Yellowstone Park records, 1959-1969.
†We estimated visitor numbers for 1970.

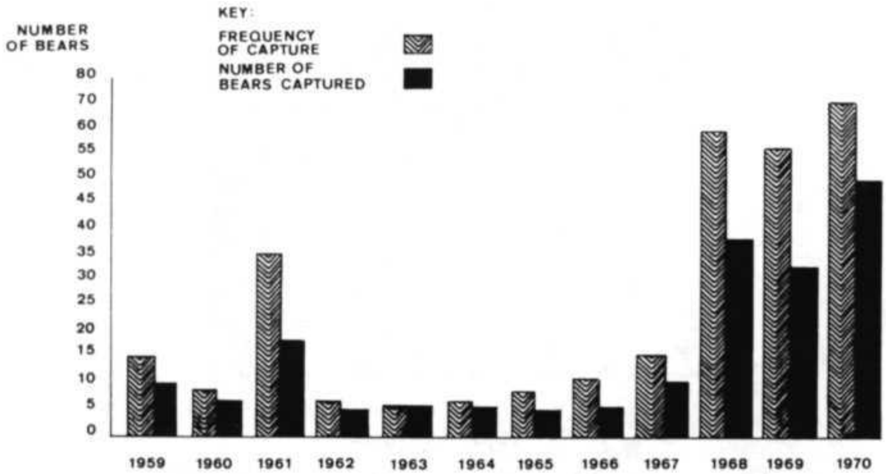

Fig. 4 Frequency of capture and number of grizzly bears captured in campgrounds.

This just equals the average annual increment (Craighead & Craighead 1967), but statistics compiled during our study indicate that as many grizzlies die each year from unknown as from known causes. Consequently, the population loss for 1970 will greatly exceed the average annual increment. It is obvious that the Yellowstone grizzly population cannot long sustain such losses.

A comparison of the annual control figures and personal injuries with Park visitation from 1959 through 1970 (Table 5, Figure 5) shows no correlation with the increase in visitor numbers. A correlation should be expected. We attribute the lack of one to the fact that the open-pit dumps served to concentrate and isolate the grizzly bear population during the tourist season. Also public use of these areas has been restricted, thereby reducing the probability of grizzly-visitor interactions. We believe that the increased number of bears killed or sent to zoos (Table 5) during 1968-1970 was directly related to the abrupt phasing out of the Trout Creek Dump and the closure of the Rabbit Creek Dump, which forced grizzly bears into campgrounds. This destroyed the effective zoning of grizzly and man that prevailed from 1959 through 1967. As we have shown, the average number of grizzlies dispatched during the last 3 years is three times the average for the preceding 9 years. Using 200 grizzlies as a maximum population estimate (based on 324 census of 3½ hours each totaling

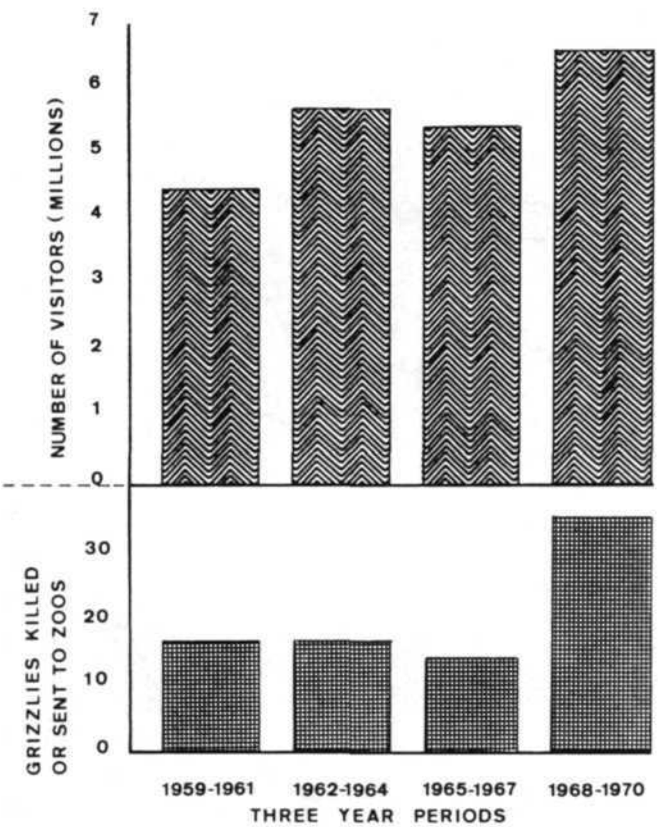

Fig. 5 Comparison of number of visitors and number of bears dispatched at Yellowstone National Park during 3-year periods, 1959-1970.

11, 340 hours, Craighead & Craighead 1967), we can calculate that the population reduction effected by control measures for 1970 alone (22 grizzlies through September 15) will exceed 10% of the Yellowstone population.

Control methods must differentiate between the dangerous, but relatively few, man-conditioned animals in the population and those essentially wild animals that for generations have fed at the remote garbage dumps and, in the course of seasonal movements or rare periods of natural food scarcity, have entered developed areas. Grizzlies become man-conditioned by eating in the presence of humans.

Transplants:

For many years, troublesome campground grizzlies in Yellowstone National Park have been transplanted to remote areas within the Park. To evaluate the effectiveness of transplant and release as a technique for disrupting the campground foraging habits of grizzlies, we marked captured animals and released them at suitable sites from 1959 through 1967. We then recorded their movements by recapturing them. Starting in 1968, this task has been performed by Park rangers. Table 6 shows that over an 11 year period, there were 145 releases of grizzlies within Yellowstone National Park at varying distances from

TABLE 6. RECORD OF THE RELEASE OF GRIZZLIES AFTER INITIAL CAPTURE IN A CAMPGROUND OR DEVELOPED AREA AND SUBSEQUENT RECAPTURE, 1959-1969.

	Distance grizzlies transported (Airline miles)				
	0–10	11–20	21–30	31–40	Totals
Number of releases after initial capture	75	46	20	4	145
Number of recaptures in any campground or developed area after release	53	32	12	1	98
Percent of recaptures in any campground or developed area after release	70.7	69.6	60.0	25.0	67.6

the campgrounds or developed areas where they were captured. Our data show that 68% of these animals returned to the same or another campground following release. Although the percentage returning decreased with the distance transported, the capture-transport-release technique within the Park is clearly only a partial solution for dealing with troublesome grizzlies. Information from campground bears radio-tracked for extended periods of time further supported this conclusion. We believe more distant releases on federal lands adjacent to the Park would prove more successful.

Campground management:

A concerted effort has been made to remove food from campgrounds or make it unavailable to bears. The installation of numerous, bear-proof garbage cans has helped the sanitation problem. However, campgrounds are still attractive to bears and will probably remain so as long as visitors are careless with their food or deliberately distribute table scraps to entice birds, bears and other animals.

BEHAVIOR OF GRIZZLIES IN RESPONSE TO REVISED MANAGEMENT PRACTICES

In 1941, officials of Yellowstone National Park abruptly closed the Canyon Village and Old Faithful feeding stations where large numbers of grizzlies and black bears were viewed by the public. The following year, rangers found it necessary to kill 28 grizzlies and 54 black bears when these animals dispersed to campgrounds and the hotels at Canyon Village, Lake and Old Faithful in search of food. An emergency situation existed that year, even though only 191, 830 visitors were recorded in the Park.

From 1968 through 1970, with visitor numbers exceeding 2, 000, 000 per year, the Yellowstone administration proceeded to repeat this type of management by abruptly phasing out the Tower, West Thumb, Trout Creek and Rabbit Creek open-pit garbage dumps. In 1967, prior to this decision, we had made a report to the National Park Service, *Management of Bears in Yellowstone National Park* (Craighead & Craighead 1967). In that report, we recommended slow phasing out of the open-pit garbage dumps, cautioning that:

'Because phasing out of refuse dumps will disperse the grizzlies by destroying an attractive, if not essential, food source, the transition from pits to incinerators must proceed gradually, enabling the grizzlies to develop new feeding habits as well as altered social behavior and movement patterns. If the transition is slow and follows a recommended procedure, it is possible that no severe changes in population level, distribution or behavior will result. If, on the contrary, the phasing out operation is abrupt, and a carefully planned procedure is not followed, the result most certainly will be increased grizzly incidents in campgrounds, accelerated dispersal of bears to areas outside the Park, and greater concentrations of grizzlies at the public dumps in Gardiner and West Yellowstone, where food will be available but where adequate protection will not. The net result could be tragic personal injury, costly damages and a drastic reduction in the number of grizzlies.'

Phase-out of open-pit dumps:

During the summers of 1959 through 1967, approximately 1, 000 cans of unsorted edibles and trash had been deposited daily at Trout Creek. The refuse was lightly covered with soil, usually on the day of deposit. The volume of food attracted and held grizzlies in the area during the summer months. During 1959-1967 we documented the effect of this artificial feeding situation on the habits and behavior of grizzlies.

In 1968, the volume of garbage taken to Trout Creek was drastically reduced and we documented the effect of this on grizzly behavior. Edibles were partially separated from trash and dumped, but not buried. The sorted food consisted of approximately 50% non-edible trash. Most of the refuse formerly dumped at Trout Creek was handled by the newly installed incinerator at Bridge Bay which had an operating capacity of 6, 000 lbs. per hour. Our records, made when the refuse was dumped, showed that a maximum of eight cans per day were deposited from June 3 through June 14; between June 15 and July 15, the number gradually increased to 40 per day. During the remainder of the summer, the number was not increased significantly except when the Bridge Bay incinerator broke down.

The early summer cut-off of, food, followed by a drastic reduction in edibles during the summer of 1968, dispersed the grizzlies throughout the Park. Our documentation of marked animals showed that many found their way into campgrounds, traveling between Trout Creek and the Canyon Village and Lake Campgrounds. Other moved back and forth between Trout Creek and the dumps at Rabbit Creek and West Yellowstone. This type of movement did not occur from 1959 through 1967 prior to the phase-out. Our censuses of population units in the vicinity of each major dump showed that these units tended to be self-contained with very little exchange of animals (Craighead & Craighead 1967).

Many unmarked grizzlies also entered campgrounds. Fifty-four percent of the 37 grizzlies captured in campgrounds in 1968, 48% of 33 captured in 1969, and 41% of 49 captured in 1970 were unmarked. The movement of practically all the Trout Creek grizzlies, marked and unmarked, was greatly accelerated. A measure of this movement and disruption of long established habits is reflected in the frequency of capture and the numbers of grizzlies captured in campgrounds each year during the period 1959-1967, as compared to similar data for 1968-1970. The number of individual grizzlies captured in 1968 is approximately four times the average for the previous 9 years and double the previous high of 1961. Frequency of capture was the highest recorded in 10 years (Figure 4).

In 1969 we continued on-site measurements of the volume of garbage dumped at Trout Creek. Between 130 and 170 cans were deposited daily from June 15 through August. Most of this was in plastic bags. Only about half the contents were edible. As in 1968, the garbage and trash were not buried, so the grizzlies that arrived at the dumps first were able to consume most of the food by evening; this left little to hold animals which arrived later. From 1959 through 1967 the general procedure was to dump trash with garbage and partially cover it with soil each day. This provided a long feeding period and allowed numerous animals to share the food. This procedure had, in the past, kept the grizzlies concentrated.

The dispersal of grizzlies that began in 1968 continued in 1969. The slight increase in the amount of garbage, designed to rectify the situation, was ineffective. The frequency of capture as well as the number of grizzlies captured in campgrounds and developed areas remained high (Figure 4). In 1970, following the closure of the Rabbit Creek Dump, frequency of capture of grizzlies in campgrounds climbed still higher to a peak of 72; just twice the value of the 1961 peak. The number of individual grizzlies captured was 49, the greatest number ever recorded (Figure 4). Thus, data on the number of individual grizzlies captured in campgrounds during the three years of revised management clearly show that the new management practices have been creating problem bears that then must be dealt with by the Park administration. In Table 7, the frequency of capture and the number of individuals captured in campgrounds and developed areas during 1959 through 1967 was totaled and compared with similar data for 1968 through 1970. The rate of capture for 9 years (1959-1967) was 117; for the past three years it was 190. The number of individual grizzlies captured for the same periods also increased.

Of the total number of grizzlies involved in campground foraging it is particularly revealing that 57 were captured during the 9 years prior to the rapid phase-out of the open-pit dumps, whereas 70 were captured during the first

3 years of phase-out (Table 7). Thus, from 1959 through 1967 an average of six grizzlies became campground foraging bears each year, but during the rapid cut-back in garbage (1968 through 1970), an average of 23 grizzlies became campground oriented each year. Data in Table 7 also show that Grant Village, which was first opened to the public in 1967, presumably had no problem bears that year, as none were captured. The following years it was visited by grizzlies. Twenty-five were captured during the three-year period of revised management. Similarly, no grizzlies were captured at Slough Creek, Tower

TABLE 7. FREQUENCY OF CAPTURE AND THE NUMBER OF GRIZZLY BEARS CAPTURED IN CAMPGROUNDS.

	1959-1967		1968-1970†	
Campgrounds and developed areas*	Frequency of capture	Individual bears captured	Frequency of capture	Individual bears captured
Canyon Village	48	33	42	24
Lake	40	26	73	48
Old Faithful	9	9	23	17
West Thumb	17	11	7	6
Grant Village	—	—	30	25
Norris	1	1	2	2
Lewis Lake	0	0	1	1
Indian Creek	2	2	0	0
Slough Creek	0	0	3	3
Tower Fall	0	0	3	3
Mammoth	0	0	1	1
Madison Junction	0	0	5	3
Totals	117	82	190	133
Corrected totals‡		75		124
Total individuals involved		57		70

*Canyon Village includes—Canyon Village and Otter Creek Campgrounds. Lake includes—Lake, Fishing Bridge, Bridge Bay and Pelican Creek Campgrounds. Grant Village opened in 1967 when the National Park Service began phasing out open-pit dumps.

†Unmarked grizzly bears entering campgrounds during 1968 and 1969 could not be individually marked because of Park Service policy prohibiting marking of any animals in Yellowstone. Thus, in addition to marked animals, a minimum number of unmarked individuals, determined by criteria of sex, age and time of capture were recorded for this period.

‡ In 16 instances, bears were captured in two areas during a year. The corrected total of individual grizzlies captured per year corrects for this bias.

Fall, Madison Junction and Mammoth from 1959-1967, but grizzlies were captured at these campgrounds from 1968-1970.

We must conclude that the new bear management practices, programmed to quickly phase-out the open-pit dumps in Yellowstone without first adequately sanitizing the campgrounds, greatly increased the probability of bear-man conflicts as more grizzlies entered congested visitor areas. This program has rapidly 'created' troublesome campground grizzlies. The administration's policy formulated to deal with this situation has been to kill or ship to zoos all two-time offenders entering campgrounds or developed areas within a successive 2-year period.

In 1969, the Natural Sciences Advisory Committee of the National Park Service met with Park administrators, biologists and consultants to review grizzly bear management in Yellowstone National Park and to formulate a bear management policy and program (Natural Sciences Adyisory Committee Report, 1969). The Committee summarized the management goals as follows:

1. To maintain populations of grizzly and black bears at levels that are sustainable under natural conditions as part of the native fauna of the Park.
2. To plan the development and use of the Park so as to minimize conflicts and unpleasant or dangerous incidents with bears.
3. To encourage bears to lead their natural lives with minimum interference by humans.

The ultimate objective agreed upon by all participants was the sanitary disposal of trash and garbage in a manner that would deny this food source to bears.

The report continued:

'But, in the meantime, there is disagreement as to the sequence of steps leading to the elimination of garbage from availability to grizzlies. One view is to cut off all garbage quickly, forcing the bears to turn immediately to natural foods. The opposite contention is to phase out garbage feeding over a period of time, 'weaning' the bears gradually. The issue hinges on which of these procedures will result in the least number of bears going into campgrounds.'

In 1970, following the distribution of the Advisory Committee report, the Park continued its phase-out policy for garbage dumps by completely closing the pit at Rabbit Creek, which prior to this time attracted and held a population that fluctuated between 22 and 48 grizzlies. Our censuses showed an 8-year average of 32 grizzlies in the area during the summer months (Craighead & Craighead 1967). Five airline miles away a fenced sanitary land-fill dump was installed at Nez Perce Creek as a replacement for Rabbit Creek. With this accomplished, grizzlies with traditions of feeding at Rabbit Creek were completely and abruptly denied a long-established food source.

Movements of individual grizzlies in response to reduced food at the Trout Creek Dump during 1968-1969:

Five female grizzlies which frequented the Trout Creek Dump were color-marked between 1960 and 1962 (Table 8). They were captured in campgrounds or developed areas for the first time following the reduction of food at Trout Creek in 1968. The long interval between marking and first capture in a campground can be explained if these bears increased their daily movements and

TABLE 8. CAMPGROUND CAPTURES OF FIVE FEMALE GRIZZLIES FOLLOWING THE RAPID PHASE-OUT OF TROUT CREEK DUMP, 1968-1969

Bear No.	Year Marked	Date of first capture in campground	Interval in years between marking & first capture in campground	Age at first capture in campground*	Number of capture areas	Frequency of capture by years	Number of offspring produced between marking & first recapture	Status of female 1969
34	1960	1969	9	19½	1	1969-1	6	Alive
39	1960	1968	8	13½	2	1968-2 1969-5	5	Alive
40	1960	1969	9	11½	1	1969-1	7	Killed for control
109	1961	1969	8	8½	1	1969-2	0	Alive
128	1962	1969	7	18½ Min.	1	1969-1	10†	Alive

* Age in years—all bears were aged by cementum layer technique. Ages designated minimum (Min) represent minimum cementum layer age. (Craighead *et al.* 1970)

†No. 128 produced 3 more cubs in 1970.

extended their home ranges in search of food. The home ranges of No. 39 and No. 40 had been established earlier by radiotracking (Craighead & Craighead, in prep.).

No. 39 extended her home range in 1968 to include Lake Campground and the Bridge Bay developed area. During 1968-1969, she was captured five times at the Bridge Bay incinerator and twice in adjacent developed areas. In both years she was probably attracted there by odors from the incinerator.

We radiotracked No. 40 for 8 consecutive years (Craighead & Craighead, in prep.). While this female was radio-monitored, she was never tracked into a campground or developed area. However, she entered the Lake developed area in 1969 and was shot.

Since grizzlies of all ages made initial campground entries in 1968 and 1969, we do not think that the advanced age of three of the five grizzlies listed in Table 8 was a factor altering their behavior and movements. They were in excellent condition when last captured; all had reproductive records. No. 128 had produced ten cubs prior to her capture in 1969. She bore three more in 1970, at a minimum age of 19½—a total of 13 cubs during the 9 years she was marked. From 1960 to 1970, the five females bore a total of 28 offspring (Table 8). It is evident that management practices which 'force' productive females into developed areas where they are subject to control could rapidly alter the population level.

Scarcity of the staple natural foods during 1968 and 1969 did not cause the movement, since the availability of these during the period was not importantly different from other years. Our data on the utilization of natural foods by grizzlies and on the relative abundance of these foods throughout a 12-year period cannot be presented here, but these fully support this conclusion. We, therefore, conclude that the five females recorded in Table 8, as well as 11 other marked grizzlies of both sexes, were captured for the first time in campgrounds in 1968 and 1969 primarily because of the acute food shortage at Trout Creek. Thirty-five unmarked individuals were also captured in campgrounds or developed areas for the first time.

Figure 6 and Table 9 show the movements from Trout Creek of 34 marked grizzlies and two recognizable cubs. Records of these movements were obtained by capturing the animals or by observing their individualized color markings. Sixteen individuals visited the Lake developed area, eight entered Canyon Village, and ten moved to the Rabbit Creek Dump. Two moved to Cooke City, three to Tower, three to West Yellowstone, one to Norris, and one to Grant Village. Eight of the marked bears visited two campgrounds or developed areas (Table 9), thus accounting for the total of 44 bears shown in Figure 6.

Dispersal of individual grizzlies following the closure of Rabbit Creek Dump in 1970:

Grizzlies inhabiting Rabbit Creek dispersed widely following the closure of that open-pit dump in 1970. Figure 7 shows the movements of 12 color-marked and 2 recognizable grizzlies to new feeding areas. All of these grizzlies were observed and recorded at Rabbit Creek for between 3 and 11 years prior to the closure (Table 10). Therefore, all could be considered resident members of this population unit.

Seven grizzlies moved 18 airline miles to the West Yellowstone Dump, which lies outside of the Park. Two joined the grizzlies at Trout Creek, 19 airline miles away; these also visited the West Yellowstone Dump. Grizzlies No. 2 and

TABLE 9. DISPERSAL OF 34 COLOR-MARKED GRIZZLIES AND TWO RECOGNIZABLE CUBS FROM TROUT CREEK FOLLOWING MANAGEMENT CHANGES AT TROUT CREEK DUMP DURING 1968 and 1969.

	Campgrounds and developed areas visited by marked grizzlies							
Marked Bear No.	Lake	Canyon Village	Grant Village	Norris	Cooke City Dump	Tower Dump	West Yellow-stone Dump	Rabbit Creek Dump
7								X
10 + (2)*						XXX		
30	X							
34					X			
39	X							
40	X							
88								X
109	X							
112		X						
128	X							
130			X					X
141	X	X						
144		X						
147								X
166							X	X
183	X							
188		X						
189								X
190							X	
194								X
201								X
207	X	X						
208	X	X						
210	X							
211	X			X				
213							X	X
217	X							
218								X
228		X						
236	X	X						
240	X							
214	X							
242					X			
256	X							
Totals	16	8	1	1	2	3	3	10

*The cubs of bear No. 10 dispersed with their mother and could be recognized.

TABLE 10. MOVEMENT OF GRIZZLIES FOLLOWING THE CLOSURE OF RABBIT CREEK DUMP IN 1970

Bear No.	Sex	Number of years previously observed at Rabbit Creek Dump	New area visited‡	Airline distance from Rabbit Creek Dump to new area
2	M	11	Old Faithful	5
			Grant Village	14
8	F	11	Grant Village	14
57	M	10	West Yellowstone Dump	18
139	F	7	West Yellowstone Dump	18
			Trout Creek Dump	19
147	M	7	Trout Creek Dump	19
164	F	7	Old Faithful	5
171	M	6	Old Faithful	5
213	M	5	Trout Creek Dump	19
217 A	M	3	West Yellowstone Dump	18
			Trout Creek Dump	19
219 A	M	3	West Yellowstone Dump	18
224 A	M	3	West Yellowstone Dump	18
226 A	M	3	West Yellowstone Dump	18
UM*	M	4	West Yellowstone Dump	18
UM†	M	10	Old Faithful	5

*This male identified by size, conspicuous wound over left eye and white patches of hair on shoulders. (UM = unmarked.)

†Large male identified by a wound exposing the upper left canine. (UM = unmarked.)

‡ New area visited was determined by observation or capture of marked or recognizable animals.

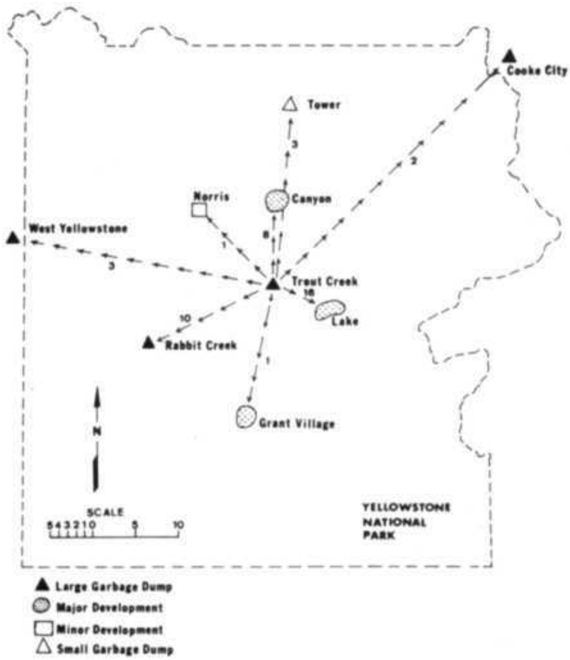

Fig. 6 Dispersal of 34 marked and two recognizable grizzlies following management changes at Trout Creek Dump during 1968 and 1969.

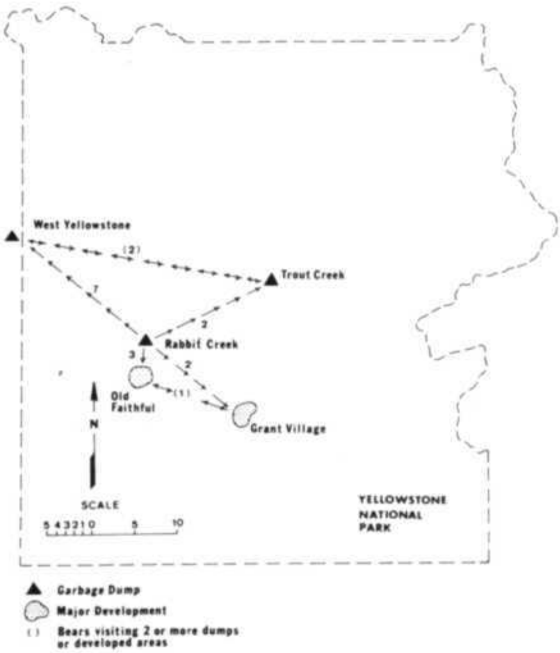

Fig. 7 Movement of 14 marked or recognizable grizzlies following closure of Rabbit Creek Dump, 1970.

Fig. 8 Two families of marked grizzlies. The reproductive history of individual females was recorded during a 12 year period.

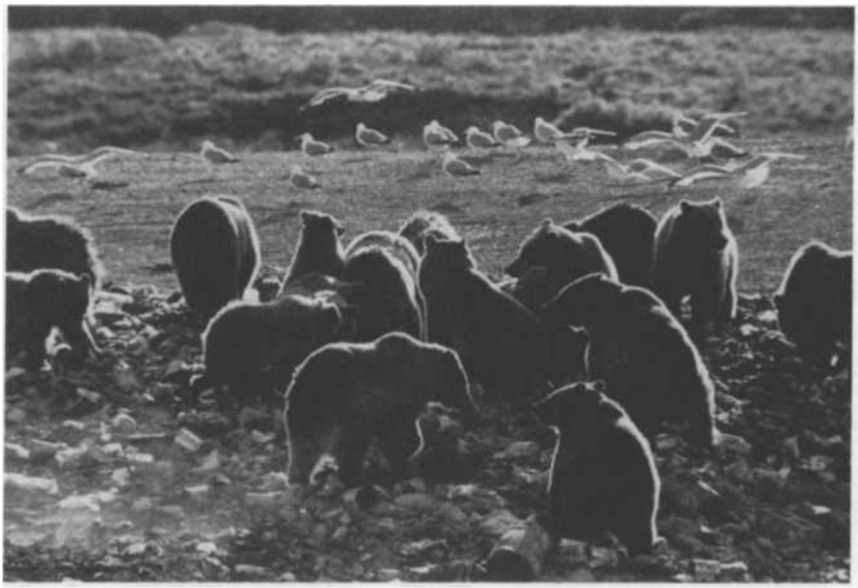

Fig. 9 Grizzly bears feeding at the Trout Creek Dump. Rapid phase out of this dump in 1967 and 1968 forced grizzlies to extend their home ranges and many entered campgrounds.

Fig. 10 A grizzly individually marked for identification, following immobilization with the drug phencyclidene hydrochloride.

Fig. 11 A female grizzly exhibiting an agressive posture at the close approach of a large male.

TABLE 11 CAMPGROUND CAPTURES OF FIVE GRIZZLIES FOLLOWING THE CLOSURE OF RABBIT CREEK DUMP, 1970.

Bear No.	Sex	Year Marked	Interval in years between marking and first capture in campground	Age at first capture in campground	Capture Areas	Frequency of Capture	Status in 1970
2	M	1959	11	15½-16½	Old Faithful	2	Killed for control
					Grant Village		
8	F	1959	11	19½ ± 2	West Thumb Grant Village	2	Killed for control
164	F	1963	7	12½	Old Faithful	1	Alive—Yellowstone
171	M	1964	6	9½	Old Faithful	3	Zoo for control
UM*	M	1960	10	22½-25½	Old Faithful	1	Killed for Control

*Large male unmarked but identifiable during a 10-year period by a wound exposing the upper left canine.

No. 8 moved 14 airline miles to the Grant Village Campground and developed area. Three grizzlies, including No. 2, moved to the Old Faithful area only 5 airline miles distant. Comparison of the 1970 census data taken at Trout Creek and West Yellowstone with other years suggests that many of the unmarked grizzlies from Rabbit Creek also moved to these other open-pit dumps.

In 1970 five Rabbit Creek grizzlies were captured in campgrounds or developed areas and four were dispatched. None of these had previous campground records. The long intervals between marking and first capture in a campground or developed area (Table 11) show that the policy of rapidly closing the long established open-pit dumps was still creating problem bears in Yellowstone. The official solution was still to dispatch the animal. There is circumstantial evidence that No. 8 severely mauled a Park visitor in Grant Village on September 3, 1970. This color-marked animal had not been captured or observed in a campground during an 11 year period prior to this time.

The Park Service plans to completely close the Trout Creek Dump during the spring and summer of 1971. At the same time the West Yellowstone Dump will be moved and fenced. This will disperse approximately 180 grizzlies in one season. This action, in all probability, will create more acute bear problems in campgrounds and developed areas in and near the Park than have existed in a 100 years of Park history.

DISCUSSION

Grizzly bears and man have coexisted in Yellowstone since the establishment of the Park in 1872. They have shared this environment during the past decade with about a 900, 000-to-1 chance of confrontations leading to personal injury. The open-pit garbage dumps that came into existence with the establishment of Yellowstone Park have become traditional feeding areas for grizzlies. A long-term study showed that these dumps have altered the bear's behavior patterns at these sites, but they have not made grizzlies dependent on man or created the incorrigible animals that are a threat to the visiting public. On the contrary, the isolated dumps, with restricted public access, have effectively concentrated grizzly bears during the height of the visitor season. They have been extremely effective in reducing the probability of grizzly-man encounters and injury.

In order to induce the Yellowstone grizzlies to adopt more natural feeding habits while preserving an optimum grizzly bear population and adequately protecting Park visitors, the long-established feeding sites must be phased out over a period of many years. Thorough sanitation of campgrounds and developed areas, both inside and outside the Park, must precede the closure of the major open-pit dumps in Yellowstone. In 1968, the Yellowstone administration initiated a management program; its major objective of rapidly eliminating open-pit garbage dumps has drastically disrupted long established grizzly bear patterns of feeding and movement. This has forced grizzlies into areas of high visitor use and vastly increased the probability of bear-man conflicts. Rapid elimination of 'artificial' food at the dumps is not forcing the Yellowstone grizzlies to quickly adjust to an all-natural food diet, but is instead moving them into unsanitized areas inside and outside of the Park.

Since practically all of the grizzlies in the Yellowstone area have fed at open-pit garbage dumps during some time in their lives, a 'wild-population' cannot be made by denying this food and then dispatching all grizzlies that find it elsewhere in campgrounds and developed areas of the Park. The present rapid phase-out policy, combined with the elimination of two-time offenders, could reduce the grizzly bear population of the Yellowstone Park.-National Forest Ecosystem to a dangerously low level in a relatively short period of time. We believe that grizzly bears and man can coexist in this vast ecosystem if management is tailored to the facts of bear behavior, if all campgrounds and developed areas are sanitized, if open-pit dumps are slowly phased out, if the visiting public is willing to accept a small risk, and if all agencies having a vested responsibility in solving the problem work cooperatively toward common objectives.

ACKNOWLEDGMENTS

This paper would not be possible except for the team assistance of many people and the financial support of numerous organizations.

We extend special thanks and credit to Jay Sumner, Harry Reynolds, Jim Claar, Maurice Hornocker and Robert Ruff, who first as students, then as research associates, worked closely with us in the field and in the laboratory. Bart W. O'Gara critically reviewed the manuscript. Special thanks are also due Mr. Lemuel Garrison, former Superintendent of Yellowstone National Park, and C. R. Gutermuth, Vice-president, Wildlife Management Institute. Their understanding and encouragement of our research made it possible for us to initiate this grizzly bear study and to maintain the continuity of effort so essential to long-term investigations.

We gratefully acknowledge the following organizations for financial aid:

National Science Foundation
National Geographic Society
Philco Corporation
Bureau of Sport Fisheries and Wildlife
Environmental Research Institute
National Park Service
University of Montana
Wildlife Management Institute
Montana Fish and Game Department
Boone and Crockett Club
New York Zoological Society
Atomic Energy Commision

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Bear Damage and Bear Control in Japan

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The bear in Hokkaido (see Frontispiece), the northernmost island of Japan, is *Ursus arctos yesoensis,* which is a kin species of the brown bear on the Asiatic Continent. The body weight of the largest one is nearly 400 kg or about 880 pounds. There are too many bears on Hokkaido, as they do much damage and disturb the development of the land. The Yeso brown bear attacks human beings, killing on the average of 1. 3 men and hurting 3. 6 men every year. The number of horses killed in one year was recorded as 44, of cattle 55 and of sheep 17,921.

Since 1955, on the average, 509 bears have been killed every year. I estimate from these statistics that about 3, 000 bears inhabit Hokkaido. Among them 1500 are females of which a half propagate each year, individual females giving birth to two cubs every two years. Therefore 750 newborn cubs appear every year. 500 bears are killed and 250 bears die of natural causes. Therefore the size of the bear population remains constant despite intensive hunting.

The damage by the bear in the rural parts of Hokkaido is very serious and so the Government encourages hunters to kill the bear by offering a bounty. The ordinary game season for the bear begins from October 1st and ends at the middle of February. However, the bear hibernates from the middle of November. So, the government issues special licenses to shoot the bear any time when a wild bear appears to be attacking human beings or domestic animals. Up to now no effective method to diminish the number of bears has been found.

PANEL 5: BEARS AND HUMAN BEINGS

SUMMARY OF DISCUSSION.

J. Marsh. I'm interested in finding out whether in Yellowstone or in the Canadian National Parks, people are, in fact, being prosecuted for feeding bears or for intimidating bears.

G. Cole. The answer for Yellowstone Park is yes; I think principally for the roadside feeding of black bears.

G. Burghardt. Do you have any figures as to how many people in a year are arrested and fined?

G. Cole. This year there were very low numbers of black bear alongside the roads. The figure that comes to my mind for the previous year, during which we had more black bears alongside the roads, was something in the vicinity of 90 citations through a summer period.

I. McT.Cowan. It seems to me that we must be searching for principles that can be generally useful. The subject matter of this Panel is one of the things that I'm particularly keen on because Yellowstone and Glacier are pioneering in a problem which is not at all unique and which we, in Canada, are just beginning to have a look at. I understand that the situation in Glacier National Park was far simpler in terms of its general complexity and, therefore, its solution than the one faced in Yellowstone. And I wonder if Mr. Martinka could, give us some indication of the situation in Glacier National Park, Montana.

C. Martinka. Glacier has never had an extensive amount of refuse available to either kind of bear, not out of a prudent management program but out of the fact that we have never had an excessive number of visitors to the park until very recently. In addition, much of our visitation has been on the periphery of the park and there have been areas where we've been able to go outside and dispose of garbage. However, although the records are not really clear, the problem with bears and refuse was recognized 30 to 40 years ago and over the last 25 years what few refuse dumps were available have been discontinued, in most cases abruptly. In one year they were closed and that was the end. There have never been any cases where this has caused any problems. The last refuse pit that we had was closed in 1968. With the exception of 25-50 garbage cans, there is no refuse available to bears in any form and there has not been for about 2 years in the park.

Attempting to relate all this to grizzly bears, we had in the past 25 years only 4 instances of personal property damage in developed camp grounds caused by them. We have never had a personal injury in a developed area in Glacier Park caused by grizzlies. I attribute this to management which has not changed substantially. The emphasis has definitely been increased, but for 25 years the Glacier Park administration has never tolerated a grizzly developing an association with a developed area, whether it be a camp ground, a residential area, concession facilities or any other kind of facility. In other words, immediately upon entrance into this type of an area, a grizzly was either trapped and transplanted or he was disposed of in an appropriate manner. Over this 25 year period, prior to 1960, this amounted to about a half a bear a year or one bear every two years. After 1960, the figure went up to an average of 2 bears a year, which—out of a population of 200, which I am estimating—I think can very easily be stood. Since 1967, which has become the reference point apparently in all bear management because we did have 2 deaths in the park, we have intensified the efforts, originally started many years ago, to make sure that refuse was no longer available to bears. In 1967, there were 4 bears taken out of the population at Granite Park Chalet where the one death occurred and there was one bear removed from Trout Lake where the other death occurred. This figure has now declined with the removal of those bears which did have garbage associations.

For example, this year in the park, perhaps partly because of an excellent berry crop, we had no property damages; we had no personal injuries by either type of bears, the first time in about 25 years that this has occurred; we had no management action whatsoever, including trail closures, campsite closures; we had no control, no trapping, or transplanting; no direct deaths of grizzlies. We had our usual little black bear problem which occurred from time to time. So this is the direction our program has taken. I feel, with a couple of exceptions where there are refuse sources available outside of the park, we have a completely wild free-ranging population of grizzlies in the park. Our research and management program is utilizing the hypothesis that wild free-ranging bears, unaccustomed to man and his food sources, present the least number of conflicts with man.

There are other things which will take years and years to test. There is a natural avoidance by grizzly bears of people, some of which may relate to just conditioning of larger numbers of people on the trail. Our park visitation has increased substantially, just like all other parks. I don't, again, have the figures but we've had over a million now for 2 years in a row. Back country visitation is, at least, keeping pace with this and perhaps increasing at an accelerating rate. Our bear problems increased somewhat as this acceleration started in the early 1960's. However, that levelled off in the mid 1960's and if the trend which has been established since 1967 continues, I would expect that this will return to a relatively low rate. So we have rejected the hypothesis that increases in visitation are necessarily accompanied by increases in bear problems.

Again as I mentioned a couple of days ago, by transplanting the bear, we don't feel this is really the treating of a symptom,—the basic cause is still the availability of refuse. This is not to say that all of a sudden bear problems are going to cease in this area. We have sub-adult black bears, for example, in the spring coming on to the roadsides, not because people are feeding them, but because there's available food in the form of green grasses and clovers growing here. The end result is somebody ultimately feeding them so there's an ecological problem involved with roadside management. I think, in the long run, this is the type of problem we're going to have a look at with respect to roadside management in the park.

Black bear incidents have been reduced to a point, when for the first time in some 25 years of reasonable records we haven't had a black bear injury in the park. The number of property damages was about 3 or 4 this year in the park. So we have substantially reduced black bear problems. Again, this may possibly be masked somewhat by the appearance of an excellent berry year. So, we feel there will be a small number of problems arising. We are not saying somebody is not going to get hurt by a sow grizzly with cubs at some time or another. Statistical chance does enter into this: however, we feel that the problem has been reduced and we feel we now have the mechanisms within our reporting systems and our management techniques to reduce this to a minimum and we feel that, at least since 1967, the hypothesis that wild bears present the least conflict with humans is working. This data will be out as a publication within the next year, at least relative to the grizzly.

J. Sumner. I'd like to ask how you get your population figures for the number of bear in Glacier.

C. Martinka. Well, I think somebody said that any estimate is a major accomplishment, and I would agree with him since there are limits to your ability to work with an animal in the forest. Quite obviously, we don't feel under those conditions that catching them all and counting them is the answer. What we have done is to establish a monitoring system. It's not a requirement but a request that all park people or other interested people report all sightings of bears that they see in the park each year. There are areas of the park that don't get very many people; there are areas of the park which receive a substantial amount of use and I have taken this information for about a 300 square mile area, and each year, as crude as this system may appear, I have eliminated all observations that I consider to be duplicate based on descriptions of the animal, size of the cubs, ages and anything else that can come out of an individual report, and estimated the number of individual animals observed on this area each year. Now I recognize this is extremely crude but it's also better than anything else we've ever had. And with this type of an estimate, I have come out consistently for 4 years in a row with between 175 and 230 bears. This is about 1 bear per 8 square miles or 9 or 7, depending which year you're operating in—it fluctuates according to the number of young that you see each year. I had some opportunities to do a little bit of intensive work in small areas where we have a lot of access and I had an opportunity to get a better idea in a local area what the densities might be. We have come up with densities as high as about 1 bear per square mile. Part of this results somewhat from the seasonal movements to preferred food sources. In one area, McDonald Creek, above McDonald Lake, which has a road going through it, we have had an opportunity to observe in detail and we get good descriptions of the bears that are seen there. We have come up with a density of 1 bear per 2 square miles for all habitats within that drainage, not just for sub-alpine huckleberry patches.

So this is the data we have. I recognize it is crude relative to what we can do with certain populations of animals. I think it's reasonably relative to the data which has been done by more precise methods, such as radio telemetry.

J. Marsh. One of the things that's a problem in doing an attitude survey about bears is that you might expect a change immediately after incidents such as you had in Glacier. Could you say whether there was any marked effect on visitor attitudes or behaviour after that incident and whether this continues through to the present day with an unrealistic expression of concern about the bear hazard in that park.

C. Martinka. All the information we have and I have been asked this question quite commonly, because it has economic bearing on the surrounding communities, suggests that this had relatively little effect. If anything, it may have tended to increase use in certain areas. For example, after some kind of a bear problem or something, it's not uncommon for every other person that goes through the gate to say, or to ask, 'Where can I go to see a grizzly ?'. So it has focused some attention on the grizzly. A number of people, both in Yellowstone and Glacier Parks after an incident, have been extremely vocal in blaming themselves rather than the bear. This tends to offset some of the adverse publicity that certain kinds of incidents cause.

J. Craighead. With a density of 1 grizzly to every 8 square miles in Glacier, a density four times as great as we've found in Yellowstone National Park, I'm rather concerned that figures like this, which are extremely crude, are accepted as basis of management for an endangered species. Obviously the percentage that are destroyed, percentage shot, all appear to be much lower. The best estimates made in former years have been about between 100 and 125 grizzlies and I think that it would be helpful if more precise censusing techniques could be developed and used because I think we could get into an awful lot of trouble with inadequate census methods, particularly if we over-estimate the number of animals.

Another point I'd like to make, regarding the different situation in Glacier and Yellowstone, is that the recreation use pattern in Yellowstone developed many, many years ago. At that time they used a horse-drawn vehicle for travelling the roads, and viewing the sights in Yellowstone. Traditionally there has been very little use of the back country in Yellowstone by the public. This is increasing, of course, now, and there will be more and more use in years to come. Glacier on the other hand has developed a recreational pattern of back country use—a great deal of hiking on the trails where people have had a greater chance of contact with bears. In Yellowstone there is a greater opportunity of bear/man contact in the campgrounds simply because there are more of them and they are much larger. Another difference is that in Glacier you had the chalets located back 8 to 10 miles from any road, where a number of people would go in, stay several days to a week, and where students would hike back and camp for a long period of time. Grizzly bears were enticed to these areas, actually hand-fed in some instances. I've visited these personally, as my colleagues have, and this did tend to create some of these man-conditioned bears that we described earlier. So I think there are some very major differences in the situation in Glacier and Yellowstone.

C. Martinka. I don't have any answer to this other than, again using indexes on these estimates, we annually have 10 to 20 different sows with young identified in the park, which would suggest, on the basis of some of the figures which have been used in the last day or two, that the population is probably around 200 animals.

S. Herrero. I'd like to ask Professor Craighead what method of population census he would recommend for the grizzly population in Glacier National Park.

J. Craighead. In view of the data that we obtained from marked animals and the fact that we've been unable to find differences in avoidance behaviour of grizzlies that have been marked versus unmarked, or any regular visitations of marked animals In the campgrounds, we would highly recommend a marking program and possible use of the radio for accurate enumeration of the population. I realize that in the national parks there is some drawback to marking animals. Generally the excuse given is that visitors don't like to see marked animals. Frankly we've not had this experience in Yellowstone. Out of 1500 elk that we individually marked and studied over a period of 8 to 9 years, only a tiny fraction were ever seen by visitors. Again, only a tiny fraction of marked grizzlies were ever seen by visitors. We have data on this. However, among black bears marked, by another research group, a high percentage were seen along the road. I think that the Yellowstone administration received criticisms on the number of marked black bears which were on the road and used this to conclude that visitors do not want to see any marked animals and that a lot of other types of marked animals are seen by visitors. What I would suggest is that an increase in marking of all types of animals in the park be carried out with an educational program that would tell the visitors why these animals have been marked. This could be done along the roads, it could be done at the camp fire talks, it could be done in many ways. We found that an average visitor is extremely interested in seeing a marked animal if he knows why it's marked and for what purpose. I really don't see how you'll get even a guestimate of the grizzly bear population in Glacier until you begin a marking program for individual animals.

F. Craighead. I'd like to mention that early in our studies in Yellowstone we solicited the help of the rangers, of various people working in the park, as well as some visitors in making observations. We eventually had to dop the analysis of all of this data, which more or less constitutes a monitoring system similar to the one described, because we found that most of these people, including some of the rangers, could not distinguish between a grizzly bear and a black bear, particularly at a distance of 3 or 4 hundred yards.

S. Herrero. I'd like to ask John Craighead what the future of the grizzly bear research project which has now been going on for 12 years, would be in Yellowstone Park.

J. Craighead. I wish I could answer that question. I think I could say what I think the future should be. We still have a large number of marked bears in the population. As I indicated, we feel that the phase-out of open dumps should be slow, and we feel that there should be an objective evaluation of it. We believe that, in view of 12 years of experience, that our team is probably as qualified to do this as any other team that might be placed in the parks to evaluate this in the future. It's very obvious that if Trout Creek is closed down, as has been stated is the policy of park service, there are going to be tremendouse changes in the movements and habits next year, more so than this year. I would even go so far as to predict that if it is done, there's very likely to be a fatality in Yellowstone. I think that this requires objective evaluation, not by the agency responsible for the resource, but by a group not responsible. That agency can accept or reject the information and so, to answer your question, we would like to continue to evaluate this situation for a number of years. In our research in Yellowstone, this has all been done under a memorandum of understanding in which we state exactly what we will do within the park, within the regulations of the national park, while the National Park Service states what it will do; in other words we have an understanding on paper. In the case of this grizzly bear study, we obtained funds from a large number of sources, covering over a million dollars in the 12 year period. None of this money came from the National Park Service, in other words, we were conducting an independent research project as far as financing was concerned, and we would like to continue to do this. In a recent letter to the superintendent requesting renewal of the memorandum of understanding, we were informed that the memorandum would not be renewed. Hopefully, this is not so because, all personal considerations aside, in the interest of the resource, what takes place in Yellowstone—phasing out of these open pit dumps—should be very carefully and throughly documented.

G. Cole. Could I make a point here that in the program that was made available to those of you who were interested, there are two points that I think should be brought up. In Item No. 11 it is apparent that the Park Service is to work with towns, private individuals, and other state and federal agencies, to encourage the proper sanitary disposal of waste so as not to attract bears to places of human habitation outside park boundaries, and I'm positive that this has been going on with the adjoining towns. Then, in the overall program, there is a section called 'Contingencies' and if I may read the first item—'Continue to use the Trout Creek dump beyond the scheduled 1971 closure on a phase-out basis if grizzly intrusions into campgrounds begin to exceed control capabilities or lead to excessive numbers of animals being destroyed.' Then another contingency is that we have the possibility of manipulating opening and closing dates of campgrounds, closing campgrounds, restricting camping to enclosed trailer or pickup units and other measures as deemed necessary. So there are contingencies in the programming and it is flexible.

A. Anderson. Dr. Craighead, I think the access to these dumps is a critical point. Do you have any of your dumps that are surrounded by visitor activity as opposed to a dump where the bear has access to the dump from a wilderness area and therefore doesn't encounter visitors?

J. Craighead. The Trout Creek dump is isolated in what you might say is wilderness-type country,—wilderness all around it. The Rabbit Creek dump is located fairly close to a road but has essentially wilderness-type country around it. It was about 5 airline miles to the Old Faithful area. The West Yellowstone dump which is outside the park is very close to a town, West Yellowstone, and also very close to a highway—100 yards—and there is access to that area by the general public. The bear population at West Yellowstone since the closure of the Rabbit Creek dump and the reduction of food at Trout Creek has greatly increased. It is very difficult to give the bears protection there. Kids even go in and shoot them with 22's. The same is true of Gardner, the same is also true at Cook City which are smaller dumps; but they are close to the roads, they are accessible to people. But the two major areas where grizzlies concentrate in Yellowstone were right in what I would say are wilderness situations.

A. Anderson. The point really is that if the bears have access to the dump from a wilderness area without encountering people, we've substantially reduced any danger of encounter, while if there is visitor activity around the dump area there is increased danger. We have one dump at Lake Louise that has grizzly activity and has had for years and the only saving feature I've seen there is the fact that it's adjacent to a wilderness area. The bears go to and from the dump, without encountering people.[1]

J. Craighead. Well, essentially the location of the dump at Trout Creek is in the geographic centre of the park and isolated in a wilderness area, if you overlook the fact that it is an artificial manipulation and that the bears there are feeding for a period of time on artificial food. Nevertheless, what this particular dump serves to do is to concentrate considerably over half the population of the bears in the Yellowstone National forest system into a single area from which people are completely restricted. During this period of time the movement of the bears is relatively small compared to the movements in

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[1] Editor's note: This has been true except for one incident. In May of 1968 Mr. Kevin Branner was attacked and injured by a grizzly bear sow with cubs. The attack took place near the base of the Olympic double chair lift, Lake Louise. The sow responsible for the attack had been feeding regularly at the Lake Louise dump, and continued to do so for a certain period after the attack. A dog which was with Mr. Branner seems to have triggered the attack because it ran to the sow grizzly and barked at her.

As recently as October of 1970, 23 individual grizzlies were seen at the Lake Louise dump. More visitors in the Lake Louise area will mean an increasing probability of human injury by a grizzly unless steps are taken to close the lake Louise dump and to isolate other garbage and food sources from grizzly bears.

spring and fall and so in a way it was a safety factor to prevent the bears from moving outside the park and to prevent the bears from moving into other parts of the park. Now, I'm not advocating this, I think eventually this should be phased-out, but I think it must be recognized that this has played an extremely important role in reducing bear/man encounters and I think this has to be taken into consideration by the Yellowstone administration and I'm sure it will be.

A. Anderson. There's something which I think we're heading towards in our parks, all over, whether it's in the future, how far I don't know, but I wonder how much consideration has been given to bearproof campgrounds. I'm thinking of the chain-mesh fence, instead of being around the bears, of being around the people. I've personally seen an awful lot of visitors in the parks that come to the park for a wilderness experience, which we are trying to provide, and they lay awake all night looking at the roof of their trailer or their tent, afraid of being bothered by bears. A good many of them crawl into the car and spend the night there for protection. I would say right today that if we set up a chain mesh exclosure and have it alongside one of our wilderness concept campgrounds, that the exclosure campground will fill up far ahead of the other ones.

G. Cole. In Yellowstone Park we have put chain-link fences with standard offsetting single strand barbed wire and 4 strands of electrified wire around the outside of the sanitary landfills. This is just the first year and I guess only time will tell whether it will prevent bears from getting in, though this may not be a good test because when you're through with a good sanitary landfill process, there's probably not much there to attract them. And if you remember one portion of my paper, as another alternative to fencing a campground, I suggested moving the campground outside of the grizzly habitat.

E. Folk. We must think for a moment of some of the other types of parks where there are elephants, lions and even poisonous snakes, and the visitors are not allowed to throw a sleeping-bag down on the ground and you have to enjoy the place from a car. Perhaps some of our parks have to be designed a little bit more that way.

S. Herrera. I want to comment on the situation which exists concerning the brown bear on Hokkaido Island. The problem, as I see it, repeats some of the problems that have historically occurred between brown or grizzly bears and man. During the past few centuries, both in North America and in Europe, these bears have come into conflict with man. This is especially true where man has brought agriculture or range cattle into areas which previously served as brown or grizzly bear habitat. In this situation the bears conflict with agriculture, ranching or even directly with man. The might of technological man in the end has always been sufficient to dominate or exterminate the bears.

This situation was well illustrated in early California. In the early 1800's with the coming of large numbers of European man to California, there was a tremendous increase in the number of incidents between man and bears. Many men were injured, many bears were killed. With the introduction of repeating firearms and greater and greater numbers of people, man gained the upper hand and, as we know, by about 1920 the complete extermination of the once numerous California grizzly was brought about. I would claim—or, at least, advance the hypothesis, that the relationship between bears and man on Hokkaido today is analogous to the relationship between bears and man which existed in early California.

I hope that we can assist Professor Inukai in dealing with the very serious problem of agricultural depredation and loss of human life, without having to exterminate the brown bear on Hokkaido.

After the wilderness has been tamed, after modern technological man has established himself, we know that a different attitude may develop toward brown and grizzly bears. Preserved in parks or game refuges these bears become part of our wildlife and indeed our cultural heritage. People may travel thousands of miles for just one glimpse of the magnificent grizzly.

Can a significent portion of the brown bear population on Hokkaido be preserved for the value we know they will have in the future? Surely our present day knowledge of the biology of the brown bear should be sufficient to allow effective management of this population without its extermination.

R. Demarchi. I've had a talk with Professor Inukai about his problem and I have suggested several methods that are being tried on species varying from coyotes to coddling moths in North America. I asked him also if there was an area where the bears could be preserved, say a natural sanctuary free from human influence and he said no there wasn't but there were areas where there could be zones created, varying from complete extermination of the bear to areas where bears and human beings could co-exist. Now, I'm not an expert in bear management or control but I'm in the business of protecting wildlife as a wild life manager and, at the same time, allowing public use of the wildlife resource. Professor Inukai's problem, I think, is one of non-compatibility between bears and human beings where, if it's allowed to continue, it will bring about the probable complete extermination of this unique population of bears. I'll give you some of the ideas that I've given to Professor Inukai and if anyone cares to carry it any further, I welcome your comments.

No. 1. To zone the areas right now so that you have these various degrees of control. There would also have to be ongoing research.

No. 2. In complete extermination areas, which we don't like to really think about but apparently are necessary, I have recommended the use of professional hunters rather than bounty systems, the use of sterilization of males and their release into the population, and chemical hormones to control the productivity of females.

No. 3. In areas where human beings and bears will be tolerated at varying degrees, I have recommended that he promote the sport hunting of these bears. If he can establish a strong use group he may get into a situation where the hunters themselves, will want to conserve this population for their use—selfish or otherwise. I don't think it's very important at this stage of the game.

J. Craighead. I realize the importance of trying to get some suggestions and answers to a problem of this type but it would seem to me that in order to really give some constructive suggestions, we need to know the size of the area of the habitat of these bears on the island and the size of this in relation to the rest of the island and land use practices; the human population density and distribution on this particular island and how it's related to the bear population; the economics of the area, how the people make a living, what things are they interested in, would they be interested in exploiting this population for hunting and so on. Also important is what values the Japanese people place on this population of bears. It's a unique population but what you would do with it or what you would suggest doing with it, would, in a large measure I think, depend on what values the Japanese people both on the island and the other islands, place on it. When we know the answer to some of these questions, I don't think that we would have too much difficulty in recommending techniques or specialized suggestions that could be put into effect but I do think we need a lot more general background information, at least than I personally have, before I could make specific suggestions.

S. Herrero. I'd like to conclude with some comments on the question of the value of bears. It seems to me that the future relationships between man and bear hinge on man's attitudes and values toward bears. Certainly for a person who has no appreciation for a grizzly or brown bear, any risk of injury is too great no matter how small it is and as the human population increases and as land use and wilderness area use increases, land use conflict between man and bear can only increase. If this happens, bears can only lose out because man has the technological superiority to assure that. So I should like to encourage both Park Service personnel and research workers to increase efforts to disseminate wildlife and bear information to the public at large—the people in the city. I don't mean your own children and family who get exposed to bears and wildlife, but I mean the kids in the city, the 90 percent of the population that's going to be living in large urban centres within the next 20 or 30 years. We must educate these people to assure for wildlife values in the future.

The Status and Conservation of Bears (Ursidae) of The World-1970

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INTRODUCTION

The bears (family Ursidae) have played an important role in the cultural history of man since earliest times. As a summit predator, adult bears, in their own habitat were virtually immune from natural predators. Their food habits and those of man brought them into conflict that became ever more intense as man improved his techniques for the cultivation of a diversified catalogue of food plants and his domestication and culture of animals.

Present evidence however, suggests that bears, though learning to fear man, as their only successful predators, suffered little if any decline in numbers at his hand until the invention of firearms and their wide dissemination throughout the human populations of the northern world.

Four to seven genera (depending upon the status of *Euarctos, Selanarctos* and *Thalarctos,* as valid genera) comprise the bear fauna of the Recent Era. All, or all but one (*Ursus*), of these genera are monospecific. No genus or species (unless the Atlas bear *Ursus crowtheri* is regarded as a species) has become extinct up to this point in time despite the constant attack by man using firearms, traps and poison for almost five centuries.

The bears, though slow breeding and potentially long lived, have proven their persistence as a life form. During the last half century however, it has become obvious that the increasing momentum of our encroachment upon the forest areas and alpine regions essential to the survival of bears has reduced many local populations to the edge of extinction. As I will record later, bears are still regarded as pests over very large areas of their range and any form of protective legislation is of recent origin even in large parts of Europe and North America where there has been a tradition of concern for wild mammals.

This review has been undertaken by means of correspondence with many people familiar with the conservation or management of bears in all parts of the world. The canvas has been particularly thorough in North America where the appropriate wildlife authority in every state and province in North America north of Mexico has been consulted. Information from certain areas and about some species has been difficult to obtain. This is particularly true of the Sloth Bear (*Melursus*) of India and Ceylon and the Spectacled Bear (*Tremarctos*) of South America.

REVIEW OF THE GENERA AND SPECIES

Malayan Sun Bear *(Helarctos malayanus)*

Gee (1967) refers to a number of recent records of this bear that substantiate its continuing occurrence in the hills south of the Brahmaputra River in Assam and southward into the Mizo Hills and to the Manipur region of north east India. It is apparently uncommon there but whether its numbers have declined in the last 30 years is not known. It has been seen in Kaziranga.

I have no recent reports from East Pakistan.

It occurs throughout Burma, most numerous in the far north and far south, usually in heavy cover. In Burma, until 1931 there was a bounty on tiger, leopard, bear and wild dog. During the period of the bounty upwards of 1000 bears (species not stated) a year were turned in for the reward. Subsequently the recorded kill was much lower, averaging about 200 per annum between 1931 and 1938. I have been unable to obtain any recent figures.

Helarctos is still widely distributed in Malaya but is nowhere abundant (Mohd Khan *in lit.* 1970). As an indication of numbers present Khan states that between 1965 and 1969 a total of 12 of these bears was reported seen or killed in the 8000 square mile Perak State of Northern Malaya.

The present emphasis upon timber production in Burma and adjacent countries to the east is resulting in rapid destruction of habitat and a decline in abundance of many of the larger carnivores including the forest inhabiting bears.

The species still occurs on Sumatra and on Borneo but there is no information on its present status there nor in Indo-China (Davis 1962).

Protection. This bear sometimes causes damage to coconut trees in plantations and under such circumstances some are shot. It is classified as big game in Malaya but is seldom hunted. Khan regards the legal protection as effective, illegal shooting carries a $1000 fine, snaring a maximum fine of $2000 or 2 years imprisonment. The major cause of destruction by man is the steel wire snare set mainly for wild pig. In other parts of its range effective protection for the species is lacking.

Sloth Bear *(Melursus ursinus)*

This species formerly inhabited Ceylon and South India with the northern boundary of its range at the Himalayan foothills and the Indian desert. It is still present in India but I have been unable to obtain any up to date information on its status or distribution. In Ceylon the Sloth Bear survives in the wilder dry jungles. It inhabits only the driest areas of the low country and does not reach the hills or wet jungle zones.

The species is protected in the National Parks and may be considered abundant in the Ruhunu and Wilpattu National Parks, although even here its crude density runs at about 1 animal per 8 square miles (2073 hectares). Land clearing and deforestation are having a greater impact than hunting (J.Eisenberg *in lit.* 1970).

In India it was abundant over large areas twenty years ago but is reduced now to vanishing status over most of its range. Objective data have been impossible to obtain but M. Krishnan *(in lit.* 1970) reports that serious efforts to find bear or their signs in Mudumalai Sanctuary (Nilgiris) in 1966, '69 and '70 failed. The species was regularly observed there as recently as 1963.

The same correspondent points to the burgeoning human population with its attendant invasion and denudation of forest areas and accompanying harassment of the bears as the cause of the decline.

In Kanha National Park, Schaller (1967) saw bears on 7 occasions during his months of field work there.

Protection. There is no effective protection in India. Even in sanctuaries poaching has been rife. Unless the protection of this species is recognized as urgent and is undertaken with vigour it appears unlikely that the Sloth Bear will survive.

In recent years Ceylon has imposed some protective legislation, including license restrictions. It is not known whether these can be effectively enforced where bears and man are in conflict of interest in the vicinity of remote villages. Apparently, apart from destruction induced by human fear and crop damage, the fat and baculum are in strong demand and serve as a further incentive for killing the Sloth Bear.

Spectacled Bear *(Tremarctos ornatus)*

The only information available on the status of this species is given by Grimwood (1969) and Erickson (1966).

To quote Erickson *(op. cit.)* the Spectacled Bear is now, and has probably always been, rare at the northern end of its range in Venezuela. In Colombia the species occurs in the west, east and central Andes mountains where its numbers have been markedly reduced. In Ecuador the status of the Spectacled Bear remains good with near pristine populations remaining throughout areas of suitable habitat, usually above 2, 000 ft. elevation. Less is known about the species in Bolivia but it appears to be in fair numbers.

Grimwood *(op. cit.)* states that in Peru the Spectacled Bear is scattered in small groups in most parts of its range west of the Andes and it is under heavy hunting pressure. To the east of the Andes its status is perhaps somewhat better but only where its range is remote from habitation.

The total Peruvian population is said to have been, at that date, not less than 800 nor more than 2000. Some are in Manu National Park and a few others in the proposed Cordillera Blanca National Park. The effectiveness of protection in these parks is not known.

This is one of the species more immediately threatened by hunting than by habitat destruction.

Asiatic Black Bear *(Selenarctos thibetanus)*

This species occurs through southern and eastern Asia from West Pakistan, Baluchistan and Afghanistan east to Indo-China, through much of China, Manchuria, Korea and Japan. There is an isolated population on Taiwan. In eastern Asia the species extends northeast through the Chinese Peoples Republic along the Boreinsky mountain ridge to the Baranja River. It crosses the Amur River into USSR between latitudes 131°50' and 136°15' north to about longitude 50° (Bromley 1965).

The main surviving population in West Pakistan is probably in the mountainous area between Dir Stab and extreme north west Swat Kahistan. 'Here again no proper population surveys... have ever been taken and the population could be under 200 head' (Roberts *in lit.* 1970). A few survive in the forested valleys of Chitral State and elsewhere through the forested lower mountain slopes under monsoon influence. They are frequently in close contact with human populations and under heavy pressure. There is a market for cubs for training as performing bears.

An isolated population, recognized as subspecies S. *t. gedrosianus*, occurs in the tropical thorn scrub forest of southern Baluchistan (Kolat region). It is now but a relict population, is under heavy local pressure, and is in danger of extermination. Its survival will probably depend upon the provision of total protection, vigorously enforced, along with a programme of compensation for crop damage.

The Black Bear was formerly quite common in the narrow belt of West Pakistan that receives some summer rain, i.e. the Murrie Hills, southern Azad Kashmir and Hazara, and the lower parts of the valleys of Swat, Dir and Chitral. They have now virtually disappeared from the Murrie Hills (one killed 1969) (Grimwood *in lit.* 1970).

They are frequently involved in killing young sheep and goats and for this reason are shot at whenever seen. There is virtually no sport hunting of this bear. Forest destruction is the primary cause of decline in numbers. Human populations are increasing in all valleys and the result is grazing of sheep and goats, cutting of timber, collecting underbrush for firewood, and cultivation of all arable land.

Protection. The West Pakistan Wildlife Protection Ordinances (1959) gave no protection to the Black Bear as it appeared neither as a game species nor a protected species. There was no provision for game reserves or national parks for the protection of large mammals including bear. Gilgit and Baltistan are administered by a special department of the central government and they too have no protective legislation. Until about 1968, Chitral, Dir, Swat and Kalam were semi-independent states whose rulers issued no written conservation laws but could, and sometimes did, take fairly effective steps to protect game. Most of the rulers maintained private hunting preserves where game, including bears, became abundant. Since these preserves were eliminated the areas have been heavily poached and all game is rapidly disappearing.

Present efforts are being devoted to promulgating a uniform wildlife conservation law to apply throughout the whole of Pakistan. The Baluchistan race of the Black Bear *(Selanarctos t. gedrosianus)* will be given protected status and the other race game status. A high fee will be levied for hunting it. However, enforcement is likely to prove difficult.

The draft of the new law also provides for national parks and reserves and two areas proposed for national parks (in Kalam and Gilgit) will include modest populations of Black Bears. Again the success of these areas for large animal conservation will depend upon the effectiveness of the law enforcement effort (Grimwood *loc. cit.).*

In East Pakistan forest destruction has virtually eliminated bears.

I have been unable to obtain any specific information upon the status of the Black Bear in India. It still occurs in some of the forested areas but in greatly reduced numbers. Schaller (1969) reports sighting Black Bears on 17 occasions between October 6 and 21, 1968, in Dachigam Sanctuary, Kashmir. If these were not repetitive sightings of one or two individuals a fair population is indicated.

The species occurs throughout Burma where it is most plentiful in the mountainous country of heavy forest, less common in the south (Yin *in lit.* 1970). The greatly increased forestry activity has brought many more people into the remote areas of Burma, Assam, Thailand and adjacent countries and has led also to greatly accelerated alteration of the forest habitat. There has been a coincident decline in bear populations but substantial data are lacking.

Small populations occur in some of the National Parks and Wildlife Sanctuaries. Specifically I am informed that there were 15 *Selanarctos* in Shursettaw Wildlife Sanctuary of Burma. The Sanctuary is 213 square miles in area (Yin *in lit.* 1970). Three others were seen in August and September 1970, in Shur-u daung Sanctuary, Shan State (126 square miles).

The Black Bear occurs through the forested areas of China, Korea and onto the islands of Honshu, Shikoku and Kyushu in Japan. There has been no attempt to census the number of the Japanese race of the Black Bear *(S. t. japonicus).* Masatomi (*in lit.* 1970) says they are scarce on Kyushu and Shikoku but abundant on Honshu.

Numbers killed per year have been:*

1925	803	1961	802
1935	964	1962	1124
1945	613	1964	908
1955	768	1965	629
1960	777	1966	880

Mean 1925-55 decades = 787/yr. Mean 1960-66= 853/yr.

*From Masatomi *(op. cit.)*

If kill is an accurate indicator of population there is no evidence of a decline in numbers through the last 40 years. There is steady invasion of bear habitat by human land clearing and almost certainly numbers will decline.

Brown and Grizzly Bears *(Ursus arctos)*

This species has the widest distribution of any of the bears. In pre-firearm days its range included the continental holarctic where it was largely confined to the tundra and subtundra and was generally absent from the heavily forested taiga. In Europe it occurred through all the mountainous areas south into Italy and the Caucasus. In Asia its western limits were in the mountains of Asia Minor, southern limits were reached in the Himalayas of India and West Pakistan and eastward through this and associated ranges through Mongolia. Hokkaido of the Japanese Islands had a population. There was an isolated population in the Atlas Mountains of North Africa.

In North America it inhabited the western mountain ranges south into Chihuahua, Sonora and northern Baja California, Mexico, and eastward across the Canadian prairies as far as western Manitoba. Insular populations flourished on Kodiak, Afognak, Baranoff, Montague, Chichagoff and Admiralty Islands. A population on the Arctic tundra and subtundra area from Alaska eastward across the Northwest Territory of Canada did not reach much beyond the Thelon River in primitive time (Banfield 1960).

Present Status in Eurasia. It is interesting to note that the species still occurs at or near both its northern and southern extremes of original distribution in both Eurasia and North America even though its numbers are greatly reduced and in vast areas it has become extinct. The North African race was exterminated about a century ago.

In the northern areas of Europe, Grenquist (1970) refers to apparent recent increases in the Brown Bear in Finland. He refers to annual kills in the 1870's of 100 bears per year, declining to 20 per year in the decade 1910-20, rising to 95 per year in the decade 1920-30; 48 per year in 1930-40; 40-50 per year in 1940-50. More recently 75 bears were shot in 1965, 97 in 1966 and 51 in 1969 (Pulliainen 1971).

This suggests a population of close to 1000 bears. Not until 1965 was there protective legislation. In that year hunting was prohibited during the winter months.

The primitive Norwegian population in about A.D. 1500 was probably less than 2000 bears. Sharp decrease in numbers began with the arrival of firearms about A.D. 1600 and continued at approximately the same rate through the 19th century and until the beginning of the 20th century, by which time the population had been reduced to isolated remnants (Myrberget 1969). The total Norwegian population is now estimated to be between 25 and 50 individuals. A particularly interesting population is that in Vassfaret, estimated at 10-20 individuals (Elgmork 1966). This has been virtually unmolested since 1949, but there appears to be a slow decline in numbers. The area is experiencing greatly increased human activity.

Despite the very small numbers, hunting is still permitted by local land owners during an open season June 15 to November 1. The late opening is a recent (1966) innovation to prevent hunting from snow-mobiles. I have no figures upon the number killed.

The population in Sweden reached a low point in the 1930's. Total protection was in force for many years but was removed in 1943. A two month open season led to intensive hunting in the mountains of Swedish Lapland. There appears to have been a movement of bears out of these mountains into the provinces of Norrbotten and Vasterbotten, where there was an increase in numbers. The total population decreased during the 1940's and 1950's. During the 1960's improved management led to a slow increase. A census in 1957 gave 252 bears (Curry-Lindahl 1965). The total population after the hunting season in 1967, appears to approximate about 400 animals though the published statistics are ambiguous (Haglund 1968).

The status of *Ursus arctos* in the USSR has been summarized for me by A. A. Kistchinski of the Central Laboratory on Nature Conservation, Moscow *(in lit.* 1970). He lists about 180 bears in Estonia, 80 in Byelorussia, 6000 in Northwest European parts of USSR, 10, 000-12, 000 in the Northeastern parts of USSR, 4000-5000 in Central European parts of USSR, and in Asiatic USSR 'several dozens of thousands' including 15, 000-20, 000 in Kamtchatka. The total USSR population was estimated by Verestschagen (1967) to be in the vicinity of 100,000 bears.

Kistschinski reports densities of up to 1-3 bears per 10 sq. km. (about 3. 8 sq. miles) in some of the most densely populated areas as in the Sikhate-Alyn Mts., Northwestern Caucasus, Altai and Sayan Mts., and near Baikal regions.

In Yugoslavia the Brown Bear has been increasing since 1940 until today there are about 2000 in the central part of the country (Isakovic 1970). In 1971 there are reported to be more than 3000 bears chiefly living in the Carpathian region of Rumania (Curry-Lindahl, *in lit.* 1971).

The southernmost population in Western Europe is the 60-80± individuals in Abruzzo National Park and adjacent mountains of central Italy. This stock inhabits an area of 600 sq. km. and offers unique opportunities for research into population dynamics. Franco Tassi (*in lit.* 1970) reports that the main reason for the shrinkage of range and decline in numbers has been the destruction of its forest habitat. Inevitably the increased contact with man gives rise to some illegal killing. Though 500 sq. km. of its range are within a National Park the area has been difficult to protect and its attenuated shape is ineffective in providing for the total needs of even a small part of the bear population.

A new programme of reimbursing farmers for bear damage is hoped to take some of the pressure off the remaining population.

Dr. Tassi also reports a population of 8-10 brown bears in the mountains near Adamello-Val di Genova-Lago di Tovel. The two relict groups are not in contact.

Small populations of such long lived animals are subject to shifts in age and sex structure and productivity that may predispose them to extinction even under conditions of total protection. Details of the numerical status of small populations existing in steady state, and the area needed to support such populations, are important in view of increasing human pressure on bears in all parts of the world.

The Syrian race of the Brown Bear is reported to still survive (Simon 1969) in the mountains of Kurdistan, in northern and eastern Iraq and possibly also in northern Syria. This is the form inhabiting the Black Sea coast up to Abkhazkaya SSR, the southern part of Transcaucasia to the south of Lake Sevan, the Gori region in Armenia and the region to the west and southwest of Sevan, Talysk and Kopet-Dag.

The Brown Bear probably occurs in high mountains from Afghanistan through southern Mongolia but I have information only on the situation in West Pakistan. Here Roberts describes the species as inhabiting the. mountains generally above 10, 000 ft. It is scarce in the arid mountains of Chitral but is still present in Gilgit. The largest numbers occur further east, in Baltistan and in the Deosai Plateau immediately south of the Indus River. The species still occurs in the Pir Panjab Mountain Range and in Kashmir.

Roberts *(loc. cit.)* does not regard hunting as an important factor in the continued survival of this bear in West Pakistan. Sport hunting is infrequent and few are shot by shepherds high on the alpine pastures. Schaller (*in lit.* 1970) found that continuous pressure by armed pastoralists in the Himalayan areas of India was responsible for steady and perhaps rapid decrease in numbers. There is at least one record of a Brown Bear shot in Bhutan, north of Bumthang, 1945.

Information upon *Ursus arctos* in Hokkaido, Japan has been supplied by Professor Tetsuo Inukai of Hokkaido University and by Professor Hiroyuki Masatomi of Senshu University. Both report that there has been little if any change during recent decades in the number of bears inhabiting the island. They estimated the present population as 3000-4000. Between 1964 and 1969 there were 3321 Brown Bears killed in Hokkaido, mean 554 per year (extremes 479-795). Because of damage to field crops, domestic livestock and some human attack (1-5 deaths/yr.) the Brown Bear is hunted throughout the year and even killed with strychnine baits (Inukai 1939, 1969). Bounties of 5000 yen or more per bear are paid, and there is also a hunting subsidy of 1000 yen per day. Persistence of the present population appears to result from very thick forest and difficult hunting conditions. However increasing forest removal and land clearing for agriculture will probably produce conditions leading to a decline.

Present Status in North America. At the present time, small populations are found in Washington, Idaho and Montana and substantial populations occur in Alaska, Yukon Territory, British Columbia, Alberta and Northwest Territories.

Glacier and Yellowstone National Parks in the United States and the complex of Rocky Mountain national parks composed of Waterton Lake, Banff, Jasper, Yoho, Kootenay and Glacier National Parks in British Columbia and Alberta include large and self-perpetuating populations.

The annual kill and estimates of total population size are shown on Table 1. Estimates are that approximately 1300 bears are killed annually out of a population estimated by my correspondents at 31,000.

It is interesting to compare these estimates with those earlier arrived at independently by Cahalane in 1964. At that time, he estimated that the population in Canada lay somewhere between 12, 000 and 16, 000 while that in Alaska lay between 8, 000 and 18, 000 as represented by 2 different contributors. There was little difference of opinion on the number of bears in Wyoming and Montana. My own figures lie within a smaller range but the indication

TABLE 1. POPULATION ESTIMATES & KILL FIGURES FOR GRIZZLY & BIG BROWN BEARS IN NORTH AMERICA

Region	Mean annual kill	Estimated population	Notes
Alaska	700 (1961-64)	12,000	Kill includes 33% for illegal or unreported kills
Yukon Territory	90	10,000	
Northwest Territory	3+ (1966-69)	500-1,000	Protected except where life or property are attacked
British Columbia	400 (1964-69)	6,800*	Est. illegal kill 25% in addition
Alberta	45	800±	Considerable poaching in addition
Washington	Nil	10±	
Idaho	1±	50±	
Montana			
outside park areas	40	200-300	
Glacier Nat. Parks	2 (1960-70)	200±	
Wyoming			
outside park areas	10±	50	30 permits issued
Yellowstone Nat. Park	10 (1967-69)	200	
	1272	31,000† 26, 000*	

*Estimated by the author

†Sum of estimates by correspondents together with author's estimate for B.C.

is that there has been no substantial change in the population of Grizzlies and Big Brown Bears in the intervening years. It is certainly true that there have been local reductions arising from progressively expanding use by man of certain parts of the mountain habitat occupied by these bears. In a few areas these declines have been consequent upon the use of alpine ranges for pasturing cattle and sheep. In other areas over-hunting has probably been the main cause. In part this has resulted from the development of extractive industries in mountain habitat of these bears, but intensive sport hunting can reduce bear populations and Pearson has pointed out verbally the particular vulnerability of the females on their relatively small home ranges. Even though these local declines may involve a relatively small part of the continental populations they may well have greater biological importance than numbers indicate. They may represent important reductions in local genotypes. They are important inasmuch as these declines will represent permanent withdrawals of some fairly large areas from habitat of the species.

The figure for the total kill is probably reasonably accurate. Departure from it will be dependent upon the number of bears, taken illegally, particularly those so taken in British Columbia and Alberta. The Alaskan estimate of 33% illegal kill is based upon the number of untagged pelts from Alaska reaching outside taxidermists for processing during the last two years (37%).

It is difficult to assess the survival status of different subspecies of the Grizzly and Big Brown Bears of North America because there is no unanimity on the taxonomy. A thorough review of the systematics of the species in North America is needed. It is interesting to note, however, that the Barren Ground Grizzly *(U. arctos andersoni)* continues to exist in the Northwest Territories and, indeed, as reported by Banfield (1960), may have been gradually extending its range eastward over the last half century.

In 1953, a relict population of grizzlies was discovered in the Swan Hills of Alberta approximately 150 miles northwest of Edmonton. Bowes (1959) estimated that there were less than 400 bears inhabiting this 8, 000 square mile region. In view of later information, I think it can be safely said there were possibly less than 100. This population persists and is under management plan by the Province of Alberta. At the time of the discovery it was suggested by some that this stock was a surviving remnant of the Great Plains Grizzly *(U. a. horribilis)* that was once so widely distributed across the Canadian prairies. This requires verification. Recently there has been a suggestion that Grizzly Bear still survive even in Saskatchewan. Tracks were seen in the Pasquias Hills in February 1970, and there is photographic evidence of one shot there in 1954 (Lane 1970).

In 1967, Leopold made known the discovery of a small population of Grizzly Bear in the Sierra del Nido of central Chihuahua, Mexico. The population (30± individuals) was believed to range also into Sierra Santa Clara and Cerro Campana.

This population is of interest because it had been self-maintaining since the early days of history. Unfortunately, it probably has been exterminated by poisoning shortly after it was discovered (Simon 1966). However, another population is known to still exist in Mexico (Leopold 1969), so this southern race, *Ursus arctos nelsoni,* is not yet extinct. Survival for very much longer appears to be unlikely.

Densities in North America. I have attempted to determine maximum densities of these bears using figures for insular or relatively isolated populations. Thus, Kodiak Island with a total area of 1.6 million acres is reported to support approximately 3, 300 bears or 1 per 500 acres (200 hectares). Similarly, Glacier National Park, of about 990, 000 acres (40, 810 hectares), is reported to have approximately 200 bears or 1 per approximately 5, 000 acres (2000 hectares). While the population of Yellowstone National Park approximates 1 to 7, 000 acres (2, 800 hectares).

The figures for the two national parks differ from that for Kodiak Island in that a relatively larger part of the total terrain included in the parks is unsuitable to this species of bear. On the other hand, the carrying capacity of the coastal islands such as Kodiak is probably greater that that of the alpine country in the interior of the continent.

On a 96 square mile sub unit of the Kodiak National Wildlife Refuge 160 different bears were identified, to give a population density of 1 per 384 acres (Troyer & Hensel 1964). This is the greatest density reported for an area of this size in any part of the world.

Pearson (*in lit.* 1971) estimates Grizzly densities upon his study area in southwestern Yukon to be 1 per 10 square miles.

It is interesting to compare these density figures with the maxima suggested by Kistchinski for the USSR. His figures are 1 to 3 bears in an area of 10 square kilometres or roughly 1 bear per 800 to 2400 acres (390-1000 hectares) (*in lit.* 1970). A density figure for Kamchatka (Ostroumov 1968) is 1 Brown Bear for 18 sq. kilometres and thus slightly lower than those on Kodiak Island.

Conservation Measures. Generally, throughout the area of its distribution in North America north of Mexico, the Grizzly and Big Brown Bears are regarded as game animals and given some form of specialized protection. In Washington, Idaho and within the national parks of both the United States and Canada, protection is officially absolute and only animals that become a danger to the public are destroyed.

In the Northwest Territories of Canada, again, the surviving population of Barren Ground Grizzlies is officially accorded complete protection, though an unknown number are killed illegally each year. Macpherson, in 1965, estimated that the number so killed might be as high as 30 per annum and if so it probably approaches closely the annual recruitment potential of the population. In Wyoming, an attempt is made to take a small harvest from the fifty or so bears that exist outside the park. To this end, thirty permits are issued annually with the anticipation, of course, that success will be very limited. In British Columbia, there is a spring and an autumn open season with a limit of one trophy per licensed hunter. Under these circumstances the bears are decreasing in local areas, and where this is apparent, it is planned to initiate a permit system in 1971. It is hoped that this will serve to further control killing in these areas. Approximately half of the annual kill is taken by nonresident hunters hunting with licensed guides. Hunting over baits is prohibited in southeastern British Columbia where these bears are present in only small numbers, but is still permitted in the north of the province.

In Alberta, a spring and an autumn season were in force for many years, but the bears may now be shot only during two spring months immediately after they have emerged from hibernation.

Alaska has made the most determined effort to introduce scientific management to the annual harvesting of its Brown-Grizzly Bear population (Erickson 1965). Many detailed statistical reports have arisen from their repeated attempts to determine accurately the size of the population, particularly those on the Alaska peninsula, on the Kodiak and adjacent islands and in the islands of southeastern Alaska. Useful statistics on percentage of cubs and yearlings in the population have been obtained, but aircraft census has proven to be inadequate for obtaining reliable data on total population or on the percentage represented by single animals (Erickson & Siniff 1963).

Hunting regulations to control the take are under constant review and are more elaborate than those enforced in other parts of North America. Apart from the usual spring and autumn open seasons, there are regulations that require all non-residents to hunt with a guide. Other regulations prohibit successful hunters from again embarking on a hunt for one of these bears within four years of taking a specimen. A recent attempt was made to limit the number of bears that could be taken by parties under the direction of a single guide in any one year, but this apparently has been ruled unconstitutional. Inasmuch as aircraft are usually used for transporting parties into the field and can easily be used for spotting bears and even for landing sportsmen near them, certain parts of Alaska have introduced regulations to the effort that a hunter may not hunt on the same day that he has travelled by aircraft.

In all parts of the north the increasing use of fixed wing aircraft and of helicopters for transport of hunters, miners, prospectors and others into remote areas poses an ever-increasing hazard to the bears. The use of helicopters for research purposes during the capture and marking of bears has revealed how effective this vehicle can be in bringing a hunter close to the large bears.

In all parts of Alaska, an attempt is made to regulate the harvest to a predetermined number. So far, this has met with considerable success despite the problems of remoteness and the difficulty of accurately assessing the size of the population to be harvested.

Hensel (*in lit.* 1970) estimates 3, 300 Brown Bears on the Kodiak Island group including Afognak Island and Shuyak Island. Of these, 2, 000 occur on Kodiak National Wildlife Refuge, 300 on the northeast end of Kodiak Island and 1, 000 on the other two islands combined. The refuge population of 2, 000 could not withstand successive harvests of 200 bears per annum for three calendar years and showed decline. The maximum kill forecast that is allowable in the management plan for the refuge is 120 bears per annum or 1 per 17 live bears pre-hunt. It is emphasized to me that even the estimates of total population size on Kodiak and adjacent islands is an informed guess arrived at after many attempts to take counts from the air and on the ground. There are great difficulties in the way of arriving at population figures even in relatively open country.

The Montana kill figure of 23 bears per year that are believed to be removed from a wild population of 200-300 would represent 1 taken for 10-14 alive. This is beyond normal theoretical tolerance limits and suggests either that the population is overharvested, the wild population is larger than that estimated or, most probably, that dispersal from Glacier Park is subsidizing the kill and thus bringing the kill ratio close to 1:17-22. This ratio seems to be a useful estimate of the conditions applying over most of the range in North America.

It is interesting to note that in Yugoslavia the 3 most productive regions, with a population of about 1220 bears, provided a harvest (1967) of 102 animals or 1 taken for 12 alive pre-hunt (Isakovic 1970). In Sweden (Haglund 1968) the most productive area, comprising Swedish Lapland together with the province of Norbotten, has produced 1 bear per 15-16 alive pre-hunt, in a mean population of about 300 bears (9 years), while providing for a steady increase.

Natural mortality is estimated at an additional 5-6% annually. The specialized situation of managing free-living bear populations in national parks will be treated later.

The American Black Bear *(Ursus (Euarctos) americanus)*

Black Bears primitively ranged over virtually all areas of North America except the central regions of the Great Plains. The species has proven more adaptable to contact with human habitation and human alteration of the environment than have the Big Brown and Grizzly Bears, and consequently, it still occupies a very large part of its former range. Black Bears still occur in a least twenty-three of the states of the United States of America, and in all Canadian provinces and territories.

Greatest densities are found in Washington, Oregon and Idaho with substantial populations also in Montana, Wyoming, Colorado, California and Arizona (Table 2). In eastern United States, the largest populations exist in Wisconsin, Michigan, New York and Maine. States reporting the complete or almost complete absence of resident populations of Black Bears include North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Iowa, Illinois, Indiana, Ohio, Mississippi, and probably Alabama, Connecticut, Delaware and Maryland. Populations in Nevada, Texas, New Jersey and Massachusetts are, in each instance, probably less than fifty bears, and the matter of continued survival must be in doubt. The densest populations reported are those from the State of Washington which estimates its total stock at between 25, 000 and 30, 000 Black Bears and Idaho which estimates upwards of 40, 000 bears. Hatler (1967) reports a 51. 5 square mile area in Alaska carrying a population at the rate of 1:10-13 sq. miles. The reported figures for populations and kills are given on Table 2.

The estimated mean annual kill in the United States, excluding Alaska, which keeps no record, over the last several years is between 17, 600 and 20, 000 and this level continues under present management practices.

Though most states were willing to provide an estimate of total population, most of the correspondents admitted that the figures offered were guesses. In matching the reported kills with the estimated total population,it is interesting to note that, of 15 states providing both figures, eight showed a relationship between kill and total population of 1 to 9 or 10; three others showed a relationship of 1 to 7 or 8; three had a relationship of approximately 1 to 20; and two had a relationship of approximately 1 to 3 or 1 to 4. Inasmuch as the biology of Black Bears would make it impossible to harvest at the latter figure for any considerable period of time without inducing a reduction in the population, it is probable that the total population estimates in these states are well below actual numbers. The states with the 1 to 20 relationship, Florida, Georgia and Texas had small populations from which only about 25 animals a year are shot. It is probable that with the very low population, little purposeful hunting of bears occurs and the kill arises largely from accidental encounters.

The total recorded kill of the Black Bears taken in the Canadian provinces amounts to approximately 7, 000 to 7, 600 bears per annum (Table 3). In Canada there is little purposeful hunting for Black bear and the kill probably has little direct relation to the available populations.

Management. There are no data fully adequate to permit the calculation of population models that would be useful in relating continually sustainable kill to population size under known population characteristics. Age specific mortality is the parameter most difficult to obtain.

Studies by Jonkel (1967) in Montana, in an almost unhunted population, reflect a mortality to first year of life approximating 5%. This is followed by very heavy mortality through the first year of independence from the mother. Mortality there may be as high as 50%. Adult mortality was estimated to be approximately 14% per annum under circumstances where there was virtually no hunting. Tentative figures from the eastern parts of North America suggest that age specific mortality there may be somewhat lower except where heavy hunting pressure is present.

During the year of Jonkel's study, there were great changes in rate of recruitment that were immediately reflected in the size of the population. Further data of this sort on Black Bear populations living under widely different environmental conditions are urgently needed if scientific management is to be applied.

A request was made for each state to indicate any obvious direction of the trend in population size. Twenty-nine states reported on this matter. Of these, 13 reported the population as increasing, usually slowly; 6 reported the population as decreasing; the rest reported no apparent change.

Regulations designed to control the harvest and thus to conserve the animals as a resource, vary greatly from state to state. In some states, as for instance in Texas, where the animal is very rare, there is no closed season. In others, such as Pennsylvania, there was no closed season on bears as recently as 1969, but there was no open season in 1970 because of a decline.

In most states where bear hunting is managed, there are either very long seasons, starting in the autumn and running through till the spring, or there-are two seasons—spring and autumn. In almost every state and province females with cubs are protected. Similarly, in almost all states and provinces, snaring or trapping of bears is prohibited. In very large measure this prohibition arises from the danger that bear snares or traps have to both man and other large mammals.

In some western states and in many areas of the deciduous hardwood forests of the eastern United States hunting with dogs is customary throughout all or part of the season, and there are some interesting regulations with respect to the number of dogs permissible. In Colorado, dogs are permitted in the spring only, with the restriction that not more than eight dogs can be used with any one hunting party. In North Carolina, ten dogs are allowed per party, whereas in California the number permitted is one dog per hunter.

The pursuit of bears with dogs is prohibited in Canada.

In general, the bag limit is one animal per hunter per annum. In British Columbia, the permitted number is two and in Alaska three, of which no more than one may be of the blue color phase.

Over most of the areas of North America where a decline in bear numbers has been noted, the emphasis has been put on habitat change induced by settlement, rather than shooting, as the most destructive influence.

In Pennsylvania, on the other hand, concentrated hunting is now the dominant influence on numbers. It is quite obvious that in many parts of North America the attitude toward the Black Bear as a sporting animal has been changing rapidly. As an example, New Hampshire reports an interesting timetable for the chronology of its bear legislation. In 1955, for the first time, the bounty was removed though the bears remained unprotected by legislation and without a closed season, the state was made responsible for damage, and it became

TABLE 2. BLACK BEAR GAME STATUS STATISTICS & POPULATION IN THE UNITED STATES OF AMERICA

State	Pop. est.	Kill/ annum	Status	Trend	Open seasons approximately
Washington	25,000	3,500-4,000	game	?	
Oregon	36, 000*	3, 600	game	steady	20 wks., split
Idaho	40, 000	3, 000	game	steady	
Montana	3-6, 000	1-2,000	game	steady	
Nevada	25	0	protected	rare	none
California	6-12, 000*	6-1, 200	game	?	13 wks.
Arizona	2,060	268	protected	rare	4 zones (9 wks. ea.)
Wyoming	3,200	400	game	steady	
Utah	300*	24	game	down	21 wks., with exception
Colorado	4, 000	550	game	up	20 wks., split
New Mexico	3, 000	3-500	game	steady	7 regions, 4-16 wks., split
Minnesota		100	not game	?	open all year (except 5 counties)
Wisconsin	6-8, 000	600	game	steady	4 wks. split & bow season
Michigan	7-8, 000	850	game	up	11 wks.
Maine	8-10, 000	1,000	game	up	30 wks.
New Hampshire	3,000*	300	game	up	13 wks.
Massachusets	25-50	8+	game	?	10 wks.

New York	4-6,000	500	game	up	4-6 wks.
Pennsylvania	15-1,800	400	game	down	none 1970
New Jersey	20	1-4	game	down	?
Connecticut	0-10	0	not game	rare	12mo.
Virginia	1,000-1,200	1-300	game	up	4 areas, 7-8 wks.
West Virginia	550	55	game	steady	3± wks., divided
N.Carolina	4, 000*	400	game	up?	5 wks., divided
Tennessee	350	30	game	up?	none 1970
Kentucky	75	0	not game	?	open all year
S.Carolina		10-	game	up?	2 wks.
Georgia	500-	25	game	up	
Florida	500-1,000	25-50	game	up?	3 zones, 6-12 wks., split
Louisiana	300	?		up	
Arkansas	250	0	game	up	none
Missouri	100	0	protected	up	none
Alaska	?	?	game	?	several regions, 9-12 mo.
S.Dakota	10	0	not game	rare	12 mo.
Texas	50	2-4	game	steady	8± wks.
Vermont	1,200-2,000	300	game	up	

*Estimated by the author.

TABLE 3. KILL FIGURES FOR BLACK BEAR IN CANADA

British Columbia	2,000-2,500	Quebec	1,000†
Alberta	400-500	New Brunswick	1242/3*
Saskatchewan	447-438/2*	Nova Scotia	156/9*
Manitoba	500	Newfoundland	58/8*
Ontario	800	Yukon Territory	120
Northwest Territories	335/12*		

† Guess; number not supplied.

* Indicates number of years represented.

necessary to report the shooting of a bear. In 1957, a special open season during which dogs could be used was established between April 1 and June 1. In 1961, the dog season was changed to May, September and October, and a regular open season was established between October 1 and December 10. In 1963, the dog season was from September 1 to November 14, while the regular open season was September 1 to December 10. In 1965, special regulations were brought in with reference to the use of the bow and arrow. In 1969, legislation went into effect requiring that all bear kills be reported within 48 hours to the nearest deer registration station. This was largely to facilitate research study of the population. In the same year there was a special season introduced for the hunting of Black Bears using primitive muzzle-loading weapons.

Thus we see, over a period of 14 years, the complete change in attitude toward the Black Bear from one that regarded the species as a pest animal to be destroyed under state sponsorship, to one of high regard for its sporting qualities. The regulations are now designed to provide a variety of different specialized recreational opportunities. Similar changes in attitude are to be seen in the evolution of regulations in a number of other states.

In the State of Louisiana there has been a re-stocking programme with bears obtained from Minnesota. Between 1964 and 1967, 156 bears were transplanted. It is interesting to note that several of the adjacent states report that some of the newly planted bears wandered across into their regions.

In the State of Maine, claims for damage incurred by farmers from bear depredations are still paid and amount to approximately $7, 600 per annum. Few other states pay for damage.

It is well known that the proportion of black to brown color phases in the population changes with geographic distribution (Cowan 1938). It is also known that two unusual color phases occur. In certain parts of coastal British Columbia, white individuals, that are really dilute brown with brown eyes, occur infrequently in an otherwise black population. This color phase is known from Princess Royal Island and adjacent islands off the central coast of British Columbia and from scattered areas in the Skeena River Valley. Recently, legislation has been introduced to prohibit killing of these white individuals. They were never common, and they have been becoming progressively more scarce.

In parts of coastal Alaska, a steel blue color phase occurs and was the original source of the description of a unique race believed to be characterized by this color—*U. a. emmonsi*. Here again the bulk of the population is black, but the blue individuals are so sought after that special legislation for their protection has been enacted. Of the permissible kill per hunter in Alaska, only one may be of the blue color phase. This phase occurs also in a limited area of western Yukon Territory where no special legislation is in force.

The Polar Bear *(Ursus (Thalarctos) maritimus)*

The Polar Bear is circumpolar in distribution and with the exception of some local reductions still occupies its primitive range. There is general agreement that the total numbers of this bear have been substantially reduced since the turn of the century and more particularly in the last 30 years. Since 1963, a well organized cooperative international research programme has been in progress. The cooperators have met formally on three occasions. The First International Scientific Conference on the Polar Bear was convened in Fairbanks, Alaska, 6-10 September 1965, a working-party met at IUCN headquarters at Morges in Switzerland 29-31 January 1968, and the Second Conference gathered again at Morges, 2-4 February 1970.

There is difference of opinion among the best informed specialists as to the probable total number of Polar Bears alive today. Figures of 8, 000 to 10, 000 appear with most frequency and the most recent statement (IUCN Bull. N-S, Vol. 2 No. 14: 118) states that fewer than 15, 000 are thought to exist. This may be a quotation of figures produced by Uspenski & Shilnikov (1969), who estimated world population as 10, 000-15, 000 and Soviet population 7, 000-8, 000. The divergent figures arise from their being no firm basis for census over the large areas of the arctic polar bears inhabit. Estimates, derived by the USSR researchers are based upon denning densities converted into numbers of breeding females in the Soviet Arctic and then using sex ratios, age ratios and the proportions of females with young to lone bears. On this basis the world population was estimated to be not more than 8, 000 individuals (Maksimov and Sokolov 1965). At the 1970 conference the total number, estimated again by Soviet biologists was placed at not more than 10, 000 (IUCN News Release, Feb. 5, 1970). I doubt that there was evidence to indicate 20% increase during the interval.

There is agreement that the kill in 1968 totalled about 1250. About 500 of these were shot by Canadian Eskimos. This is not significantly different from the figures estimated in 1965.

Uspenski (1969) attempts to summarize the mean annual kill of Polar Bears in the Soviet arctic and in the world by decades since the 18th century. One of his tables is given here as Table 4.

TABLE 4. MEAN ANNUAL POLAR BEAR HARVEST IN THE WORLD FROM 1900 TO THE 1960's

Decade	Eurasia	Soviet Arctic	Greenland	Canada	USA	Total
1900	820	420	150	400		1,370
1920	1,020	720	200	500		1,720
1930	1,350	1,050	200	250	150	1,950
1940	950	650	150	350	150	1,600
1950	700	400	150	450	200	1,500
1960	300	50	150	500	250	1,250

The research already undertaken has led to the concept that there are regional populations in various parts of the holarctic that are relatively sedentary and that the interchange between them is probably low and probably also involves males more than females. These populations differ in their density, and in the extent to which they are hunted. Further research may indicate that they differ in other important ways (Jonkel 1970). On the world scene 5 more or less identifiable populations probably occur: (1) Spitzbergen-Franz Josef Land-east Greenland (2) Hudson Bay (3) the high Canadian Arctic (4) high Canada-eastern Alaska (5) western Alaska-eastern USSR. In the more detailed view of Canadian biologists there is evidence for regarding the Canadian Polar Bears as consisting of 8 such populations for management purposes (Jonkel 1970 *op.cit.).*

Conservation. Protective measures include total prohibition of the shooting of Polar Bears in the USSR since 1956; and a prohibition upon shooting by other than Eskimos in Canada, with the recent modification that a quota has been established in the Northwest Territories limiting the permissible kill to 386 bears per year. These are assigned on a village or regional basis. It is also possible for a village through an eskimo hunter, and with permission of the Northwest Territories game authority, to authorize the filling of a quota-right by guiding an outside hunter upon a hunt. Cubs, yearlings and females with young are totally protected.

Greenland has enacted regulations to protect cubs and females with young, designated suitable firearms, prohibited traps, snares or set guns and hunting from aircraft or over-snow vehicles.

Somewhat similar regulations are in force in Norway where sport hunting is limited to one bear per tourist. Here however set guns were still permissible in 1970, but prohibited in 1971, at which time also quotas were established.

In Alaska hunting with the use of aircraft is standard practice. The season there is relatively long, extending from April 21 to October 14. This is in interesting contrast with the Greenland season which prohibits hunting between June 1 and October 1. There is no doubt that the difference reflects availability and the class of hunter participating.

There are no reliable data yet upon the vital questions of age specific mortality rate or reproduction rate within any of the populations but the research in progress is the best organized, best funded and best planned of any research on the Ursids and should lead to the development of scientifically sound conservation measures. Already some populations have been identified that are being hunted well below the replacement capacity.

Another most important outcome of the research has been to identify the most important denning areas. Protection of these from disturbance arising from human activity is of critical importance and should constitute a significant stricture upon plans for oil and mineral exploration in these areas of the Soviet and Canadian Arctic. The extent of denning upon the sea ice is unknown. The small number of females with cubs sighted off Alaska as compared with the much larger component of females with yearlings suggests that few bears den on the ice in this region.

MANAGEMENT OF BEARS

It is possible to identify some generalizations on matters of management. It is obvious that within the last 50 years, with few exceptions, bears of all species throughout the northern hemisphere have ceased to be looked upon as serious competitors to man. No longer are they subject to destruction by any means at any time and frequently with government subsidy.

Bounties have disappeared expept for a private bounty on Black Bears in a small area of West Virginia and an official bounty upon Brown Bears on Hokkaido. There are still large areas in Asia Minor, Afghanistan, Pakistan, India, Burma, and possibly China, where Brown Bears are afforded no protection. In general however throughout Europe, USSR and North America all bears are regarded as important members of the biota and regulations are operating to perpetuate the species for sport hunting or for their contribution to the native economy.

No very ingenious management devices have been conceived and management, in the absence of reliable population data, can only be regarded as crude. Under these circumstances rule of thumb calculations suggest that for the Brown-Grizzly and Polar Bears harvests may not exceed more than 1:17-20 except under unusual circumstances that give rise to high recruitment rates. A somewhat higher harvest ratio may be tolerable for the American Black Bear, but this will depend on local circumstances arising from the food production of the environment, density tolerance, and the degree to which hunting substitutes for natural mortality.

In some areas of the United States the tenor of regulations is to improve and manage the recreational aspects of bear hunting as well as maintaining the population. In general there has been a tendency to shorten seasons. In some places emphasis is placed upon the spring season and thus to separate bear hunting from the open seasons for deer and other ungulates.

The increasing use of aircraft for industrial transport and for movement of hunters into remote areas has introduced a new threat to effective management of the Brown-Grizzly Bear in northern North America. No effective techniques have been devised for controlling the illegal use of such vehicles in the hunting and killing of bears.

In the prospect that expansion of human populations into now wild lands will continue, it is important to seek information upon minimum Viable populations, and the size and nature of ranges capable of supporting such bear numbers. Some clues are available from existing data. Relict populations of Grizzly Bears in Yellowstone and Glacier Parks demonstrate that populations of 200± bears occupying range at 5-7, 000 acres per bear are successfully self maintaining. Some island populations in Alaska could certainly yield data on this point. The Sierra del Nido population of 30± bears on 2-5, 000 acres was apparently self sustaining; the Abruzzi Park group of 60-80± bears occupies only about 600 sq. kilometers.

When we look at the Black Bears in the United States we find that Erickson *et al.* (1964) had a population that varied through the years from 84 to 168 animals on the 400 square mile study area in Northern Michigan. Jonkel (1967) on his 80 sq. mile area had a maximum density of 1.2 per sq. mile.

The smallest kills are from Georgia 25/yr., Texas 2-4/yr., Mass. 8/yr., West Virginia 55/mean over 21 years, Tennessee 31 (19-50), New Jersey 1-4, Florida 25-50, a total of 146-177. These states estimate their populations as 500, 50, 25-50, 525-594, 350, 20, 500-1000, or a total of about 2000-2600 for a kill approximating 1 bear per 1.3 to 1.8 sq. mile.

It appears therefore that minimum harvests have been taken on a continuing basis from populations estimated to be 50 bears or less. The total of the three smallest takes is 11 bears from a total number of about 120 bears or roughly 1 in 10. I do not know whether this 1/10 relationship has been built into the statistics by a conversion factor used at the department level to estimate total population from their reported kill. The three smallest apparently self-sustaining state populations are thought to be in the order of 20-50 animals.

A population of 50 bears with normal distribution of sex and age categories would include but 6 or 7 females of breeding age, producing not more than 4-5 surviving cubs per year. Thus the entire recruitment would be only 3 or 4 animals per year and the yield on a long term basis could not be more than that or 1 in 12-18. It seems likely therefore that viable populations as small as 50 bears could exist but they could not support a sport hunting programme of consequence. A population of Black Bear to yield 25 trophies a year would have to be about 300 bears as a minimum.

In Grizzly-Brown Bears, with their lower reproductive rate, similar figures would suggest 400-500± bears as necessary to provide an annual take of 25-35 animals. This comes very close to the calculated permissible take on Kodiak Island.

Among the world's bears the two species in greatest danger seem to be the Spectacled Bear and the Sloth Bear. Very little is known about either species and it would be well worth while stimulating long term studies of each of them. At the subspecies level the Baluchistan race of the Asiatic Black Bear, the Mexican Grizzly, the Syrian and Alpine Brown Bears, and if identification is correct, the relict populations of the plains Grizzly in the Swan Hills area of Alberta, are those in greatest hazard of extermination. In most instances human encroachment on habitat, that reduces its essential wildness and intensifies contact and conflict with man, are the forces likely to result in permanent loss of these interesting types of bears.

MANAGEMENT IN PARKS AND PROTECTED AREAS

The management of the bears in National Parks and protected areas is of increasing importance as the use of such areas by people increases rapidly. Larger numbers of visitors into the more remote areas of parks will increase the number of contacts between people and bears (Martinka 1970) and perhaps render the 'wilderness' less suitable as bear habitat. Most species, however, readily respond to man based food sources, habituate to people, lose their fear of them, and thus invite contacts that can result in serious injury or death to people and a resulting outcry against the presence of bears (Martinka *op. cit.,* Cole 1970, Craighead 1970).

There are two major sources of injury to man by bears. One is as old as man himself—accidental and sudden close contact in densely vegetated terrain that gives rise to reflex agonistic behaviour on the part of the bear. The other is the habituation of bears to expect food from man, via garbage, handouts, or food stores in tents and automobiles. Both participants in such contacts tend to lose fear of and respect for the other. Krott & Krott (1962) have proposed that the nature of the interaction has bear to bear characteristics. The problem faced by National Park administrators then becomes one of educating visitors to understand and respect bears and to re-educate bears into living wild and avoiding close contact with man. The matter has been closely studied recently by the National Scientific Advisory Committee for U.S. National Parks with special reference to the problems of Glacier and Yellowstone Parks in Montana. It is under review in Canada.

Management goals that have been identified include (a) to maintain population of Grizzly and Black Bears at levels compatible with natural carrying capacities, (b) to regulate the behaviour of man in the park so as to minimize conflicts, and (c) to encourage bears to live their natural lives with minimum interference by humans (Leopold 1969).

The demands of the management exercise can be summarized under the following headings: (1) Removal of all trash and garbage from access by bears (Cole 1970, Martinka 1970). This will involve garbage disposal by incinerators or burial in bear proof areas, as well as bear proofing all waste containers in all parts of the park.

There can be legitimate differences of opinion in the likely reaction of bears to the withdrawal of a food source they have been accustomed to for many generations. We are familiar with the upsurge of bear damage complaints that arise when even a fully wild population faces a mast or berry crop failure. The anticipated consequences will be heavily dependent upon local circumstances and will certainly differ from one park to another.

It is urgent therefore to maintain constant and sensitive contact with the changed behaviour and to be prepared to counteract events likely to lead to added problems. These will involve:

(2) Intensive public education and enforcement of regulations involving people and behaviour even to temporary exclusion of hikers from some areas.

(3) Special concern for campgrounds such as patrols by night, drift fencing with electrified components, closing or relocation of campgrounds that prove to be particularly prone to bear contact.

(4) Research to develop a variety of means of deterring bears from campsites and similar situations as well as in the direct confrontations that may occur. The responses of bears to ultrasound, lights, repellent odours, repellent gases and similar devices, explosives such as noise grenades, roman candles or railway flares and other novel devices, should all be the subject of experimentation.

(5) Under certain circumstances provision of temporary food supplements, in areas remote from human activity—such as helicopter drop of carcasses of surplus big game or old horses etc. to encourage movement of bears away from traditional garbage areas and a return to appropriate patterns of natural feeding during a phasing out period of the education.

(6) Some bears will prove intractable. They must be removed, preferably by live trapping and transplanting into areas far removed from the ranges of their experience and with due concern for potential troublesome contacts with people. In making such transplants it is particularly important that the release plan acknowledges normal return distances.

For example, studies by Pearson (verbal report) in Yukon Territory suggests that relocation of mature grizzlies within 50 miles for females or 100 miles for males is likely to be unsuccessful. Cole (1970) reports 60% success with 50 Grizzlies of mixed age transplanted distances of 6-49 miles. Only 20% of yearlings and 2 year olds returned after transplant. Helicopter transport will probably be required but the cost may be justified when dealing with rare species. Careful documentation of experiences with distance transplant should be published to increase our knowledge on this point.

Troublesome bears that resist re-education and cannot be removed alive by transplant or into zoos may have to be killed. Where very rare genotypes are involved special effort should be made to avoid this necessity.

In the case of the Grizzly, Sloth Bear or Spectacled Bear, the rare and locally endangered species, the responsibility of the authorities is heavy. For example, 250-300 Grizzlies may contain no more than 15-20 breeding females in any one year. Thus a particular concern should be to protect this group. They should occupy a position of special priority.

Furthermore the re-education may have consequences far beyond the immediate scene. It may drive garbage habituated bears out of the parks onto areas where they will find their way to community food sources where they will enjoy none of the respect they merit within the park. A stock can be destroyed as effectively by moving it out of a protected into an unprotected area as it can be by shooting it on the spot. Coordinated local and regional action is called for.

At the present level of our understanding of bear populations and bear behaviour all such projects should be conducted in a research framework and the opportunity for learning is great.

ACKNOWLEDGEMENTS

In compiling the data upon which this review is based I have enjoyed the help of many biologists and administrators. In particular I acknowledge the prompt and helpful replies to my request for information on the part of the wildlife administrators of each State of the United States of America and of each Canadian Province. I regret that they are too numerous to thank individually.

Correspondents in all parts of the world provided information, advice, and references that are cited in the text. I am particularly indebted to the following: J. Eisenberg, Smithsonian Institution, Washington, D.C.; M. Krishnan, Myalpore,Madras,India: Tun Yin, University of Rangoon, Rangoon, Burma; I. R. Grimwood, Pakistan Forest Institute, Peshawar, N.W.F.P., Pakistan; T. J. Roberts, Roberts Cotton Associates, Khanewal, West Pakistan; K. Curry-Lindahl, Nairobi, Kenya; Tetsuo Inukai, Hokkaido University, Sapporo, Japan; Hiroyuki Masatomi, Senshu University, Bibai, Hokkaido, Japan; A. A. Kistchinski, Central Laboratory on Nature Conservation, Moscow, USSR; Franco Tassi, Parco Nazionale d'Abruzzo, Pescasseroli, Italy; Mohd Khan, Malay Nature Society, Kuala Lumpur, Malaysia; Arthur Pearson, Canadian Wildlife Service, Whitehorse, Y. T., Canada; Charles Jonkel, Canadian Wildlife Service, Ottawa, Canada; John J.Craighead, Montana Coop. Wildlife Res. Unit, University of Montana, Missoula, Montana; Robert L.Rausch, Arctic Health Research Centre, College, Alaska; C. J. Martinka, U.S. National Park Service, Glacier Park, Montana; Glen F. Cole, U.S. National Park Service, Yellowstone National Park, Montana; Richard J. Hensel, U.S. Fish and Wildlife Service, Kodiak, Alaska; J. W. Lentfer, Dept. of Fish and Game, Naval Arctic Research Lab., Barrow, Alaska; W.E. Stevens, Canadian Wildlife Service, Edmonton, Alberta.

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