A LITERATURE REVIEW ON BLACK BEAR POPULATIONS AND ACTIVITIES

by
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and
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JUNE 1967

NATIONAL PARK SERVICE AND COLORADO
COOPERATIVE WILDLIFE RESEARCH UNIT

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for
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Part I. Introduction

Black bears (*Ursus americanus*) are a major attraction in Yellowstone National Park. Bears commonly seen by visitors are those attracted to visitor-use areas by an abundance of artificial food. This association of bears with man, however, has caused them to lose their fear of him. As a result, bears have injured visitors and caused thousands of dollars worth of property damage every year. As annual visitation to Yellowstone Park increases, the problem can be expected to become more acute and will necessitate a revision of present policies.

To insure that changes in policy will be justified, the National Park Service financed two research projects to obtain information on activities and population characteristics of black bears in Yellowstone National Park. This is a review of literature for these two studies.

Classification

The black bear belongs to the class Mammalia, the order Carnivora and the family Ursidae (Simpson, 1945). Unfortunately, the literature is inconsistent regarding black bear classification at the lower taxonomic levels of genus, species and subspecies. Two generic names, *Euarctos* and *Ursus,* consistently have been used. More recent authors generally have preferred *Ursus.* Hall and Kelson (1959) gave the scientific name of the black bear as *Ursus americanus* Pallas and listed 18 subspecies occurring on North America. In contrast, Anthony (1928) placed the black bear in the genus *Euarctos,* listing six species and four subspecies. *Ursus americanus* is the scientific name most frequently used in recent literature. In addition to black bear, other common names include brown bear, cinnamon bear, common black bear and American black bear.

Distribution

Trippensee (1948) gave the following as the distribution of the black bear:

> The wilder areas of the Northeastern United States and Canada; the northern part of the Lake states and western Ontario; the mountainous portions of New York Pennsylvania, the South Atlantic states; and the wild forested sections of the Gulf states, together with the mountainous regions of Mexico, the Western United States, Canada, and Alaska, constitute the present black bear range in North America.

According to Gilbert (1951a), 38 states, including Alaska, and all Canadian Provinces listed the black bear in their fauna. This agrees closely with the distribution shown by Burt and Grossenheider (1952, Fig. 1). Both Burton (1962) and Palmer (1954) claimed the black bear formerly was more abundant and widely distributed in North America.

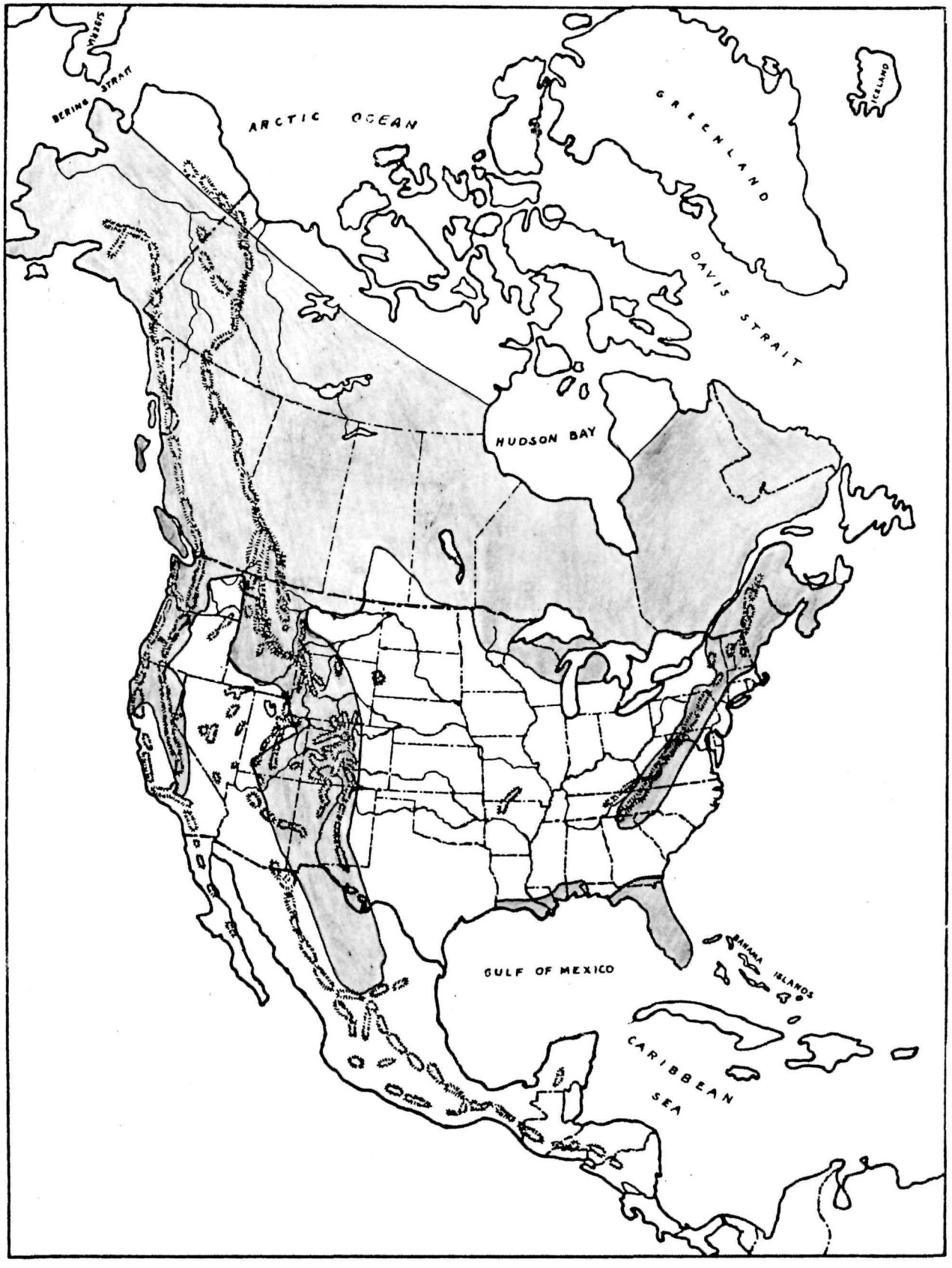

FIG. 1. *Geographical distribution of the black bear (Burt and Grossenheider, 1952).*

Part II.
Black Bear Characteristics, Activities and Capture Methods

by Victor G. Barnes, Jr.

Characteristics

The black bear is the smallest of the North American bears (Palmer, 1954). The body is heavy and supported by four, short, stocky legs. A black bear walks with its head held low and the middle of its back arched. (Grinnell, et al., 1937). The skull is flat in profile (Seton, 1913), the ears small and rounded, and long fur practically conceals the short tail (Burt and Grossenheider, 1952). Bears walk on the entire foot (plantigrade) and each foot has five clawed toes. The short-curved claws of the front feet particularly are adapted for climbing (Cahalane, 1947).

Color

Color phases of the black bear vary greatly, even within local areas, and it is not unusual for more than one color phase to occur in the same litter (Palmer, 1954 and Moore, 1953). There is a report of a captive cub whose color changed from cinnamon to extreme dark-brown in two years (Miller, 1955).

The most common color phases, in order of their abundance, are black, brown and cinnamon. In eastern North America the black phase dominates, in the West the brown phase is prevalent and various brown-black ratios occur between these two areas. In a New York study reported by Black (1958), all bears captured were of the black phase. Most bears in Pennsylvania are black, although cinnamon-colored bears occasionally are reported (Pennsylvania Game Commission, 1952). Gilbert (1951a) found 50 percent of the black bears killed by Colorado hunters were brown and 44 percent were black. He also reported two grey-colored bears killed in Colorado in 1950. Jonkel (1960) conducted a black bear study in the Whitefish Range of Montana and found: 73 percent black, 25 percent brown and about two percent blond.

Two more color phases occur in Alaska. Most abundant is the luxuriant-brown chocolate phase. Black bears of this color frequently are mistaken for brown or grizzly bears (*Ursus arctos middendorffi* and *Urcus arctos horribilis*). The blue or glacial phase (whitish-blue) is rare and its distribution is confined to the coastal areas lying between Cross Sound and Cape St. Elias in the Southeastern Gulf of Alaska (Erickson, 1965).

Perhaps the most unique color phase is found on Gribble Island, British Columbia. Kermode's bear, as it is known, is smaller than most black bears, has brown eyes and a white or creamish coat (Palmer, 1954 and Moore, 1953). Most sources classify it as a sub-species of black bear, but Cahalane (1947) identified it as an albino. Anthony (1928) considered it a separate species.

In addition to the main pelage color, some black bears have white breast marks (Seton, 1913 and Cahalane, 1947). There is considerable disagreement in the literature as to the frequency with which these white patches occur. According to Burt and Grossenheider (1952), Moore (1953) and Cahalane (1947), all black bears have a brown muzzle. Wright (1910) claimed that the claws always match the color of the coat.

Size

Black bear young are small at birth. Baker (1904) reported two cubs born in a private zoo in Ohio each weighed 9 oz. and measured 8½ inches in length. Schoonmaker (1928) told of a cub born in the wild that weighed only 6 oz. when taken from its mother a few days after birth. Cubs grow rapidly and at 2 months of age will weigh about 5 lb. At 10 months they may weigh 50 lb. or more (Seton, 1909 and Gerstell, 1939). According to Skinner (1925), black bears reach maturity at 3 years but continue to increase in size and weight for several years. He claimed rate of growth and age of growth termination vary with individual animals. Wright (1910) and Gerstell (1939) reported bears do not attain full growth until the sixth or seventh year.

Weights of black bears captured in Montana are presented in Table 1. It shows weight variations occurring in black bears between age group, sex, and season of year. As a comparison, weights of black bears from other areas of the United States are presented in Table 2.

TABLE 1. *Weights (lb.) of black bears by age class, Whitefish Range, Montana (Jonkel, 1960).*

Age	Feb.	Mar.	May	June	July	Aug.	Sept.	Oct.	Nov.	Avg. Wts. M	Avg. Wts. F
Cubs				16 (2)*	20 (4)	28 (6)		38 (3)		25	26
Yearlings	57 (2)		17 (1)	40 (5)	49 (3)	52 (3)	70 (8)	74 (2)		55	59
2-year olds**			52 (1)	58 (4)	81 (5)	81 (2)	100 (1)				
Sub-adults***										93	91
Females			126 (3)	100 (4)		122 (1)					
Males			130 (2)	121 (2)			137 (2)				
Adults										196	141
Females	135 (1)			116 (3)	131 (7)	148 (7)	158 (4)	154 (4)			
Males			206 (3)	226 (9)	175 (2)	177 (3)	190 (3)		288 (1)		

*The number of bears in each group.
**May include a few yearlings and 3-year olds.
***May include some 2- and 4-year olds, but mostly 3-year olds.

Large bears seldom exceed 500 lb. Gilbert (1951c) reported a male which weighed 665 lb. field-dressed. This bear, whose live weight was estimated at 800 lb. was killed in the Mt. Blanca area of Colorado. Other large bears for which live weights have been verified include two males from California, one weighing 620 lb. and the other weighing 680 lb., a 599 lb. male from New York and a 633 lb. male from Pennsylvania (California Fish and Game Dept., 1961).

Several researchers have determined spring to fall weight changes. Stickley (1961) found an average increment of 42 lbs. (2.4 lbs. per week) for 13 bears retrapped in Virginia. Included was a male that gained 7.6 lbs. per week. Knudsen (1961), while studying bears in Wisconsin, recorded weight gains of 65 to 75 lbs. for mature females and up to 130 lbs. for mature males.

TABLE 2. *Weights of black bears from Florida, Pennsylvania and Yellowstone National Park.*

Area	Average weight (lbs.) by age class: Cub	Yearling	Adult M	Adult F
Yellowstone National Park (Kittams, 1948)*	80	....	....	233
Pennsylvania (Stickley, 1961)	....	76	157	119
Florida (Harlow, 1961)	....	....	305	189

*Kittams specified that the weights were taken in September and included three adult females and five cubs.

TABLE 3. *Measurements (in inches) of seven black bears from Colorado (Gilbert, 1951a).*

Age	Total length (avg.)	Height at shoulders (avg.)	Tail length (avg.)	Length of hind foot (avg.)
Cub (1)*	36.0	21.0	3.5	6.0
Yearling (3)	49.0	24.3	4.5	7.3
Adult (3)	69.6	30.0	7.0	9.2

*Number of bears in each group.

An excellent summary of weight increment and loss was presented by Jonkel (1960). He found that in spring weight either was lost or barely maintained until approximately the end of July and referred to this interval as the "negative foraging period." One exception was a female that gained weight during this period, but she had access to a garbage dump. From about the end of July until the first or middle of November bears gained weight at a rate of approximately one lb. per day. Jonkel (1960) called this the "positive foraging period."

According to Cahalane (1947), the total length of adult black bears will vary from 4½ to 6½ ft. and height at the shoulders will vary from 25 to 40 inches. Measurements of seven bears from Colorado are presented in Table 3. They provided a comparison between age groups.

Murie (1954) gave the following as average foot measurements for adult black bears:

	Front foot	Hind foot
length	4½ inches	7 inches
width	3¾ inches	3½ inches

Senses

The senses of sight and smell are well developed in black bears, but their eyesight is extremely poor (Skinner, 1925, Seton, 1909, and Kinney, 1940). Authorities agree that bears rely primarily on their keen sense of smell to locate food and detect intruders. Moore (1953) claimed bears use their smelling ability to determine from "bear trees" the sex and species of animals that previously rubbed or clawed the tree.

Sounds

Although normally silent, black bears are ver-

satile in voice ability and numerous descriptive words and phrases have been used to depict their sounds. According to Dufresne (1946), the black bear voice ranges from growls of anger to a wide variety of whines, sniffs and snorts. Seton (1909) listed a variety of sounds. Grinnell et al. (1937) gave this account of an alarmed bear:

> When threatened by an intruder it may give a low warning growl and as a hostile demonstration may champ its jaws and click teeth together; when startled a bear is prone to make a whistling sound by expelling breath suddenly and violently.

Murie (1954) wrote a similar description. He noted that a bear in a threatening mood makes coughing sounds or "champs" its jaws. If mildly annoyed it will growl in a low, smooth sound and if in trouble will emit a strong, variable, moaning sound. Zappler (1963) claimed a bear in pain will bawl and sob and an angry male could be heard ½ mile away.

Females and their cubs generally are the most vocal. They converse in low grunts, mumbles and squeaks (Cahalane, 1947). If a female has a fight with another bear, the cubs often get excited and utter bark-like sounds (Skinner, 1925).

Sign

A black bear's front foot usually leaves the imprint of a pad and five toes. A smaller, round heel-pad may or may not register. The front claws of the grizzly are considerably larger than those of a black bear and can provide a means for differentiating between tracks of the two species (Murie, 1954). The track left by the hind foot is similar in appearance to that of the human footprint.

According to Murie (1954), bear scats tend to maintain a fairly even diameter. Scats are likely to contain sizeable quantities of hair when bears are feeding on carrion, although grass is the predominant item found in most droppings. In certain seasons, scats may contain a mass of wood debris mixed with ants, a mass of pine nuts, or berries. Seton (1909) felt there was no sure way to distinguish between black bear and grizzly scats, but grizzly scats generally were larger.

Claw marks on trees that have been climbed indicate the presence of black bears in an area. Also, bears will strip bark from trees and consume the underlying cambium. Occasionally trees can be found that have been bitten, clawed and rubbed against by bears. These are "bear trees," which serve as signal posts, and are located along trails (Grinnell, et al., 1937).

Other signs include chewed-up trail markers, scooped-out anthills, turned-over rocks and buffalo chips, torn stumps and logs, clawed-out banks where bears have dug for roots or small mammals, and bear wallows. Turned-over garbage cans and scattered contents often indicate the presence of bears around ranches, camps and in national parks (Murie, 1954 and Grinnell, et al., 1937).

Habits and Abilities

The habits and abilities of black bears are many and varied; definite and predictable patterns are few. Hornaday (1922), for example, listed five universal traits of bears: playfulness, spasmodic treachery, contentment in captivity, love of water and mischevious enterprise. He further stated they are proficient in the art of expression and are known for their quick change of temper. According to Rush (1939), bears are best typified by aimlessness of purpose and clownishness. Kinney (1940) summarized the ideas of many authors when he wrote that black bears are "neither vicious nor pugnacious, highly intelligent, often impulsive and wholly unpredictable."

Curiosity Perhaps much of the apparent lack of purpose displayed by black bears is a result of their investigative nature. Skinner (1925) suggested the curiosity of bears may be keen, intellectual investigation. He stated that bears frequently will follow a man in a forest or travel through a camp without attempting to obtain food. According to Rush (1939), bears always are investigating and because of this, rarely travel in a straight line. Despite their curiosity, bears generally are elusive and wary (Seton, 1909 and Skinner, 1925). Exceptions are those animals that lose their fear of man due to close association with him (Moore, 1953).

Bluffing Black bears are known for their ability to bluff, and Skinner (1925) recognized them as the most proficient bluffers among wild animals, both against people and other bears. Kinney (1940) suggested that this bluffing ability was due in part to their reluctance to physically defend themselves or their young. He stated, however, that bears are courageous fighters when necessity demands. Mills (1932) believed bluffing generally was done for the sake of amusement.

Play Black bears are noted for their playfulness. This especially is true of cubs, although adults also amuse themselves with play activity (Cahalane, 1947 and Skinner, 1925). Adult play, however, is an individual action except in the case of a female with cubs. Occasionally lone adults will engage in friendly wrestling or games of chase; this occurs most during breeding season. Play activities of individual animals include sliding down tree limbs, having mock fights with small bushes or trees (Kinney, 1940) and coasting on snow (Skinner, 1925).

Rubbing During spring and early summer black bears generally are plagued by insects and irritation caused when the winter coat is shed. Because of this, they frequently are observed rubbing against trees and rocks (Cahalane, 1947). Another common habit is that of straddling a small

tree and letting it rub the belly as the animal walks over it (Murie, 1954 and Skinner, 1925).

Bathing and Wallowing Bathing is a habit bears enjoy during warm, summer months. Wright (1910) reported that most bears take daily baths in regular bathing holes. Both muddy and clear-water pools have been used (Grinnell, et al., 1937). Cahalane (1947) reported that bears have been known to take baths in hot-spring pools. Seton (1909) stated that wallowing in mud was a constant practice in hot weather and that bears occasionally have been observed wallowing in carrion and garbage.

Resting Thickets or windfalls near feeding areas are the most common resting places of bears. Each has a favored resting locality. Young bears spend more time resting in trees, especially when older animals are in the vicinity. Caves and dens apparently are used little (Skinner, 1925).

Individual bears tend to occupy certain thickets, but don't necessarily return to the same one each day, Grinnell et al. (1937). He found that one bear may have as many as a dozen beds in one thicket. Kinney (1940) believed bears were less accustomed to using specific resting areas and stated that they rest wherever and whenever they become tired. In Wood Buffalo National Park, Canada, Soper (1942) found many beds that had received heavy use and suggested that bears frequently return to the same bed.

Bear Trails Bears have a habit of repeatedly following a given route, stepping each time in the footsteps made by other bears (Grinnell, et al., 1937). In areas where bears are numerous, these pathways are well-worn and the animals usually are reluctant to deviate from them. In Yellowstone National Park, Skinner (1925) found many bear trails leading to garbage piles and reported individual bears were particular as to which ones they used.

Bear Trees Different ideas have been expressed regarding the use and function of certain trees apparently of special significance to bears. These trees have been given several names, including bear tree (Murie, 1954 and Seton, 1913), marking post (Spencer, 1955), bear blaze, bear-marked tree, bear-bitten tree and challenge tree (Bailey, 1930). Both Bailey (1930) and Seton (1913) reported that bear trees were abundant in Yellowstone National Park.

Grinnell (Grinnell et al, 1935) had the opportunity to watch a black bear use one of these trees and gave a detailed account.

Various authors have regarded bear trees as measuring posts for passing bears or have associated them with territory and breeding. Murie (1954), however, believed these were not the primary functions of bear trees and felt it was a sign post, similar to the scent post of the dog tribe, primarily a place for comfortable rubbing.

Several different tree species are used: yellow and white birch (*Betula* sp.), aspen (*Populus tremuloides*), balsam fir (*Abies balsamea*), white cedar (*Thuja occidentalis*) (Spencer, 1955), and ponderosa pine (*Pinus ponderosa*) (D. L. Gilbert, personal communication). Seton (1909) reported aspen was most commonly used in the Rockies.

Physical Abilities Black bears, and especially cubs, possess exceptional climbing ability and spend a considerable amount of time, asleep and awake, in trees. Individual animals often have special trees they will use for months or even years (Wright, 1910 and Mills, 1932). However, Skinner (1925) claimed that climbing ability is restricted in the fall because of increased weights of the bears.

According to Zappler (1963), black bears can run at a speed of about 25 mph over short distances and on one occasion Hill (1942) clocked a running bear at just less than 30 mph. Bears also are good swimmers (Cahalane, 1947) and are able to stand erect on their hind legs (Skinner, 1925).

Periodicity The ability of black bears to adapt to a variety of situations is probably the reason the literature is in disagreement as to whether they are nocturnal, diurnal or both. Erickson (1965) wrote that black bears in the wild state primarily are nocturnal. Wright (1910), however, believed they are active both day and night. He claimed that black bears in country inhabited by grizzlies are more active during the daylight hours because they prefer to avoid the primarily nocturnal grizzlies.

Bloomfield (1964) suggested that some black bears in Yellowstone National Park are diurnal, while others are essentially nocturnal. He believed those bears begging along roadsides during the daytime were not the same animals that visited campgrounds at night. In contrast, Dixon (1929) found evidence indicating many of the same bears that begged along roadsides during the daytime also raided campgrounds at night. Skinner (1925) observed bears in the Park at all hours and concluded that they sleep as much during the day as at night. He noted that bears feeding at garbage piles were primarily nocturnal early in the season, but quickly became accustomed to the presence of people and from then on were equally active during daylight hours.

Life History

Reproduction

Breeding Activities Breeding records for black bears are few, but those available indicate both sexes attain sexual maturity at about 3½ years of age (Baker, 1912, Erickson and Nellor, 1964, and Rausch, 1961). Although Stickley (1961) observed three captive, yearling females mating, all of them died before he was able to determine if they were pregnant.

Breeding season generally is the only time adult males and females tolerate each other (Cahalane, 1947) and it usually occurs from June through mid-July over the entire range of the species (Jonkel, 1962 and Erickson and Nellor, 1964). Stickley (1961) trapped females in heat in June, July and August, which suggests the breeding season might be summer-long. Also in contrast is a report by Skinner (1932), of a pair of black bears observed mating in September in Yellowstone National Park. According to Erickson and Nellor (1964), females are in a condition of continuous heat during breeding season and remain so until bred.

Cockrum (1962) maintained black bears are monogamous, and the same was suggested by Trippensee (1948) and Skinner (1925), who reported bears pair off and mate in seclusion. Stickley (1961) suggested bears are polygamous and D. L. Gilbert (personal communication) believed bears are promiscuous when congregated at garbage dumps. Skinner (1925) reported males engage in courting fights of short duration which are extremely noisy but usually result in little damage to the participants.

Females with suckling cubs (four to five months old) apparently do not breed (Schorger, 1949 and Grinnell, et al., 1937), although Baker (1912) reported captive females have been known to breed in successive years if the cubs were lost or separated from the mother prior to breeding season the second year.

The gestation period is approximately seven months (Zappler, 1963, Rausch, 1961 and Baker, 1912) and the young are born from late January through early February (Gerstell, 1939 and Baker, 1912). Litter size generally varies from one to four, with two being the usual number, one and three occurring frequently, and four only rarely (Erickson, 1964b and Cahalane, 1947). Several reliable sources have reported females with five cubs (Matson, 1952) and there is one verified report of a female with six cubs (Rowan, 1947).

Care of Young Males have no part in the care and rearing of cubs. Females, however, are extremely attentive and vigorously defend their young. Kinney (1940), for example, witnessed a male attempt to knock a cub down, only to be thwarted by a vicious attack from the mother. The female, he continued, suffered several injuries, but refused to attend to them until the safety of the cub was insured. Females frequently will send cubs up a tree during times of alarm (Zappler, 1963 and Grinnell, et al., 1937) and Jonas (1959) reported that during rest periods sows may send the cubs up a tree and then sleep at the base of the tree. Skinner (1925), while observing bears in Yellowstone National Park, found that females feeding at garbage piles often sent their cubs up a tree when other bears were in the vicinity.

Apparently, the willingness to protect young varies with individual animals and with the situation. Erickson (1957) recorded the reactions of bears during trapping operations and noted seven of ten females with young did not display strong maternal instinct; they quickly abandoned the cubs when danger was imminent. Those that displayed aggressive tendencies could be discouraged with loud noises. Matson (1946) reported females have been known to abandon cubs under natural conditions. According to Erickson (1959), cubs of either sex may be self sufficient as young as 5½ months and as small as 18 lbs.

Most females are patient with their cubs (Mills, 1932), but they are strict disciplinarians and do not hesitate to punish disobedience (Cahalane, 1947, Kinney, 1940 and Seton, 1909). Punishment usually is in the form of a swift blow delivered with the front paw.

Although Wright (1910) concluded that cubs are weaned and abandoned prior to winter denning, Cahalane (1947), Jonkel (1962) and Zapper (1963) reported that family groups do not break up until the following spring, or when the young are approximately 18 months old. According to Grinnell, et al., (1937), cubs often spend their first winter in the same den with the female or nearby. Termination of the family relationship occurs just prior to breeding season and usually is permanent. There are, however, exceptions. In a personal letter to Schorger (1949), O. J. Murie reported observing a family group in Yellowstone National Park that temporarily broke up during the breeding season and later reunited for a short period.

Movements

Daily Movements Apparently black bears have limited daily movements during most seasons of the year and especially when food is readily available. Jonkel (1963) observed bears feeding on huckleberries (*Vaccinium* sp.) in September and found that individual animals or family groups tended to occupy the same general area from day to day. Knudsen (1961), studying bears in Wisconsin, concluded that during short periods most bears of both sexes stay in small areas.

Seasonal movments Seasonal movements of black

bears generally are dictated by food availability (Skinner, 1925). Chatelain (1950) found that bears on the Kenai Peninsula of Alaska concentrated along streams during salmon runs, but moved to berry patches above timberline in the fall. Bears were scattered widely during other seasons. Spencer (1955) discovered a similar situation in Maine. He reported that the bears' food habits changed with the season, resulting in population shifts which concentrated bears from any given locality into relatively small areas of abundant food. Migrations resulting from food shortages have been reported in Colorado (Gilbert, 1952), Pennsylvania (Pennsylvania Game News, 1952), Virginia (Stickley, 1957), Wisconsin (Schorger, 1949) and Yellowstone National Park (Heller, 1925).

Other factors may be responsible for seasonal movements. Jonkel (1963) found adult males moved to higher basins following breeding season. Skinner (1925) reported bears became restless in fall and made long trips. He also stated that immediately after denning, bears often moved to lower elevations and then work back up as the snow melts. Another possibility suggested by Schorger (1949) was that intraspecific intolerance may develop during periods of high bear populations and cause some individuals to emigrate.

Trapping records reported by Erickson and Petrides (1964) indicated limited summer movements of black bears in Michigan. The average movement of 13 bears retrapped during the study was 2.1 miles, and all of these animals were captured and recaptured in summer. Average, minimal, summer ranges of adult females and adult males were determined to be approximately 6 and 8 square miles, respectively. In Virginia, the mean movement of three bears recaptured the summer of tagging was 1.3 miles (Stickley, 1961).

An analysis of fall hunting returns in Michigan indicated a general movement from summer range to autumn range and that bears traveled over wider areas in fall (Erickson and Petrides, 1964). Data collected by Stickley (1961) suggested a similar pattern for bears in Virginia. The average movement of 30 bears harvested the fall after tagging was 7.6 miles. This was considerably larger than the average summer movement of 1.3 miles. Males killed in the fall had moved an average distance of 10.0 miles, while the mean movement of females was only 1.8 miles.

Home Range Trippensee (1948) believed bears traveled in a large circuit rather than a home range, Mills (1932) suggested the average range was a radius of five miles, and Cahalane (1947) estimated that home ranges of adult females and adult males were about 10 and 15 miles in radius, respectively. According to Spencer (1955), home range varies with conditions of topography and food supply.

Erickson and Petrides (1964) recorded black bear movements for 5 consecutive years (1952-1957) in Michigan and found that time elapsed between marking and recovery had little relation to distance moved, indicating bears tended to remain in the same general areas from year to year. The mean, minimum movement of 25 bears, which were released where first captured, was 4.6 miles. Eleven movements of ten adult males averaged 5.4 miles and nine movements of seven adult females averaged 1.4 miles. A movement of 19.4 miles by a female and cub was the maximum recorded during the study and raised the average for all adult females to 3.2 miles. The greatest distance traveled by an adult male was 11.9 miles. Mean, minimal, annual ranges were estimated to be 20 square miles for adult males and 10 square miles for adult females.

Only slight differences were detected between bears that used dumps and those that did not. The mean movement of six "dump" bears, all adult males, was 4.8 miles. Two recoveries, however, were made at the original capture site. Exclusion of these recoveries raised the average to 6.7 miles, which was similar to the 6.6-mile mean movement of the four adult males that did not utilize dumps.

In a Wisconsin study, the maximum recorded movement was 46 miles by an adult male. Movements of all males averaged 15 miles and there were indications that fully mature males traveled greater distances than young males (Knudsen, 1961). This was in disagreement with Stickley (1961), who reported the movements of yearling and adult males were similar. Thirty-six miles was the greatest distance moved by any of the 17 adult females tagged by Knudsen (1961) and 15 of them were recovertd within 2 miles of the original release site.

Jonkel (1962), in Montana, reported significantly smaller movements (Table 4) and home ranges (Table 5) than those determined for bears in Michigan (Erickson and Petrides, 1964) and Wisconsin (Knudsen, 1961). He gave two reasons for the small home ranges: (1) a high population density in the study area and (2) trapping was not conducted on a complete-grid basis. His data

TABLE 4. *Distances between points of capture or observation for black bears in Montana (Jonkel, 1962).**

Age When First Captured	Sample Size	Avg. No. of Cap. or Obs.	Greatest Distance in Miles	
			Avg.	Range
Cub	12	4.5	1.4	.7- 2.6
Yearling	8	3.3	1.3	.0- 4.9
Sub-Adult				
Females	7	3.6	1.6	.2- 2.5
Males	9	4.0	1.5	.0- 5.7
Adult				
Females	11	4.8	1.6	.9- 2.6
Males	13	3.6	4.7	.5-11.0
Dispersing 2½ Year Olds	4	2.5	21.9	19.9-27.0

*Includes animals captured or observed two or more times.

showed home ranges of adult males to be greater than those of adult females, sub-adult males, and yearlings.

TABLE 5. *Minimal home ranges of black bears in Montana (Jonkel, 1962).**

Age When First Captured	Sample Size	Avg. No. of Cap. or Obs.	Minimum Home Range in Sq. Miles	
			Avg.	Range
Cub	7	6.3	.43	.26- .59
Yearling	3	4.7	.23	.02- .44
Sub-Adult				
Females	6	4.2	.47	.04-1.31
Males	4	4.4	.42	.23- .69
Adult				
Females	6	6.1	.61	.31-1.26
Males	8	4.5	1.47	.02-3.43

*Includes animals captured or observed three or more times.

Dispersal of Young Bears From field observations, Jonkel (1962) concluded yearlings often remain within the home range of their mother after the family group has broken. He found dispersal of young animals from the resident population occurred in the 2½-year-old group (Table 4). A report by Stickley (1961) of a 90-mile movement by a 2½-year-old male suggested a similar situation might have existed in Virginia.

Erickson and Petrides (1964), however, presented data that did not concur with the above. Three bears marked as yearlings moved 6.4, 1.6 and 6.1 miles after 69, 319 and 454 days, respectively, and a fourth animal marked as a cub was recovered one year later 3.7 miles from the original capture site. These data indicated dispersal among young bears was limited.

Movements of Transplanted Bears Based on recoveries of 17 bears released at points other than the original capture sites, Erickson and Petrides (1964) concluded bears in Michigan have a tendency to re-establish when removed from their home range. The bears were transplanted distances varying from 2.4 to 158 miles, averaging 39.7 miles. The average distance from original capture site to recovery point was 34.1 miles and only three animals were recovered near the capture site. The mean distance from point of release to recovery was 22.1 miles, indicating transplanted bears tended to travel considerable distances in unfamiliar surroundings. Adult bears traveled further than young bears and adult males moved greater distances than adult females.

Only two bears displayed homing tendencies. An adult male was removed 96 miles and 35 days later was killed within 6 miles of the original capture site. The other bear, an adult female, was removed 64 miles and 120 days later was recovered 19 miles from the capture site.

Troublesome bears that have to be transported to remote areas of Yellowstone National Park apparently are reluctant to re-establish in the unfamiliar surroundings. Murie (1944) reported one ranger as saying that transplanting "problem" bears was 50 percent effective. He also told of a female and three cubs at Fishing Bridge that was removed 12 miles and returned to the area in 24 hours. V. H. Cahalane (in Trippensee, 1948, no reference given), who at the time was in charge of the Section of National Park Wildlife, National Park Service, estimated the removal method to be only 30 percent effective.

Winter Denning

Winter dormancy in black bears is a mechanism permitting survival during periods of food scarcity (Grinnell, et al., 1937 and Erickson, 1965). In southern United States and Mexico bears might sleep only for a few days at a time (Cahalane, 1947), while further north the winter denning period often lasts from five to six months (Table 6). Even in northern United States and Canada bears may come out of their dens for short periods (Cottrell, 1925, Martindale, 1926 and Mills, 1932) and some animals apparently remain active during mild winters (Gerstell, 1939 and Gilbert, 1952).

TABLE 6. *Estimated dates of winter denning periods of black bears.*

Authority	Location	Dates
Erickson (1965)	Alaska	Late Oct. to April or later
Gilbert (1952)	Colorado	Nov. 1-15 to Mar. 15-Apr. 15
Jonkel (1962)	Montana	Early Nov. to early April
Bailey (1930)	Yellowstone National Park	Late Oct. to early April

A variety of sites have been used for winter dens, including standing or fallen hollow trees, caves, windfalls, excavated holes and the bases of uprooted trees (Schorger, 1949). Erickson (1964b) reported that bears in Michigan preferred holes in hillsides or excavations under logs. In Yellowstone National Park black bears have denned in old hot springs and geyser openings, in basements, under buildings (Skinner, 1925) and in drainage culverts (Barnes and Bray, 1966). Many bears, and especially pregnant females, line dens with leaves and grass (Zappler, 1963 and Erickson and Petrides, 1964). Erickson (1965), found some bears use little or no shelter.

In Michigan, Erickson (1964b) found snowfall was a factor determining when black bears enter winter dens. He also determined denning by adult females and juveniles, as compared with adult males, was more abrupt, commenced sooner and was completed earlier. In Yellowstone National Park, however, Skinner (1925) found adult males usually were first to emerge from their dens and Rust (1946) concurred for bears in Idaho. Temperature and food abundance are two other factors that might affect time and duration of winter denning (Cahalane, 1947, Skinner, 1925, and Schoonmaker, 1938).

Most bears spend several days in and around their dens before beginning the dormancy period (Erickson, 1965 and Skinner, 1932) and observations by Aldous (1937) indicated emergence from dens might be a gradual process. Grinnell, et al., (1937) reported bears were not active when they first emerged from their dens in spring.

Food Habits

Black bears are omnivores (Seton, 1909 and Palmer, 1954) and eat a variety of foods. According to Trippensee (1948), a bear will eat almost anything a pig will eat, including carrion, flesh, fish, insects, roots, fruits, berries, nuts and tree seeds.

Bennett, et al., (1943) examined black bear scats in Pennsylvania and found wild cherries (*Prunus* sp.) were the most important summer food, comprising 52.7 percent of the total food volume. Other items in order of importance were acorns (*Quercus* sp.), 12.6 percent; bees and wasps, 11.5 percent; woodchuck (*Marmota monax*) remains, 15.7 percent; and blackberries (*Rubus* sp.), 4.6 percent. The important fall and winter food items were acorns, 36.3 percent; beechnuts (*Fagus grandifolia*), 31.1 percent; apples (*Malus* sp.,) 10.9 percent; and wild grape (*Vitis* sp.), 9.2 percent.

Cottam et al. (1939) analyzed 14 stomach samples from bears killed in the fall in Virginia and West Virginia and found oak (*Quercus* sp.) and blueberry (*Vaccinium* sp.) were the most important foods. They made up 52.0 percent and 17.5 percent of the total foodstuffs, respectively.

From a combined total of 48 scats and stomach samples collected in Colorado, Gilbert (1953) determined that serviceberry (*Amelanchier* sp.) was the most important plant food, constituting 23.6 percent of the total volume. Combined plant material accounted for 64.5 percent of the bulk, while insects and animal material made up 17.2 percent and 7.0 percent, respectively.

Murie (1944) analyzed scats of black bears in Yellowstone National Park and found the following by volume: plants—81.17 percent, insects and associated debris—9.13 percent and mammal remains—2.05 percent. Of the total volume, natural foods made up 92.35 percent, while garbage accounted for 6.24 percent. Scats collected in campgrounds contained 89.28 percent vegetable matter and only 10.48 percent garbage.

An earlier study by Murie (1937) illustrated how bears may alter their diets when an unusual food source becomes available. During the summer of 1935, grasshoppers and crickets (Orthoptera) were more abundant than usual in the Jackson Hole (Yellowstone National Park region of Wyoming) and apparently were the major summer food items that year. Sixty-eight scats were examined by Murie (1937) and 58 of these were composed entirely of the two insect forms. Crickets were more abundant in the scats than grasshoppers. Three other scats contained varying portions of cricket remains. The author suggested that bears, even those that normally fed at dumps, were feeding almost entirely on the insects.

One of the most extensive food habits studies was conducted by Tisch (1961) in the Whitefish Range of Montana. He analyzed 815 scats and four stomach samples and grouped them to represent four periods: spring, summer, fall and late fall.

Spring scats were comprised predominantly of vegetative materials, the main food items being grasses (Graminae), angelica (*Angelica dawsoni*), sweet cicely (*Osmorhiza* spp.), horsetail (*Equisetum* spp.), ants (Formicidae), clover (*Trifolium* spp.), cow parsnip (*Heraculum lanatum*), common dandelion (*Taraxacum officinale*) and sedge (Cyperaceae). Cow parsnip, huckleberries (*Vaccinium* spp.) and horsetail, in that order, had the highest frequencies of occurrence in summer scats. Other important foods were ants, grasses, sweet cicely and angelica, indicating similar spring and summer food habits. Volumetric occurrences of grasses, however, were less in summer.

Huckleberries and whitebark pine (*Pinus albicaulis*) nuts were the preferred fall foods of the bears in Tische's (1961) study area. Herbaceous foods, however, remained an important part of the diet. Food items that occurred most frequently in fall scats, in addition to huckleberries and pine nuts, were angelica, woodrush (*Lazula glabrata*), ants, swamp currants (*Ribes lacustre*), service berries (*Amelanchier alnifolia*), red osier dogwood (*Cornus stolonifera*) and mountain ash berries *Sorbus* spp.).

Examination of scats deposited in late fall showed the fruit of mountain ash as the most important food item. Other major late fall foods were grasses, angelica, service berries, snowberries (*Symphoricarpos* spp.) and cow parsnip.

Table 7 presents a summary of seasonal use of various food classes as determined by Tisch (1961). In the stem and leaf category grasses, angelica, sweet cicely, cow parsnip, horsetail, clover and sedge appeared to be the most important. Common dandelion, Indian paintbrush (*Castilleja* spp.) and huckleberry were prominent in the blossom category. Huckleberry, whitebark pine, service berry, mountain ash, snowberry, swamp current, red osier dogwood and honeysuckle (*Lonicera* spp.) had the highest frequencies of occurrence in the fruit and seed category. Insects, especially ants, were the most frequent animal foods. Volumetric occurrences of insects, however, were low. Two other important insect forms, besides ants, were hornets (Vespidae) and bumblebees (Bomidae). Identified mammal remains were primarily those of elk (*Cervis canadensis*) and moose (*Alces alces*). Rodent remains were found

in four scats and the remains of a black bear cub were identified in one scat. Bird remains occurred only three times.

According to Chatelain (1950), bears are not physically capable of capturing live animals readily, but will lose no opportunity to eat meat whenever they can. He studied bear-moose relationships on the Kenai Peninsula of Alaska and reported that bears, both black and brown, were factors in moose survival, particularly on calving grounds. He cited several reports of black bears feeding on, killing, or chasing moose calves. Black bear predation on elk calves and/or deer fawns has been reported in Washington (Schwartz and Mitchell, 1945), Yellowstone National Park (Howell, 1921) and California (Grinnell et al., 1937). Tisch (1961) suggested bears may prey on adult cervids that are in poor nutritional condition and Grinnell et al. (1937) stated that they occasionally kill adult deer that are sick or crippled. Carrion, however, apparently accounts for much of the cervid remains found in black bear scats and stomach samples (Rust, 1946, Chatelain, 1950 and Tisch, 1961).

Several incidents of cannabalism in black bears have been reported, Seton (1909), Cahalane (1947), Hornocker (1962), and Arnold (1930). Jonkel (1962) observed a yearling feeding on the carrion remains of its hunter-killed mother.

Smaller mammals black bears have been reported to consume include mice, chipmunks (*Eutamius* spp.), ground squirrels (*Citellus* spp.), pocket gophers (Geomyidae), marmots (*Marmota* spp.) (Cahalane, 1947), coyotes (*Canis latrans*) (Murie, 1944), porcupines (*Erethizon dorsatum*) and red squirrels (*Tamiasciurus hudsonicus*) (Spencer, 1955).

Analyses of bear scats and stomach samples reveal remains of birds, fish and reptiles infrequently. Moore (1953) listed snakes and birds as black bear foods and Wright (1910) included frogs and toads. Consumption of fish has been reported by Soper (1942), Skinner (1925), Hill (1942), Gilbert (1951c) and Chatelain (1950). Cahalane (1947) stated bears occasionally prey on nesting birds and bird eggs. Rowan (1928) believed individual animals may systematically search lake shores for duck eggs and Traverner (1928) suggested bears may steal eggs from hawk nests. Small quantities of bird remains were found in scats and stomach samples from West Virginia (Cottam, et al., 1939) and Maine (Spencer, 1955).

TABLE 7. *Frequency of occurrence of foods identified in 819* black bear* scats collected in the Whitefish Range, Montana, 1959 and 1960 *(Tisch, 1961).*

Items Identified	Spring 1959 (156)	Spring 1960 (149)	Summer 1959 (163)	Summer 1960 (135)	Fall 1959 (70)	Fall 1960 (86)	Late Fall 1959 (5)	Late Fall 1960 (55)	Totals (819)
Plant Remains									
Stems and leaves	98.7	99.3	86.5	87.4	55.7	77.9	20.0	80.0	86.9
Blossoms	35.9	47.0	18.4	14.1	0.0	1.2	0.0	0.0	21.5
Fruit and seeds	1.2	2.0	46.0	53.3	97.1	97.7	100.0	100.0	44.4
Total plants	100.0	100.0	99.4	100.0	100.0	100.0	100.0	100.0	99.9
Animal Remains									
Insects	36.5	46.3	66.3	55.5	51.4	26.7	0.0	5.5	45.3
Mammals	5.8	8.7	2.5	5.2	1.4	4.4	60.0	0.0	5.0
Birds	0.0	0.0	0.6	0.0	1.4	1.2	0.0	0.0	0.4
Other (garbage, debris, etc.)	1.3	4.7	3.7	1.5	0.0	0.0	0.0	0.0	2.1

*Four stomach samples included.
Numbers in parentheses indicate the number of scats analyzed.

A habit of bears that often has concerned the lumber industry is that of "cambium feeding" (Lauckhart, 1955). This type of feeding is typical of black bears throughout their range, although it is most prevalent in the Pacific Northwest. Trees are damaged when bears strip bark from and lick or chew the exposed cambium. Studies have shown that black bears prefer different species of trees in various areas, including redwoods (*Sequoia sempervirens*) in California (Glover, 1955 and Fritz, 1951), balsam fir (*Abies balsamea*) in Maine (Zeedyk, 1957), white spruce (*Picea glauca* in Alaska (Lutz, 1951), Douglas fir (*Pseudotsuga menziesii*) in Washington (Levin, 1954) and Engelmann spruce (*Picea engelmannii*) in Yellowstone National Park (Contor, 1957). Cambium feeding is most common in the spring and early summer (Lauckhart, 1955, Fritz, 1951 and Skinner, 1925) and may be the result of spring food shortages (Resner, 1953 and Levin, 1954).

Habitat Utilization

Almost all descriptions of black bear habitat emphasize two important requirements: forest conditions and food availability (Table 8). Suitable forest habitats provide escape cover, protection during periods of inclement weather, and winter dens in overturned roots and hollow trees. Trees and shrubs provide important fruits and seeds, forest openings supply grasses and forbs, and dead trees are sources of a variety of insect foods (Trippensee, 1948).

Erickson (1965) found black bear habitat in

Alaska similar to that in other areas of North America. Trippensee (1948) stressed the importance of habitat variety and concluded typical habitat in the East consisted of ". . . a well-watered, forested area having a mixed stand of conifers and numerous streams, ponds and lakes."

TABLE 8. *Habitat types utilized by black bears in various areas.*

Authority	Location	Habitats Utilized
Erickson (1957) and (1964)	Michigan	**Spring:** semi-open forest types with lush grasses, strawberries (*Fragaria* sp.) and serviceberry; bears also utilize abandoned homesteads and lumber camps. **Summer:** areas with fruit-bearing shrubs and small trees are preferred. **Fall:** upland hardwoods are used heavily; bears also forage in mature oak stands, abandoned homesteads and lumber camps. **Late Fall:** conifer and mixed conifer-hardwood swamp areas are preferred.
Knudsen (1961)	Wisconsin	Large forested areas with an abundance of highlands, swamps and marshes are the best habitats. Mixtures of a variety of shrubs and small trees are also utilized. Large areas of aspen (*Populus tremuloides*) and jackpine (*Pinus banksiana*) are poor habitats
Harlow (1961)	Florida	Well interspersed mixtures of flatwoods, swamps, scrub oak ridges, bayheads and "hammock" habitats are the best areas.
Soper (1942)	Wood Buffalo National Park (Canada)	The aspen-spruce (*Abies* sp.)-pine forest type of the Alberta Plateau uplands is a preferred habitat type. Bears also utilize the poplar (*Populus* sp.)-spruce forest along rivers. Muskeg and salt plain areas are poor habitats.
Gilbert (1947)	Colorado	The largest bear populations are found in the montane and subalpine forests surrounded by the chaparral type of oak brush, serviceberry and snowberry.
Grinnell, et al., (1937)	California	Bears are found primarily in the heavily timbered areas adjacent to the chapparral type.
Stickley (1957)	Virginia	Large stands of mature oak support the largest populations, especially in the fall.

Small parks and meadows apparently are preferred spring foraging areas in mountainous regions. In Montana, Tisch (1961) found most of the spring food items first became available in dry mountain meadows and in Colorado, Gilbert (1951b) observed bears grazing in small mountain parks in spring. Tisch (1961) listed several other spring foraging areas of bears, including roadsides of the spruce-fir type, stream banks, south-facing slopes and snowslide areas. In spring and summer bears have been observed feeding on insects at the edges of snowbanks near timberline (Skinner, 1925 and Mills, 1932).

Tisch (1961) found bears in the Whitefish Range, Montana, utilized the same general areas in spring and summer. He determined that moist sites and creek bottoms of the spruce-fir type produced important herbaceous foods consumed during summer. In fall the bears concentrated in different areas as various food items became available. The most important late fall feeding areas appeared to be creek bottoms and seral and climax stages of the spruce-fir type. Huckleberry patches and stands of whitebark pine were utilized in early fall.

Intraspecific Relations

Black bears essentially are solitary animals and remain so irregardless of population numbers (Seton, 1909). Kinney (1940) stated they begin solitary life as yearlings, but Cahalane (1947) reported young of the same litter often travel together as yearlings and break up as 2½-year-olds.

In Montana, Jonkel (1962) observed varying degrees of intraspecific tolerance throughout the year. In early spring bears formed small feeding groups of two or three animals and were tolerant of each other to a distance of about 50 yards. Males and females became tolerant of each other during breeding season.

Larger and more loosely associated feeding groups were formed in fall. During a nine-day period in September, 1962, Jonkel (1963) observed bears feeding on huckleberries and found the minimum distance of intraspecific tolerance to be approximately the same as that determined for spring feeding groups. The bears, however, tended to be more dispersed than in spring. The center of the huckleberry area was occupied by the larger animals, apparently all males, while a female with a cub and a 3½-year-old male remained on the periphery of the main feeding area.

Erickson (1965) reported limited aggression among bears concentrated on small areas. He stated that females with cubs avoid other bears. In Michigan, he found sows with cubs rarely fed at garbage dumps.

Skinner (1925) observed frequent antagonism among bears congregated around hotels, camps and garbage dumps in Yellowstone National Park. Because of this, only a few animals fed together at one time. He found large bears tended to dominate smaller ones and sometimes one of the larger males would attempt to monopolize a carcass or scrap pile. Exclusive possession of a large quantity of food was difficult to maintain, however, and the defending bear usually had to fight off repeated challenges or relinquish the claim.

Interspecific Relations

Skinner (1925) maintained black bears associate very little with other animals and rarely kill anything larger than squirrels or woodchucks. He felt big game animals generally are either

curious or indifferent towards black bears and rarely display signs of fear.

Black bears are known, however, to prey on new-born young of ungulates. Grinnell, et al., (1937) reported witnessing a bear kill a fawn and begin to consume it in the presence of about 15 mature deer. The adult animals milled in excitement and emitted "blowing or snorting" sounds, but never approached closer than 100 yards. In Yellowstone National Park, Howell (1921) saw a black bear kill an elk calf and reported the mother and three other adults were in an excited state but made no attempts to defend the calf. In contrast, Kearns (1934) and the Wyoming Fish and Game Commission (1956) reported incidents of cow moose attacking black bears in defense of their young.

Seton (1909) claimed black bears have three enemies: mountain lions (*Felis concolor*), grizzlies, and porcupines. Skinner (1925) believed black bears and mountain lions ignore each other. He wrote, however, that bears sometimes are reluctant to challenge mountain lions or wolverines (*Gulo luscus*) feeding on carcasses. According to Seton (1909) and Cahalane (1947), wolves (*Canis lupes*) occasionally kill cubs or weakened adults.

Black bears generally avoid grizzlies. Finley and Finley (1940) observed black bear-grizzly relationships at garbage feeding grounds in Yellowstone National Park and found that the two species seldom associated with each other. They reported black bears usually remained away from the feeding areas when grizzlies were present. Cahalane (1947) claimed most black bears will climb a tree when a grizzly is near. Three instances of grizzly predation on black bears have been reported (Jonkel, 1962).

Skinner (1925) stated black bears and coyotes often are seen in the same general area, but that bears will not tolerate coyotes feeding with them. He wrote, however, of a bear and a coyote playing together. In Sequoia National Park, Boyer (1949) found the remains of a yearling bear that apparently had been pulled out of a tree and killed by two coyotes.

Yeager (1928) related how a female and two cubs were attempting to feed on an elk carcass while under attack from 40 to 50 ravens (*Corvus corax*) and magpies (*Pica pica*). He stated the female had a difficult time protecting the cubs, who were forced to lie on their backs while fighting the attacking birds.

Capture Methods

Drug Capture

The use of quick-acting drugs administered by means of projectile syringes is a comparatively recent development in the capture of wild animals. Harthoorn (1965) wrote:

> The best known consideration is the marking of animals for study of their movements, growth, incremental, and mortality rates. Capture of animals by quick-acting drugs is an alternative to shooting for certain studies that may be carried out as easily on the live animals as on the cadaver. . . . This not only prevents unnecessary waste of animals, but enables studies to be carried out in national parks and nature preserves.

Craighead et al (1960) successfully used this method to capture free-roaming grizzlies in Yellowstone National Park. Once an animal was located, they estimated its weight and prepared three syringe darts containing varying dosages of succinylcholine chloride. The animal then was approached to within 50 ft. and shot in the neck,

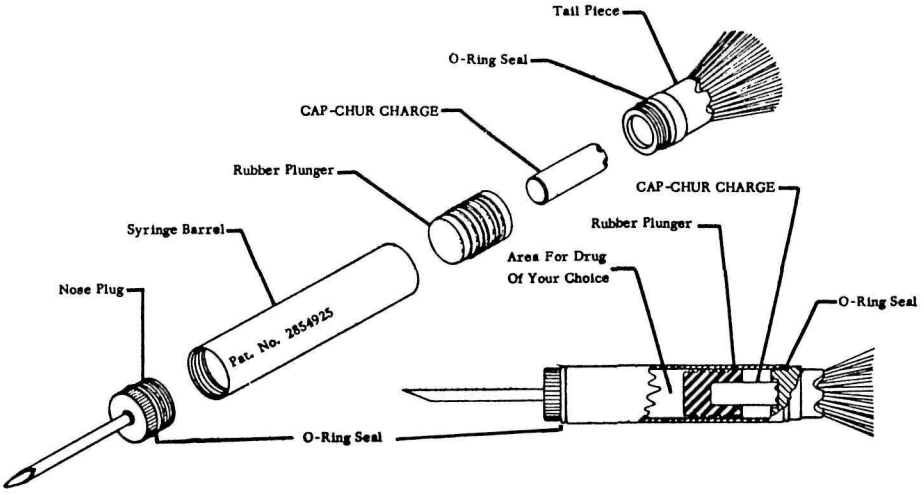

FIG. 2. *Diagram of the Cap-Chur syringe and components that permit rapid drug injection (Palmer Chemical and Equipment Co., Inc.).*

using a gas-powered (CO_2) rifle. The additional darts were used if the first dose was inadequate. Jonkel (1960) also used a gas-operated gun and projectile syringes to immobilize free-roaming black bears in Montana. Drug capture has been effectively used on several other species of big game in Africa and North America (Buechner et al. 1960).

Several types of syringes and delivery methods have been used and are described in detail by Harthoorn (1965). The most recent syringe development permits drug injection in a fraction of a second (Fig. 2). An explosive charge, containing a primer cap, a few grains of black powder, a small spring and a brass firing pin, detonates on impact. This causes a rubber plunger to force the drug through the syringe needle (Denney, 1964). This syringe is manufactured by the Palmer Chemical and Equipment Company, Douglasville, Georgia. The Palmer Company presently produces a complete set of equipment for drug capture, including the Cap-Chur gun, a .50 caliber CO_2 Crosman, a Powder Projector, a 32-gauge single-shot shotgun, and a CO_2-powered pistol. Paxarms Limited, a company located in Timaru, New Zealand, also manufactures a complete set of drug-capture equipment.

Culvert Traps

Culvert traps used to capture black bears in Michigan (Erickson, 1957), New York (Black, 1928) and Virginia (Stickley, 1961) were 8 ft. long, 3 ft. in diameter and made of steel culvert-pipe. Erickson (1957) concluded the trap back was the most important factor in trapping success and preferred an open-metal, grid type. The most effective trap doors apparently were those sliding straight down (guillotine-type). Various mechanisms have been used to release the trap door; the basic arrangement, however, has consisted of bait attached to a lever which was connected by a cable to a steel rod supporting the trap door (Erickson, 1957 and Black, 1958). Bears are reported to be difficult to lure when food is abundant; thus, culvert traps should be set near game trails and at sites of greatest bear activity (Black, 1958 and California Game and Fish Department, 1961). Erickson (1957) suggested the traps should be partially concealed, sheltered, well stabilized, and have dirt spread on the floor.

Steel Traps

Erickson (1957) found steel traps were more versatile and economical than culvert traps, but that they caused more injuries to bears. He used No. 4½ steel-spring traps placed in baited, dirt-hole, cubby sets. These sets permitted bears to approach the bait from only one direction. In each set a trap was placed 18 inches from the bait, four to six inches on either side of the mid-center line, and with the long axis parallel to the center line. Cloth then was placed over the trap jaws and a layer of dirt was added. Guide and stepping sticks were used to make bears step on the trigger pan and a toggle (drag) was attached to each trap. Another variation used by Erickson (1957) was to conceal a trap in loose dirt and place bait around it.

Stickley (1961) used No. 150 Newhouse steel traps with toothless, offset jaws. In order to lessen escapes, he placed the jaws perpendicular to the midline of the trap set so they would strike the flat side of a bear's foot. A 6 ft. chain connected each trap to a canted, double-hooked drag. He found steel traps were more effective than culvert traps, but that a large percentage of the steel-trapped bears were injured. Of 98 bears caught in steel traps, 28 suffered either broken legs (4), compound foot fractures (2), or broken or separated toes (22).

Aldrich Snare

Black (1958) caught bears with steel traps (Nos. 4, 4½ and 150) concealed in small, "V-shaped," cubby sets constructed with cull pulpwood, stumps

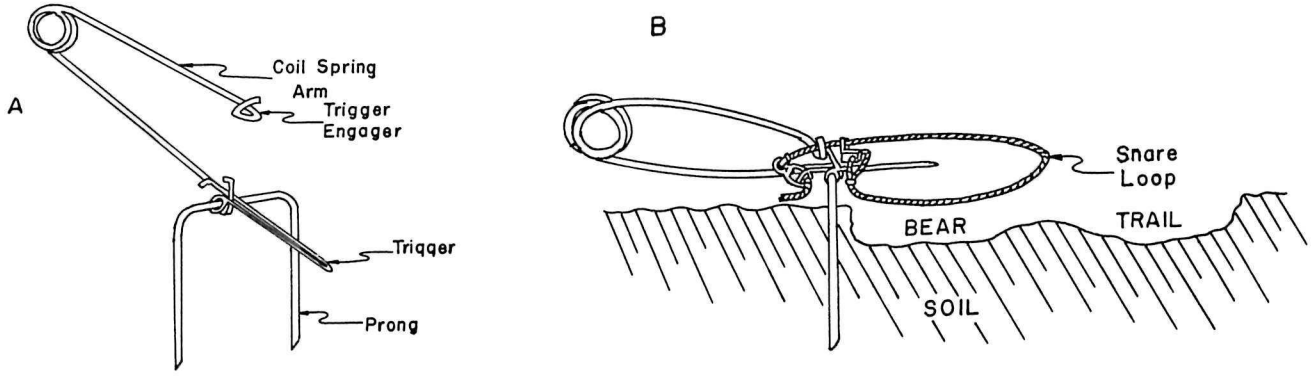

FIG. 3. *The Aldrich foot snare: A—Coiled spring; B—Snare in set position (Troyer et al., 1961).*

or rocks. These sets were two ft. wide at the entrance and tapered to a width of one ft. at the apex. Placement of the traps was similar to that described by Erickson (1957). In addition, trail sets were used along paths leading to garbage dumps and to capture the cubs of trapped females.

Black (1958) found No. 150 traps, with teeth removed, were effective and caused the least damage to bears. No. 150 steel traps also were used successfully to trap black bears in Montana (Jonkel, 1960) and brown bears in Alaska (Troyer, et al., 1962).

The Aldrich foot snare (Fig. 3) is a relatively new capture device and has received limited use in wildlife studies. Apparently its most extensive application has been for black bear control on large commercial forests of the Pacific Northwest (Bacus, 1964).

Troyer, et al., (1962), used snares to capture brown bears on the Kodiak National Wildlife Refuge, Alaska. He described the snare as follows:

> . . . each device consists of two separate parts, a steel cable snare and a spring that releases the snare. The snare is made of 3/16-in. airplane cable and the spring from ¼-in. spring steel. The spring serves to force the snare loop upward as well as closing it around the leg; after firing, the spring drops free of the snare.

Foot snares can be used either in trail sets or in cubby and bank sets (Jonkel, 1960 and Bacus, 1964). Troyer, et al., (1962) reported snares less efficient than steel traps because they caught an animal's foot only if it was placed completely inside the loop; a foot placed on the edge of a steel trap could be caught. They concluded, however, that snares had four definite advantages over steel traps: (1) The cost of snares was approximately one-fourth that of No. 150 steel traps, (2) they were safe to handle and could be used in areas frequented by humans, (3) snares were light and therefore easy to transport, and (4) bears incurred fewer foot injuries in snares than in steel traps.

Handling Trapped Bears

Erickson (1957), Black (1958) and Stickley (1961) used similar handling techniques on bears captured in culvert traps. The traps were sealed and ether then sprayed into the chamber until the bears became anesthetized. Bears were maintained under anesthesia by continual applications of an "ether cone," which is a bucket containing a layer of ether-saturated cotton, or by intraperitoneal injections of pentobarbital sodium. On a few occasions, Erickson (1957) used succinylcholine chloride to immobilize bears that first had been anesthetized with ether. Attempts by Black, et al., (1959) to anesthetize bears with oral administrations of pentobarbital sodium were unsuccessful.

Erickson (1957) used a choker (a chain loop attached to a length of pipe) and ropes to subdue bears caught in steel traps. The animals then were anesthetized with an ether cone or by intraperitoneal injections of pentobarbital sodium. The latter procedure was preferred because of the danger involved when placing an ether cone over the nose and mouth of a bear.

Another device used to administer drugs consists of a syringe mounted on a long rod or pole. Troyer et al. (1962) immobilized snared brown bears with succinylcholine chloride, using a nylon syringe mounted on a 10-ft. section of hollow, aluminum pole. He reported the pole could be lengthened to 30 ft. with additional sections. Following immobilization, the animals were secured with ropes and anesthetized with intraperitoneal injections of pentobarbital sodium.

Stickley (1961) anesthetized steel-trapped bears with syringe darts fired from a Cap-Chur gun. The projectile syringes, which contained pentobarbital sodium, were fired into both intraperitoneal and intramuscular areas. This same method was used to administer succinylcholine chloride to brown bears and black bears trapped in Aldrich snares (Troyer, et al., 1962 and Jonkel, 1960) and to grizzlies caught in culvert traps (Craighead, et al., 1960).

Drug Evaluations

A summary of drugs and dosages that have been used on black bears by various researchers is presented in Table 9.

Succinylcholine chloride Craighead et al. (1960), wrote the following:

> Succinylcholine chloride is not an anesthetic but a short-acting skeletal muscle relaxant that blocks nervous transmission at the myoneural junction. It is sold under various trade names (Sucostrin, Anectine) and chemically is diacetylcholine. It replaces acetylcholine (the chemical compound that activates skeletal muscles) and blocks nervous transmission at the myoneural junction. Muscular paralysis persists until the diacetylcholine is hydrolyzed by cholinesterase in the blood and normal nerve transmission at the myoneural junction is again resumed.

Muscular paralysis brought on by succinylcholine chloride is of short duration, recovery is rapid and the animals are fully conscious and sensitive to pain while immobilized. Paralysis proceeds in the following order: eyelids - jaws - legs - abdomen - intercostal muscles - diaphragm. Respiration becomes depressed when the upper intercostal muscles are affected, and prolonged apnea may result. Artificial respiration is the only effective therapy for respiratory failure induced by the drug (Black, et al., 1959 and Craighead, et al., 1960).

Craighead et al. (1960) reported fat weight

should not be included when determining dosage. They occasionally had to give grizzlies multiple doses of succinylcholine chloride, but found single doses were more satisfactory. Solutions of the drug are unstable and should be kept cool (Harthoorn, 1965).

Pentobarbital sodium Black et al, (1959), describing this drug, wrote:

> The principal effect of pentobarbital sodium and other barbituates is to depress the central nervous system. It induces anesthesia with a minimum of excitement, and is rapid, particularly when given intravenously. Recovery may take hours, but is usually smooth and comparatively quiet. A wide margin of safety, between the anesthetic dose and minimum lethal dose, is a principal reason for its wide use.

Erickson (1957) determined dosages on the basis of flesh weight and reported injections into muscle or fat deposits resulted in a slow release of the drug into the circulatory system. He found the main advantage of pentobarbital sodium over ether was that bears could be worked on at leisure when anesthetized with the latter. Troyer, et al., (1961) noted reduced respiration rates and complete relaxation in brown bears properly anesthetized with pentobarbital sodium.

Ether The central nervous system is more susceptible to ether than other body systems. Ether produces rapid anesthesia and recovery, is the safest of all general anesthetics, and is inexpensive. Its main disadvantages are that it irritates mucous membranes, is not completely stable in storage, and can be explosive if concentrated.

Respiratory stimulants Black et al. (1959) used three central nervous system stimulants to counteract the effects of anesthetizing drugs: Am-pent (trade name for a form of pentamethylenetrazol), picrotoxin and amphetamine. He found Am-pent was the most desirable because it was non-toxic and had a wider safety margin than the other two stimulants. Stickley (1961) used Mikedemide and amphetamine solution, but only the latter produced noticeable effects on anesthetized bears.

TABLE 9. *Dosages and the resulting "knock-down" and recovery times of drugs used to immobilize or anesthetize black bears.*

Authority	Drug	Dosage	Time to immobilize or anesthetize	Recovery time
Erickson (1957)	Ether	Approx. 1 lb. per bear	7 min. (ave.) when sprayed into culvert trap; 5 min. (ave.) when administered with an ether cone	Approx. 5 min.
	Pentobarbital sodium	0.9-2.0 1.1 ave.) body weight	11 min. (ave.)	189 min. (ave.)
Black (1959)	Ether	0.9-1.0 1.1 ave.) lbs. per bear	6.5-44.0 (11.1 ave.) min.	2.7 min. (ave.)
	Pentobarbital sodium	11.9 mg. per 1 lb. body weight (ave.)	15 min. (ave.)	47 min. - 10¼ hrs.
	Succinylcholine chloride	0.1-0.4 (0.23 ave.) mg. per 1 lb. body weight	2.7 min. (ave.)	11 min.*
	Chloroform (Used to anesthetize 4 bears but its use discontinued due to toxic effects)			
Jonkel (1960)	Succinylcholine chloride	1 mg. per 5 lb. body weight	.....	28 min. (ave.)
Stickley (1961)	Pentobarbital sodium	21.4 and 13.0 mg. per 1 lb. body weight (ave.) for intraperitoneal and intramuscular injections, respectively.	47 and 97 min. (ave.) with intraperitoneal and intramuscular injections, respectively	3-8 hours

*The recovery time recorded for only one bear.

Part III.
Factors Relevent to a Population Study of Black Bears

by Olin E. Bray

Field Sign

Census methods have been developed which relied on field sign left by animals rather than visual observations. Spencer (1955) tried tracks for censusing black bears. Klein (1959) attempted track differentiation for censusing brown bears, and Edwards and Green (1959) modified Klein's methods and made a follow-up study on grizzly bears.

Skinner (1925) reported a bear's front paw usually left a track showing only the imprint of the toes and ball of the foot. According to Murie (1954) the heel pad of the front foot occasionally registered under excellent conditions, and he reported the typical adult black bear front print to be 3¾ inches wide by 4½ inches long (heel pad showing), and the hind foot 3½ inches wide by 7 inches long. Grinnel, Dixon and Linsdale (1937) pointed out a black bear's tracks, unlike those of a grizzly, rarely showed claw marks unless the animal was running.

Spencer (1955) tried using scats to census black bears. Murie (1954) wrote that the typical scat of an adult black bear was 1⅜ inches in diameter. There appeared to be no characteristic by which black bear and grizzly scats could be differentiated. Size gave a hint, but occasionally there was overlap. Seton (1909) wrote about a black bear in captivity that defecated about five times a day.

Spencer (1955) tried to use marking posts and stump workings to census black bears. Other sign left by black bears which might be useful in censusing bears include: torn up logs, turned over rocks and buffalo chips, scooped out anthills, diggings (Murie, 1954), wallows (Grinnel et al., 1937; Trippensee, 1948), and stripped and girdled trees (Lutz, 1951; Murie, 1954; Glover, 1955; Zeedyk, 1957).

Essential Factors

Habitat

Knudsen (1961) believed the best habitat for supporting a black bear population was large, forested areas with highlands, swamps and marshes liberally intermixed. A mixture of a variety of tree and shrub species also were preferred. Stickley (1957) believed the best bear range was areas that were inaccessible and possessed a variety of food in great abundance. A variety of forest and shrub species that produced a good mast crop each year seemed to be preferred.

Trippensee (1948) and Knudsen (1961) noted the beneficial effect of edge. Knudsen (1961) stated, "Large areas of pure aspen or jack pine are relatively poor bear habitat although the bears do move through these areas quite commonly."

Food

Troyer and Hensel (1964) studied the Kodiak bear in Alaska and found food was the most important factor regulating population density. He noted bears tended to congregate where food virtually was unlimited, and usually they stayed within one mile of the food supply.

Stickley (1957) found many accounts in the literature of movements of emigration of bears from one area to another, presumably because of food shortages. Spencer (1955) learned food abundance affected black bear densities in different habitat types, and stated, "As food habits change with the seasons, shifts occur in the population which tend to concentrate bears from any given locality into relatively small areas of abundant feed."

Techniques

Marking Methods

Ear Tags Taber and Cowan (1963) reported ear tags were easy to affix, visible, and individual numbers and return addresses could be stamped on them; thus making it possible to compile data on individual animals. Metal ear tags proved to be a good device for marking black bears, Erickson (1957), Black (1958), Jonkel (1960) and Stickley (1967), and for marking grizzlies, Craighead, Hornocker, Woodgerd and Craighead (1960).

Black (1958) found both the small sheep-hog size and larger cattle size ear tags to be satisfactory, but the large size was best. Erickson (1957), Stickley (1961) and Hornocker (1962) (whose studies were with Craighead et al., [1960]) reported using cattle-size ear tags.

Taber and Cowan (1963) commented, "Often it is desirable to place tags low on the ear, where the cartilage is heavy, and on the inner edge, where there is greater protection." From the tagging success related by Black (1958), Stickley (1961) and Erickson and Petrides (1964), it was apparent that ear tags could not be relied on as a permanent marker.

Color Streamers Vinyl plastic ear streamers have been used on black bears by Jonkel (1960). Craighead et al. (1960) used plasticized polyvinyl chloride tape on grizzly bears in Yellowstone National Park. Hornocker (1962) reported that polyethylene rope and Herculite (a nylon impregnated fabric) also were used for marking grizzlies in Yellowstone National Park.

Knowlton, Micheal and Glazener (1964) used a plasticized nylon fabric (Day-GLO-SAFLAG) to mark white-tailed deer (*Odocoileus virginianus*) and turkeys (*Meleagis gallopavo*). The material proved to be flexible, tough, and resistant to cracking and tearing. Marked animals could be recognized to 400 yards with the naked eye, and positive identification of individuals could be made at 150-200 yards with 7x35 binoculars.

Mutilation Stickley (1961) attempted to tattoo black bears on the inside of the ear, but thick hair prevented use of this technique. Jonkel (1960) mentioned using skin tattoos on black bears, but did not indicate the body location. Grizzly bears in Yellowstone National Park were successfully tattooed behind the foreleg, where hair was thin, and on the upper lip (Hornocker, 1962).

Erickson (1957) told of toe-clipping black bears and said it was best to clip at the first joint, for profuse bleeding occurred if the toe was clipped at the second joint. He also recommended clipping toes only on the rear feet.

Paints and Dyes Dyes have been used successfully for marking small mammals (Taber and Cowan, 1963), and large animals by Clover (1954), Hansen (1964) and Simmons and Phillips (1966). White (1960) used paint as a marking substance for Clover's marking apparatus. Black (1958) tried marking black bears with paint. One bear's markings were obscure eight days later, but they aided identification.

Other Markings Jonkel (1960) mentioned using plastic leg bracelets on black bears, but furnished no details. Disk markers have been attached to ear tags on elk, but these increased the loss of the tags (Craighead and Stockstad, 1960). Richter (1955) applied "Scotchlite" tape to ear tags on cottontails for night identification and obtained satisfactory results with a five-cell flashlight.

Aging Methods

Tooth Replacement Rausch (1961) related that milk teeth of black bear cubs were in place three months after birth, and replacement of milk teeth began in June. Stickley (1957) reported accurately aging bears, within two months, during their first year by erruption of permanent teeth. Criteria for erruption of permanent teeth was given by Stickley (1957) and Rausch (1961).

Tooth Wear Stickley (1957) commented that due to the omnivorous feeding habits of bears tooth wear could only be used as a generalized technique for aging bears. Marks and Erickson (1966) wrote, "The amount of wear and the teeth involved within individual age groups were highly variable and precluded refinement of the method beyond that reported by Stickley (1957)."

Growth Lines and Cementum Layers Rausch (1961) felt the annual growth zones of dentine on canines could be used to designate a black bear's age through the sixth year. Marks and Erickson (1966) believed external growth lines were invalid, but the use of canine cementum layers appeared promising. Stoneberg and Jonkel (1966) and Saver, Free and Browne (1966) reported cementum layering of canines to be a good aging criteria.

Other Methods Gilbert (1951a) could find no correlation between teeth and age of black bears. Spencer (1955) measured total length, length and width of the fore and hind feet, nose pad width, and average diameter of upper and lower canines at the gum line, but found excessive individual variation in growth rate eliminated the measurements as a reliable aging technique.

Stickley (1957) determined that the size and presence of corpora albicantia in ovaries, and number of convolutions in skull sutures were invalid for aging, but skull suture closure could be of limited use. Marks and Erickson (1966) related crainal suture closure and epiphyseal closure in forelimbs could be used. Jonkel (1962) recorded weight, and measurements of the baculum, lower canines, and rear pads. He believed only the baculum and rear pad measurements could serve for aging. Stickley (1957) usually classified any baculum less than 125mm (5 inches) in length as that of a yearling. Marks and Erickson (1966) wrote that baculum size was closely related to age, but body weight was of no use for aging. Erickson and Nellor (1964) reported that length and width of male bear skulls (not fe-

males) and baculum length consistently increased with age and provided indices of age for male bears.

Erickson and Petrides (1964) aged bears as cubs, yearlings and adults and found:

> Cubs (5-8 months old) were readily identified by their small size and deciduous dentition. Yearling bears (17-20 months old), as determined from known age speciments, possessed clean, incompletely errupted adult dentition; in males the penis could be only partially extruded from the penis sheath; in females the teats measured not more than four millimeters in both length and basal diameter. Older bears were larger than cubs and yearlings; their teeth were stained and worn; the penis could be fully extruded from its sheath; and teat measurements exceeded the above.

Erickson and Nellor (1964) related the cub baculum could not be extruded at all, and the baculum of bears in their third year could be totally extruded only by force. They also established testicle and ovary weights were useful age indicators when considered by season and reproductive state.

Marks and Erickson (1966) found bear canines showed sexual dimorphism, and Rausch (1961) reported the greatest length and transverse diameter (proximal to and parallel with the dentine-enamel junction) of the upper canine could be used to determine sex. In summary, it appears no satisfactory field technique for aging has been developed.

Census Methods

Leopold (1933) and McCutchen (1938) commented about the importance of census methods in management of wildlife, and Steinhoff (1947) wrote that the population of an area had to be determined before management techniques could be applied intelligently, and as wildlife management was intensified, census methods had to be improved.

Davis (1963) wrote:

> The word 'census' is defined as a count, which includes details as to sex, age, etc., of a given species for a given area. As such, it means an actual count as, for example, the number of rabbits in a cage. Since such counts of wild animals are rarely possible, or even desirable because of the cost required, estimates usually are made by some sampling procedure. These estimates, being samples, have variability, but permit inferences about the population.

Ruff (1939), Pulling (1940), Rasmussen and Doman (1943), Edson (1951) and Kelker (1958) compared censuses and trends, and reported a true census was seldom possible or feasible. Estimates must be obtained by sampling methods, and these estimates should be compared with former or subsequent estimates to formulate a trend. Population trends then should be compared with environmental trends.

In response to form letters distributed by Gilbert (1951a), no state or province reported using a census method for determining black bear population numbers. Spencer (1955) stated, "No wholly satisfactory method has been devised for censusing black bear."

Direct Enumeration by Totals or Samples Hazzard (1958) reported direct enumeration census methods included those in which all or a portion of the population was seen or counted. Some of the methods based on ratios or removal methods might be considered methods of direct enumeration, but these methods have been classified independently.

Drive Census "A drive is a method of censusing animals usually applied in such a manner that a straight line of drivers move across a selected area and either force the animals back through the line or out between counters stationed around the periphery", [sic] (Hazzard, 1958). McCain (1939) favored areas up to 300 acres in size for drives, and Olsen (1938) commented that drives in Superior National Forest, Minnesota, were difficult to manage successfully on areas larger than 560 acres. Steinhoff (1947) related that deer drives were most efficient on small areas. Considering that the highest black bear density reported was 1/0.8 sq. mi. (Jonkel, 1960), it would appear impractical to make a census drive for black bears on an area as small as 560 acres. Erickson (1940), Dice (1941), Saugstad (1942), and Rasmussen and Doman (1943) felt drives were usually impractical as a census method due to the expense induced by the time and manpower required.

Aerial Census Rush (1932) considered an aerial census "hopeless" for black bears. Gilbert (1951b) questioned aerial censusing because of the scarcity of animals. He indicated that in Colorado it would be necessary to make the census after the bears had emerged from dormancy, but before service berry and oakbrush leafed out (Gilbert, 1948). Four flights were made over Yellowstone National Park to test the feasibility of aerial counts for censusing grizzlies, but the technique was discontinued after the counts were proved invalid (Hornocker, 1962).

Strip or Cruise Census "In the strip or cruise method of censusing big game animals, animals are counted within a 'strip' along a predetermined course, the width of the strip being the average flushing or jumping distance of the animal in question" (Hazzard, 1958). Hayne (1949a) reported some carnivores avoided the observer so successfully that 'flushing distance' was considered greater than range of visibility. Hayne did not single-out the black bear, but as pointed out by Skinner (1925) and Grinnel et al. (1937), the black bears' keen senses have allowed it to avoid humans in its natural habitat. Thus, it could be assumed black bear might be included in Hayne's category of "certain carnivores."

Trap Line Census Dice (1941) wrote, "The number of individuals of the species concerned which are caught in a given time is divided by the product of the number of traps set multiplied by the number of nights the traps are in service." Dice (1941) and Studholme (1943) reported using this method, but limited it to small mammals. Due to the time involved in making "trap sets" for black bears, and the length of the trap line required to sample a representative area, this method appears impractical for black bears.

Roadside Census This method entails systematic counts of animals from automobiles in areas of restricted interference along established routes" (Hazzard, 1958). Ruff (1939), Rasmussen and Doman (1943), Schrader (1944) and Hahn (1945) advocated the use of the roadside census, and Studholme (1943), Lord (1963) and Davis (1963) listed variables involved.

According to Davis (1963), one of the greatest advantages of the roadside census was that a large area could be covered quickly. Schrader (1944) found success by this method depended on a large number of miles being driven. No reference was located which indicated this method had been used for censusing bears. However, in an area like Yellowstone National Park where bears beg along the roads, this technique might be useful.

Spot Census Rasmussen and Doman (1943), Hunter and Yeager (1949) and Dasmann and Taber (1955) reported using the spot census for deer, and Hall (1950) censused elk by this method. Rasmussen and Doman (1943) considered the spot census as the most practical method for determining trends in mule deer.

Jonkel (1962) attempted to determine black bear densities by making counts on sample observation units. His data indicated black bear density sample units should be established on mountain meadows in the spring, or on open huckleberry areas in September.

Direct Count Hornocker (1962) made direct counts of grizzlies at Trout Creek dump in Yellowstone National Park. He found direct counts compared favorably with those obtained by the Schnable Method. He believed they were more accurate than estimates obtained by the Petersen Index. Since counts were made only on recognizable individuals, this method yielded a minimum population figure.

Troyer and Hensel (1964) used direct counts in Alaska to determine the number of Kodiak bears feeding along salmon streams during the spawning period. To reduce the possibility of duplication, the color, size, conformation, behavior characteristics, and location of each single bear and family group were recorded. Movements of bears to and from streams were negligible. This method gave a population estimate 20 percent lower than that obtained by the Schnabel Method.

Other Spencer (1955) reported careful investigation of summer resort dumps, town dumps and logging camp dumps provided valuable sources of information pertaining to black bear populations.

Population Estimates Based on Ratios and Removal Methods

Lincoln Index (Petersen-Jackson Method) Hayne (1949b) commented that this technique involved marking a number of animals in a population and later recapturing a portion of the population to observe the proportion of marked animals. Then an estimate of the population was computed by dividing the total number marked in the population by the proportion of marked in the sample (see the following formula), under the assumption that the sample would estimate closely the proportion marked throughout the entire population.

Formula:

$$\frac{\text{total population}}{\text{total number marked}} = \frac{\text{total number in sample}}{\text{number of marked in sample}}$$

Green and Evans (1940), Hayne (1949b), Adams (1951), Couey (1951), Wood (1954), Geis (1955), Eberhardt, Peterle and Schofield (1963) and Davis (1963) discussed the Lincoln Index, but most of their studies were limited to small mammals.

Hornocker (1962) used the Petersen Index for grizzly bears in Yellowstone National Park. This method produced estimates lower than those obtained by direct count or the Schnabel Method, and he concluded the latter techniques were more accurate than the Petersen Index. He believd one factor contributing to the low estimates was the small number of bears handled during the first year of study.

One question arising about the Lincoln Index which Hayne (1949b) commented upon was a way of averaging a series of estimates so the estimates were not based upon individual sets of data.

Schnabel Method According to Lord (1961), the Schnable Method was a refinement of the Lincoln Index, and was adapted to continuous trapping over a period of time. Flyger (1959) stated its advantage over the Lincoln Index was that it averaged a series of ratios, thus reducing the chance of an extreme estimate from sampling error. He also reported two variations; the trap-retrap or trap-sight.

Formula:

$$\text{Estimated Population} = \frac{\text{(number captured in one day) (number marked previously that are available for capture on day of trapping)}}{\text{(number marked caught in one day)}}$$

Besides making direct counts Hornocker (1962) used the Schnabel Method to estimate the population of grizzlies at Trout Creek dump in Yellowstone National Park. He used the trap-sight variation and obtained estimates which corresponded closely with the direct counts. Troyer and Hensel (1964) used the Schnabel Method

in Alaska. They also made direct counts, and found the Schnabel Method estimate was 20 percent higher than the number obtained by direct count. They contended the difference might have been due to inclement weather, which created poor visibility.

Removal Methods Erickson and Petrides (1964) used marked-unmarked ratios of bears killed by hunters in Michigan to obtain population estimates of black bears. Estimates obtained by removal methods usually rely on hunter kill figures, so they would not be applicable to National Parks.

Indirect Enumeration—"Indirect enumeration includes those census methods in which the animals are not actually observed. Such methods provide an index to population numbers" (Hazzard, 1958).

Tracks Bell (1937), Dice (1941), Rasmussen and Doman (1943) and Steinhoff (1947) wrote about using tracks to census mammals. Spencer (1955) attempted to inventory the tracks of black bears coming to bait stations. This proved useful only in early summer before fruits and berries ripened.

Klein (1959) used track differentiation to determine the number of brown bears using salmon streams in Alaska. He believed the greatest fallacy of this method for obtaining a population index was to determine the portion of the population not utilizing salmon streams during counts. Variables inherent in this method rendered it unsuitable to obtain a population index in his study area, but it could be used as an indicator of relative abundance or seasonal usage if restricted to small areas. Reliability of the track differentiation method decreased as size of study area increased.

Edwards and Green (1959) modified Klein's method slightly for a population study of grizzlies in British Columbia. After attempting to segregate measurements into groups representing individual bears, they concluded, "This failure resulted from the tracks of bears not being sufficiently distinctive for individuals, and from the sample being so large that, for each measurement, it was possible to construct a smooth frequency curve having no significant irregularities attributable to individuals." They concluded that this technique was of little value for determining grizzly populations in their area.

Other Spencer (1955) made random cruises of known mileage by foot and canoe in Maine to count black bear scats, marking posts and stump workings to estimate bear densities.

Population

Densities

Spencer (1955) commented that estimates of abundance of black bears varied according to terrain, topography and general conditions. By using the cruise line census method, he sampled over 20 percent of the area considered to be "bear range" in Maine. Observations of bears and bear sign were recorded, and the data indicated a ratio of 1/2.4 linear miles. Spencer called this ratio the "Game Density Index," and by squaring this index he calculated the black bear density in Maine to be 1/5.6 square miles. Stickley (1957) distributed questionnaires to game wardens and determined the density of black bear in Virginia to be 1/3.9 square miles.

The national forests in California have an estimated black bear density of 1/2.5 square miles, with some national forests having densities as high as 1/1.3 square miles (Trippensee, 1948). By using the Lincoln Index, Erickson and Petrides (1964) calculated the population of their study area in Michigan from the marked-unmarked ratio of bears killed by hunters, and determined the density to be 1/3.4 square miles. Due to their experience in the area and the improbability of receiving a proportionate number of reports of untagged bears, they believed this to be a low estimate. The researchers did not describe the habitat types in their study area, but they indicated the study area included 400 square miles in the Upper Peninsula in Alger and Schoolcraft counties, Michigan, which supported one of the state's highest bear populations.

From observations of marked bears and bears recognizable by natural markings, Jonkel (1960) estimated a density of 1/0.8 square mile on his study area, which covered about 80 square miles in the Whitefish Range of Montana. "The entire area is mountainous, with elevations between 4,000 to 7,000 feet approximately. . . . The area is heavily timbered with spruce and fir, except for clear-cut logged areas and some open park, slide rock, and snow slide areas. Some of the area has been burned in the past and is now covered with lodgepole pine and larch reproduction" (Jonkel, 1962).

On Jonkel's observation units, the greatest number of bears per observation were seen from April to June and during September. An open-burn unit, and another unit showing a high ratio of bears per observation in September, had considerable huckleberry undergrowth in contrast to mountain-meadow types which showed high densities in April and June. Black bears reached their greatest degree of concentration in September (Jonkel, 1962).

Sex and Age Ratios

Erickson and Petrides (1964) found variations in sex and age ratios of black bears according to manner of capture and the bears' way of life. They reported a statistically significant difference (significance level not reported) between sex and

age ratios of bears captured with culvert or steel traps. Culvert traps caught predominantly older bears (Table 10), and primarily males, of both wild and dump animals. Steel traps were selective for younger bears, and for females among older bears.

Black (1958) also reported steel traps to be selective for younger and smaller animals. He attributed this selectiveness to the size of the No. 4½ steel traps used. Erickson and Petrides (1964) also reported using No. 4 steel traps. They commented that perhaps older bears, principally males, were more aggressive and less wary of culvert traps, thus accounting for the increased capture of older males by culvert traps.

Chi-square tests indicated that sex and age ratios for bears frequenting dumps were significantly different (significance level not reported) from those of wild area bears. The sex ratio was significantly different from a 50:50 ratio for dump bears, but not for bears captured in wild surroundings. It appeared that the majority of the dump bears were adult males although differences were not statistically significant (Erickson and Petrides, 1964).

Black (1958) reported a male-female ratio of 300:100 at dumps (Table 11), and commented that apparently the preponderance of males was due to a difference in behavior between sexes. Knudsen (1961) believed the predominance of males at dumps was due to males moving greater distances than females.

Erickson and Petrides (1964) reported data for nuisance bears was lacking for a meaningful analysis of sex and age proportions, but observations indicated a greater tendency for adult males to become nuisances. Chi-square tests showed age proportions were statistically different (significance level not reported) from those of bears captured in wild surroundings, and the sex ratio showed a significant deviation from a 50:50 ratio.

While discussing black bear mortalities Erickson and Petrides (1964) stated, "Rates of return were not statistically different from one another, although a larger body of data might support the logical conclusion that yearling bears sustain a lighter mortality than either cubs or older animals." They also stated, "Proportionately higher returns for older females than for older males . . . indicates possible higher mortality rates among adult females. Higher mortality rates are indicated also for females accompanied by young . . . There were no statistically significant differences, however, in returns by sex for any age class." Spencer (1955) found females with cubs more susceptible to hunting or trapping than other bears.

A summary of black bears captured by Erickson and Petrides (1964) has been presented in Table 10, except that bears reported captured by "various other means" were omitted. Erickson and Petrides stated, "Sex and age ratio data for bears captured

TABLE 10.
Summary of black bears captured during tagging studies in Michigan by Erickson and Petrides (1964).

Age class	Number of bears captured by various methods									Per cent in each age class		
	Culvert box-traps			Steel spring-traps			All methods					
	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	All bears
Wild bears:												
Cubs	0	0	0	5	7	12(a)	26	16	42(a)	42	28	36
Yearlings	2	2	4	9	11	20	12	15	27	20	27	23
Older bears	10	4	14	12	18	30	23	25	48	38	45	41
Total	12	6	18	26	36	62(a)	61	56	117(a)			
Percentage of total	67	33	100	42	58	100	52	48	100	100	100	100
Dump bears:												
Cubs	0	0	0	0	0	0	0	0	0	0	(b)	0
Yearlings	0	1	1	1	0	1	1	1	2	4	(b)	7
Older bears	21	5	26	2	0	2	23	5	28	96	(b)	93
Total	21	6	27	3	0	3	24	6	30			
Percentage of total	78	22	100	(b)	(b)		80	20	100	100	(b)	100
Nuisance bears:												
Cubs	0	0	0	0	0	0	2	0	2	(b)	(b)	18
Yearlings	0	0	0	0	0	0	0	0	0	(b)	(b)	0
Older bears	1	2	3	0	1	1	6	3	9	(b)	(b)	82
Total	1	2	3	0	1	1	8	3	11			
Percentage of total	(b)	(b)		(b)	(b)		73	27	100	(b)	(b)	100
All bears:												
Cubs	0	0	0	5	7	12(a)	28	16	44(a)	30	25	28
Yearlings	2	3	5	10	11	21	13	16	29	14	25	18
Older bears	32	11	43	14	19	33	52	33	85	56	50	54
Total	34	14	48	29	37	66(a)	93	65	158(a)			
Percentage of total	71	29	100	44	56	100	59	41	100	100	100	100

(a) Does not include one cub of undetermined sex killed and eaten by another bear.
(b) Numbers too small to warrant use of percentages.

by miscellaneous means are largely without comparative value. Most were cubs, and captures among adults were selective with respect to sex." Bears captured by "various other means" were included under "all methods."

Sex Ratios Black bear sex ratios reported in the literature were summarized and presented in Table 11, which showed a preponderance of males. In Tables 11 and 12, bears were classified as "wild," "dump," or "nuisance" animals. Erickson and Petrides (1964) classified bears as "wild," "dump," or "nuisance" animals according to their apparent way of life. "Wild bears were those taken in areas at least a half-mile from human habitation . . . Dump bears were those captured at garbage dumps or other artificial foraging sites. Nuisance bears were those trapped near human dwellings in response to requests for their removal." Except for nuisance bears, Erickson's and Petrides' classifications were used in Tables 11 and 12 to the extent that completeness of information allowed. Nuisance bears included any bears trapped or killed because they had become a menace to mankind.

Age Ratios Black bear age ratios reported in the literature were summarized in Table 12, which

TABLE 11. *Summary of sex ratios from black bear studies.*

Capture Methids	Type of Bears	No. Bears	% M	% F	M-F Ratio	Reference
Hunter kill (V)	W*	231	55	45	122:100	Gilbert (1951a)
Bounty trappers, hunter kill**	W, N*	263	58	42	136:100	Spencer (1955)
Steel trap, Aldrich snare	W	105	45	55	94:100	Jonkel (1962)
Steel trap, culvert trap	W	29	42	58	72:100	Black (1958)
Steel trap, culvert trap	D	96	75	25	300:100	Black (1958)
Steel trap, culvert trap***	W, D, N	96	56	44	129:100	Stickley (1961)
Hunter kill**	W*	X	53	47	113:100	Stickley (1961)
Steel trap, culvert trap, bounty trappers, control trappers	W, D, N	158	59	41	143:100	Erickson and Petrides (1964)
Steel trap, culvert trap	W	80	55	45	120:100	Erickson and Petrides (1964)
Steel trap, culvert trap	D	30	84	16	533:100	Erickson and Petrides (1964)
Hunter kill (V)	W, D, N	255	48	52	92:100	Erickson (1964b)
Hunter kill (U)	W, D, N	745	59	41	144:100	Erickson (1964b)
Average			58	42	182:100	

M—Male F—Female W—Wild D—Dump N—Nuisance V—Verified
U—Unverified X—Not reported
*—may include dump ans/or nuisance bears
**—all reports may not be verified
***—includes retraps

TABLE 12. *Summary of age ratios from black bear studies.*

Capture Methods	Type of Bears	C No.	C %	Y No.	Y %	SA No.	SA %	A No.	A %	Reference
Hunter kill (V)	W*	44	19	53	23	**		133	58	Gilbert (1951a)
Steel trap, Aldrich snare***	W	16	9	33	20	45	26	76	45	Jonkel (1962)
Steel trap, culvert trap***	W, D, N	2	2	27	29	**		65	69	Stickley (1961)
Steel trap, culvert trap, bounty trappers, control trappers	W, D, N	44	28	29	18	**		85	54	Erickson and Petrides (1964)
Steel trap, culvert trap	W	7	13	15	28	**		32	59	Erickson and Petrides (1964)
Steel trap, culvert trap	D	0	0	2	7	**		28	93	Erickson and Petrides (1964)
Total		113		159		45		419		
Average			15		22		6		57	

C—Cub Y—Yearling SA—Sub-adult A—Adult V—Verified
*—may include dump and/or nuisance bears
**—sub-adult class not used
***—includes retraps

showed cubs and yearlings constituted less than 50 percent of the populations. Except for Erickson's and Petrides' data, the percent for yearlings was higher than for cubs. Jonkel (1962) was the only researcher who classified bears as sub-adults. If he had combined sub-adults and adults as did other researchers, 71 percent of the bears he handled and 63 percent of the summarized average would have been classified as adults.

Stickley (1957) reported an average cub-adult ratio of hunter kills in Virginia of 30:100. From observations made in various parts of Montana during a four-year period, Jonkel (1965) reported a 24:100 cub-adult ratio. In Maine, Spencer (1955) gave a cub-adult ratio of 28:100.

Jonkel (1963) found 40 percent of the females were accompanied by cubs in 1959, 19 percent in 1960, 12 percent in 1961, and 18 percent in 1962. He believed the decline from 1959 to 1962 might have been the result of a food shortage.

Jonkel (1965) reported an average litter size of 1.7 cubs on his study area during a six-year period. One litter of grizzly bears was included in Jonkel's information, and the data for two years were based partially on yearlings from the previous year. Observations reported in various parts of Montana over a four-year period indicated an average black bear litter size of 1.6 cubs. The average litter size in Florida was 2.2 cubs (Harlow, 1961), and in Maine, 2.4 cubs (Spencer, 1955). Erickson (1964b) related, "Among 176 family groups from which hunters reported killing bears, the mean litter size was 2.05 cubs. Litter size frequencies were 23 percent singletons, 52 percent twins, 21 percent triplets, and four percent quadruplets."

Estimates in Yellowstone National Park

Numerous estimates of the black bear population in Yellowstone National Park have been reported (Table 13), but none of these estimates were determined by reliable census methods.

Approximately 20 black bear cubs were seen during the summer of 1922 (Albright, 1923). The "actual count" of 174 black bears in 1927 (Table 4) included 41 cubs (Albright, 1928), and the count of 227 bears in 1928 included 52 cubs (Toll, 1929).

Dixon (1929) wrote, "I found the bear population at various points coincides closely with the tourist population. More tourists mean more garbage, which in turn results in more bears at the feeding grounds. As nearly as can be determined from early records, there are today as many, and probably more, bears, both black and grizzly, in Yellowstone than existed when the Park was first visited by white men."

TABLE 13. *Population estimates and actual counts of black bears in Yellowstone National Park.*

Year	Actual Count	Estimate	Reference	
1919		100	Albright	(1920)
1924		200	"	(1925)
1925*		150	Skinner	(1925)
1925*		less 150	Heller	(1925)
1925		225	Albright	(1926)
1926		275	"	(1927)
1927	174	350	"	(1928)
1927*		150	Skinner	(1927)
1928	227	440	Toll	(1929)
1929*		350	Dixon	(1929)
1929	440	490	Toll	(1931b)
1930	357	465	"	(1931b)
1931	306	517	"	(1932)
1932	323	525	"	(1933)
1933	325	525	"	(1935)
1934	244	500	"	(1935)
1934		591	Barrows	(1936)
1935	244	500	Rogers	(1936)
1935		633	Barrows	(1936)
1936	195	621	Rogers	(1937b)
1936		621	Barrows	(1936)
1937	184	520	Rogers	(1938)
1938	166	450	"	(1939)
1939	228	509	"	(1940)
1940	199	510	"	(1941)
1941		550	"	(1942a)
1945		450	"	(1946)
1946		450	"	(1947)
1948		360	"	(1949)
1949		360	"	(1950)
1950		360	"	(1951)

* refers to the publishing date

Estimates of black bear populations and the actual number of individuals counted were presented in some of the Yellowstone National Park Superintendent Reports (Table 13). Dixon (1929), the only reference located which indicated the method for making "actual counts," reported that in August, 1929, actual counts were taken every other day over an eight-day period, and the largest count was reported as the actual count.

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Acknowledgments

The authors wish to express their appreciation to the people and agencies who cooperated to make this report possible. Special acknowledgment is given the Colorado Cooperative Wildlife Research Unit, and its participating agencies: Colorado Game, Fish, and Parks Department; U. S. Fish and Wildlife Service; Wildlife Management Institute; and Colorado State University. Financial assistance was provided by the National Park Service.

Deep gratitude is expressed to Dr. Fred A. Glover, Leader, Colorado Cooperative Wildlife Research Unit; Dr. Douglas L. Gilbert, Professor of Wildlife Biology; and Dr. Terry A. Vaughan, Assistant Range Biologist, Range Management; for supervision and valuable assistance.