BLACK BEAR FOOD HABITS IN YOSEMITE NATIONAL PARK

DAVID M. GRABER,[1] Department of Forestry and Resource Management, University of California, Berkeley, CA 94720
MARSHALL WHITE,[2] Department of Forestry and Resource Management, and Museum of Vertebrate Zoology, University of California, Berkeley, CA 94720

Abstract: A 5-year study of black bears (*Ursus americanus*) in Yosemite National Park commenced in 1974 to provide park managers with information necessary for professional stewardship of the species. At the time, both the public and the National Park Service were concerned about increasing property damage and personal injuries caused by bears, and that actions by visitors and park staff were inimical to a wild, healthy bear population. Black bear food habits were investigated to determine the role of food of human origin in bear diet. We found that plants comprised 75% of the diet of Yosemite black bears. Herbage, including grasses, sedges, and herbaceous dicots, was the principal food during spring and early summer. Nuts and berries, expecially manzanita (*Arctostaphylos* spp.) and oak acorns (*Quercus* spp.) predominated in the late summer and fall. Insects, especially ants (Formicidae), and deer (*Odocoileus hemionus*) were the principal animal foods. Foods of human origin constituted 15% of the bear diet. Great annual fluctuations in the proportions of the major food categories reflected varying weather patterns and efforts by the Park Service to eliminate human foods from black bear diets.

Int. Conf. Bear Res. and Manage. 5:1–10

Bears hold a special place in the imagination of the American public, for they are the largest predatory animals most people will ever see free of confinement. American black bears are in many ways the quintessential park animal. Although they still occur throughout most of the forested regions of North America (Cowan 1972), they are by virtue of their ecology, ethology, and status as popular rifle targets secretive animals rarely seen. In national parks, however, black bears have adapted to their protected status and the rich food resources that accompany park visitors by becoming bold marauders. The sight or sound of a 100 to 200 kg beast poking around one's camp in the gloom of night has provided a thrill tinged with varying degrees of terror to generations of tourists. The price exacted for this event is often a ruined tent, backpack, or food cooler, a damaged automobile, or occasionally an injury.

Prior to World War II, some western national parks, including Yosemite, sought to provide visitors a spectacle with a minimum of risk by feeding bears garbage at official sites, complete with ranger talks and bleacher seating. Some parks, notably Great Smoky Mountains and Yellowstone, also developed traditions of tourists intentionally feeding bears. Thus the dark and powerful marauder acquired another side, the begging buffoon. The sight of 10 bears crowded unnaturally together to feed on garbage, or one standing on its hind legs to reach a proffered morsel, added to the confusion in the public's eye as to just what a black bear really was.

In 1963, the report of the Special Advisory Board on Wildlife Management in the National Parks to Secretary of the Interior Stewart Udall (Leopold et al. 1963) set a new direction to National Park Service wildlife policy by stressing scientific management based on research. Yosemite National Park, which had long ago abolished intentional feeding either by staff or visitors, and which had closed its last dumps to bears in 1971, initiated in 1973 its first explicit "Human–Bear Management Program," and simultaneously contracted with the University of California for research intended to provide ecological data necessary for professional management of black bears.

The field work for this study was conducted from 1974 through 1978, a period when bear "incidents"—property damage or personal injury—were sharply on the rise, and when captures and relocations by the Yosemite Division of Resources Management rose to record levels (Harms 1977). Also during the study period all garbage cans in the Park were bear-proofed, and a visitor education campaign was instituted and intensified to secure proper storage of food.

Our study of black bear food habits was one element of a project that sought to obtain basic information as well about population dynamics, physical characteristics, and home range, and to

[1] Present address: Sequoia and Kings Canyon National Parks, Three Rivers, CA 93271.

[2] Present address: Museum of Vertebrate Zoology, University of California, Berkeley, CA 94720.

detect—if possible—what effects Park visitors and management activities were having on bear ecology.

This study was funded by the National Park Service through a cooperative agreement with the University of California, Berkeley, Department of Forestry and Resource Management. We are grateful to Jan van Wagtendonk for his support, and to the many other staff members of Yosemite National Park who gave generously of their time. Audrey Goldsmith, Robert Hare, Tina Hargis, Kurt Nelson, and Howard Quigley provided excellent field and laboratory assistance.

STUDY AREA

Yosemite National Park occupies 308,000 ha on the western slope of the central Sierra Nevada in California. Elevations range from 600 m in the foothills to 4,000 m along the Sierra Crest. Yosemite's topography is dominated by 2 river systems, the Merced and the Tuolumne. Both emerge from headwaters in the high glaciated basins, bare ridges, and granite peaks of the east Park, and flow westward through deep glacial canyons.

Cool, moist winters and hot, dry summers characterize Yosemite's climate. Average precipitation in Yosemite Valley (1,200 m) is 92 cm/year, of which 87% falls from November through April. Average temperatures range from −3 C to 8 C in December, 12 C to 32 C in July. Temperatures are lower, and precipitation generally is greater, at higher elevations. Because of the vagaries of the Pacific High (pressure system), the storm track which carries most precipitation from the Gulf of Alaska exhibits great variability in latitude, which in turn results in considerable variation in annual precipitation and yearly temperature regimes (Gilliam 1962). Annual precipitation during the study period varied from 144 cm for the period October 1977 through September 1978, to 55 cm for the year ending September 1977. These latter 2 years, when precipitation declined to 32% of normal and discharge from the Merced River was only 25% of normal, constituted a severe drought. Less extreme variation is common: the coefficient of variation of precipitation is 26%.

Plant distribution in Yosemite is strongly influenced by elevation and topography. Five major vegetation types are arrayed in irregular, overlapping belts by elevation as follows. Botanical nomenclature is taken from Munz and Keck (1973). Chaparral and foothill woodland is the principal vegetation below 1,000 m, comprising 2% of the Park along the western margin. The mixed conifer forest, ranging from 1,000 to 2,100 m and occupying 21% of the Park, is dominated by ponderosa pine (*Pinus ponderosa*), sugar pine (*P. lambertiana*), incense-cedar (*Calocedrus decurrens*) white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), and 3 groves of giant sequoia (*Sequoiadendron giganteum*). This vegetation type also includes stands of California black oak (*Quercus kelloggii*), moist meadows, and a complex shrub understory. Both the chaparral-foothill woodland and the mixed conifer forests were subjected until this century to periodic fires ignited both by lightning and intentionally by Indians. Fire suppression—supplanted by limited prescription burning in the past decade—has led to a shift toward less fire-tolerant species, canopy closure, and the resultant loss of shade-intolerant herbs and shrubs (van Wagtendonk 1974).

The red fir zone is located between 2,000 m and 2,600 m elevation and constitutes 23% of the Park. Although red fir (*A. magnifica*) is dominant on well-drained sites, other conifer species occur together with shrubs such as huckleberry oak (*Q. vaccinifoia*), greenleaf manzanita (*Arctostaphylos patula*), and bush chinquapin (*Chrysolepis sempervirens*).

The most extensive vegetation type in the Park is lodgepole pine–subalpine. It occurs between 2,400 m and 3,200 m and covers 40% of the Park. Nearly pure stands of lodgepole pine (*P.contorta*) occupy this type over much of its extent. Extensive subalpine meadows composed principally of sedges (*Carex* spp.) and some grasses are found in this zone, most notably at Tuolumne Meadows. Fourteen percent of Yosemite lies above timberline (3,200 m). The region is characterized by broad expanses of barren rock and boulders, alpine tundra, and fell fields.

Yosemite had 428 km of paved roads, and more than 1,200 km of trails. Annual visitation from 1968 to 1978 ranged from 2.3 to 2.7 million people. Use of Yosemite's back-country (those areas normally visited only by overnight backpackers or equestrians) has increased from 78,000 visitor nights in 1967 to 182,000 in 1979 (National Park Service files). Development has had the greatest impact on the 2 principal glacial canyons: Hetch Hetchy Valley and Yosemite

Valley. Hetch Hetchy has been completely submerged by O'Shaughnessy Dam since 1923. Yosemite Valley, while only 10% developed, is intensively urbanized in its eastern half which receives 23,000 visitors daily (Natl. Park Serv., unpubl. draft environmental statement, U.S. Dep. Inter., Washington, D.C., 1978).

METHODS

Scat Processing

We collected 1,404 bear scats from 1974 through 1978. We initially collected scats from areas representative of all major vegetation types, contrasting areas with and without human use. Most collecting was done from June through October. With experience and given budget constraints we later concentrated on areas frequently used by bears.

Scats for which age could be determined to within 1 month were collected. In 1974 we permitted some fresh scats to deteriorate outdoors and found we could distinguish scats less than 1 month old from those 1–2 months old.

Scats were placed in paper bags and sun dried, then later oven-dried at 60 C for 72 hours. Volume was estimated by water displacement. Scats were then rehydrated and washed through a 2-mm sieve. Items were identified by eye or with a dissecting microscope, and the percent volume of each estimated to the nearest 1%. We assigned each scat element to one of the following classes: herbage (roots, stems, or leaves); reproductive plant parts (flowers, fruit, or seeds); animal matter; human foods (garbage and pilfered visitor's food); debris (items apparently inadvertently consumed, such as wood when feeding on ants).

Food Digestibility and Scat Analysis

We compared the undigested fecal remains of food items by their mean percentage of the volume of all scats within a sample, and secondarily by their frequencies of occurrence. Neither of these measures relates consistently either with actual quantity of food items consumed or with their digestibility, but taken together they permit comparisons of similar food items.

Hatler (1972) compared stomach and scat contents and concluded that proportions of green plant parts (herbage) are little changed, but that proportions of animal tissues are much reduced in scats. Poelker and Hartwell (1973) also found that proportions of animal matter were greatly reduced from stomach to scat samples. They detected major differences in the proportions of tissues of various plant species between stomach and scat samples.

Mealey (1980) applied proximate analyses to foods of grizzly bears (*U. arctos*) and compared the results to parallel analyses of the same foods from scats. He found substantial differences in digestibility among different foods, and in proportional digestibility of given nutrients (e.g., crude protein) from one food to another.

If digestibility is inversely related to the proportional representation of a food item in a scat, then it is misleading to compare percent composition of grass (Gramineae) or clover (*Trifolium* spp.) with acorns or deer. This is complicated further because food items often are identified in scats from tissues that are largely indigestible, such as berry seeds, pine nuts, or acorn hulls which a bear might avoid had it the facility to do so. Thus, large-stoned fruits such as cherries (*Prunus* spp.) are more readily found and dominate volumetrically in scat compared to small-seeded fruits such as gooseberries (*Ribes* spp.) or blackberries (*Rubus* spp.) although the digestibility of the latter group is higher.

The distorted relationship between diet and contents of scats is greatest with animal tissues. Large amounts of birds and mammals can be reduced to small pieces of bone, feather, and hair. The soft parts of insects are digested readily. Exoskeletons of adults are largely indigestible; larvae and pupae usually leave only minute residues in scats.

Volumetric analysis of scat contents of black bears, then, appears to overestimate the proportion of herbage actually consumed, and to underestimate reproductive plant parts and especially animal foods. This distortion can be reduced by considering both percent volume and percent frequency of occurrence of each food in scat contents.

RESULTS AND DISCUSSION

Seasonal Diet Patterns

Yosemite bears vary their diets seasonally, reflecting changes in availability of food items (Fig. 1).

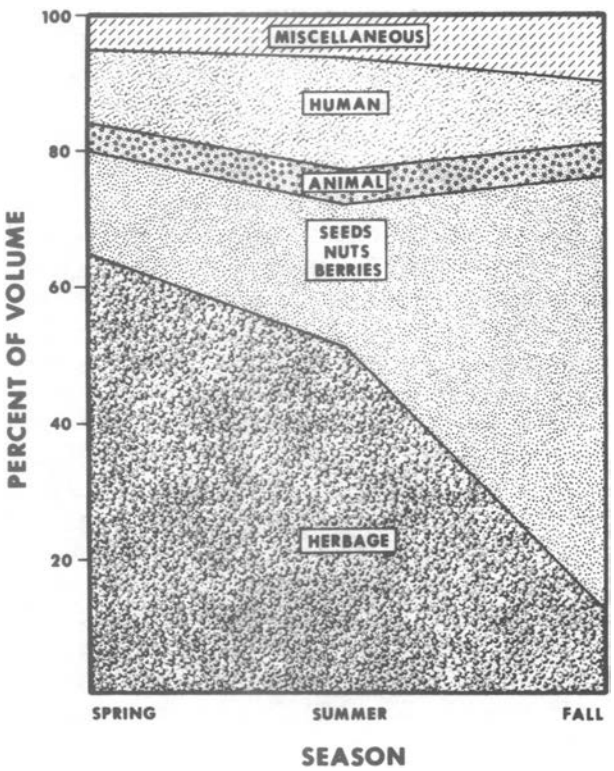

Fig. 1. Seasonal changes in composition of black bear diets in Yosemite National Park, based on scat collections, 1974 through 1978.

Herbage. — Leaves and stems, almost entirely from herbaceous plants, formed the largest part of the diet of black bears in Yosemite National Park (Table 1). The use of herbage declined from spring to fall. Grasses and grass-like plants (sedges, rushes, etc.) were the largest class of herbage. *Agrostis, Poa,* and *Avena* were commonly eaten grasses. Forbs were the second most important class of herbage, particularly *Trifolum, Montia, Perideridia,* and *Lupinus*.

In spring and summer, before nut and berry crops ripen, herbage usually is the most important food source for black bears in North America, often contributing half — or more — of the diet (e.g., Tisch 1961, Piekielek and Burton 1975, Boyer 1976, Eagle 1979, Beeman and Pelton 1980). Brown bears also eat mostly succulent herbage after green-up (e.g., Mealey 1980). Horsetails (*Equisetum* spp.) are often an important spring dietary item (Murie 1944, Tisch 1961, Hatler 1972, Boyer 1976). Although present in riparian habitat below about 2,000 m, horsetails are a minor spring food in Yosemite (Table 1).

Seeds, Nuts, and Berries. — Reproductive plant parts were the 2nd most heavily consumed bear foods. Their importance was greatest in the fall (Table 1). Manzanita and oak acorns were the major foods in this category. In Yosemite Valley,

Table 1. Contents of 1,404 black bear scats collected in Yosemite National Park, 1974 through 1978. Listed items within each category comprised at least 1% of total scat volume.

	Spring (N = 420)		Summer (N = 897)		Fall (N = 81)		All year (N = 1,404)	
Item	% vol.	% freq.	% vol.	% freq.	% vol.	% freq.	% vol.	% freq.
Herbage	65	85	51	68	12	33	53	71
Grasses, sedges, rushes	43	70	35	58	10	30	36	60
Forbs	11	25	12	26	2	7	11	25
Trifolium spp.	4	6	1	2	0	0	2	3
Equisetum spp.	2	4	1	7	0	2	1	4
Reproductive Plant Parts	15	46	21	47	64	89	22	49
Arctostaphylos spp.	5	17	9	22	11	25	7	18
Quercus spp.	9	13	4	7	11	17	6	9
Apples and pears	<1	1	3	4	25	30	3	5
Pinus spp.	<1	1	1	2	7	17	1	3
Prunus emarginata	<1	1	2	4	5	14	1	4
Animal Matter	4	43	5	46	5	43	5	44
Insecta	2	32	3	35	1	25	2	33
Formicidae	1	19	2	26	1	10	2	23
Odocoileus hemionus	1	2	1	3	2	4	1	3
Other Mammalia	1	7	1	6	1	14	1	7
Human Foods	11	29	17	31	9	21	15	30
Debris	3	30	5	29	9	27	5	29
Unidentified	1	2	1	2	3	5	1	2

abandoned apple and pear plantings provided important fall foods for the bears as well as for a variety of other vertebrates. Pine nuts and bitter cherries (*Prunus emarginata*) also were eaten regularly at higher elevations: bears in Little Yosemite Valley were observed in summer 1977 to dig out and eat caches of pine nuts that had been buried by small mammals (T. Hargis, pers. commun.).

Other fruits eaten were dogwoods (*Cornus* spp.); gooseberries and currants (*Ribes* spp.); blackberries, raspberries, and thimbleberries (*Rubus* spp.); coffeeberries (*Rhamnus* spp.); western chokecherries (*Prunus demissa*); serviceberries (*Amelanchier* spp.); huckleberries and bilberries (*Vaccinium* spp.); and snowberries (*Symphoricarpos* spp.).

Seeds of herbs frequently were found mixed with the green parts of these plants. We observed one bear selectively stripping the seed heads from grasses in a meadow, but this must have been exceptional behavior because herb seeds provided only a minor portion of scat volume (Table 1).

Heavy use of seeds, nuts, and berries, as they become available during the year, has been reported in most black bear food habits studies in North America. Bennett et al. (1943) listed wild cherries as important food in summer, and beechnuts (*Fagus grandifolia*), acorns, and apples in fall in Pennsylvania. In the Great Smoky Mountains bears rely principally on squawroot fruits (*Conopholis americana*) in early summer, then switch to blackberries and huckleberries, and in fall use acorns and beechnuts as well as blackberries and cherries (Eagle 1979, Beeman and Pelton 1980). Berries are a major part of the summer black bear diet in Washington (Lindzey and Meslow 1977).

Animal Matter.—Bears in Yosemite fed on animal matter at a remarkably constant rate throughout the year (Table 1). Insects were found in a third of the scats. Ants, especially carpenter ants (*Campanotus* spp.), were most commonly eaten. Yellow jackets (*Vespula* spp.), bees (Apidae), and termites (Isoptera) also occurred frequently in scats.

Insects are the most common animal food of black bears. Ants were the insects most frequently reported eaten by Chatelain (1950) and Hatler (1972) in Alaska, Spencer (1955) in Maine, Tisch (1961) in Montana, Boyer (1976) in southern California, and Beeman and Pelton (1980) in Tennessee. Wasps (Vespidae), which show strong year-to-year fluctuations in numbers, were reported as significant food items by Bigelow (1922), Tisch (1961), Hatler (1972), Boyer (1976), and Beeman and Pelton (1980). Other insects used in significant quantities have been beetles in Tennessee (Eagle 1979) and grasshoppers and crickets during an irruption in Wyoming (Murie 1937).

Mule deer was the only common vertebrate food. Deer remains occurred either as traces of hair, or at volumes averaging 50% that included hair, bones, and other tissues. The small amounts of hair probably represented feeding on carrion. In the summer of 1975, Graber observed a bear in Tuolumne Meadows feeding on a road-killed carcass. This bear ripped through the hide and fed on viscera. Such feeding could leave small amounts of hair as the only identifiable residue in scats. Scats dominated by deer remains usually represented bears eating fawns, as indicated by hair characteristics, and small bones and hoofs. Black bears kill and eat a few fawns (King 1933, Thaxter 1933, King 1967), and also scavenge dead fawns.

Cervid remains in black bear scats primarily represent consumption of juveniles and carrion (e.g., Schwartz and Mitchell 1945, Arner 1948, Chatelain 1950, Tisch 1961, Hatler 1972). Observations of predation on elk (*Cervus elaphus*) calves have been reported by Howell (1921), Barmore and Stradley (1971), and Pederson et al. (1974).

Bear hair appeared in 5% of the scats, but never with other tissues, and only in 1 case in amounts over 3% volume. We think this hair is a result of grooming rather than cannibalism. Other mammal remains identified in scats were all rodents, including porcupine (*Erethizon dorsatum*) and California ground squirrel (*Spermophilus beecheyi*).

There were small amounts of bird feathers, bones, or egg shells in a few scats. In only 1 case could a bird be identified; it was a Steller's jay (*Cyanocitta stelleri*). We found 6 reports of black bear predation on birds. Of these, 4 listed a woodpecker as the victim. Two occurred in

Table 2. Elevation comparisons of the contents of 1,404 black bear scats collected in Yosemite National Park, 1974 through 1978.

Item	Precent volume in scats					
	1974	1975	1976	1977	1978	All years
Herbage						
<1,800 m	8	44	32	50	32	35
1,800 – 2,400 m		45	71	59	62	62
>2,400 m	9	68	60	65	45	60
All elevations	8	59	52	57	51	53
Reproductive plant parts						
<1,800 m	38	19	53	25	43	41
1,800 – 2,400 m		39	12	16	20	18
>2,400 m	35	3	4	8	6	5
All elevations	38	14	25	17	24	22
Animal matter						
<1,800 m	4	0	4	3	1	3
1,800 – 2,400 m		4	8	5	4	5
>2,400 m	10	1	12	3	2	6
All elevations	4	2	7	4	3	5
Human Foods						
<1,800 m	40	35	10	16	18	16
1,800 – 2,400 m		4	8	13	6	9
>2,400 m	31	26	19	16	33	22
All elevations	39	22	12	15	14	15

Yosemite (Dixon 1927, Smith 1955), and 2 occurred elsewhere (DeWeese and Pillmore 1972, Franzreb and Higgins 1975). Taverner (1928) suggested that black bears in Alberta raid raptor nests in trees; McKelvey and Smith (1979) found one in a bald eagle (*Haliaeetus leucocephalus*) nest.

Graber observed black bears fishing in Yosemite on 2 occasions, and there were 2 verified accounts by Park employees of bears successfully catching trout during this study. Use of salmon by black bears was reported by Piekielek and Burton (1975) in northern California, and in Alaska by Frame (1974) and others. We do not, however, believe fish today is a significant food resource for bears in Yosemite.

In the past century, damming, bank alteration, introduction of exotic fish, and intense sport fishing have greatly altered the Yosemite fishery. Chinook salmon (*Oncorhynchus tshawytscha*) once spawned in the lower reaches of the Park (Storer and Usinger 1963), and perhaps provided a significant source of protein for bears.

Human Foods. — Foods originally intended for human consumption were a major part of black bear diets in many parts of Yosemite National Park (Table 1). They were used most in summer when visitation was greatest, least in fall when natural foods were most abundant. Until 1971, garbage dumps were the chief source of human foods for bears in Yosemite. After dumps were eliminated, garbage receptacles became the major source. Since 1975, most garbage containers have been "bear-proofed." Bears now take food from visitor camps and picnic sites, from automobiles, and from the stores and caches of backpackers, hikers, and other back-country visitors (Harms 1977).

Debris. — Debris is material which we presume bears ingested inadvertently while foraging. It includes dry conifer needles, twigs, dry leaves, wood fragments, tree bark, soil, and pebbles. Debris was a small, but regularly occurring, scat element (Table 1). It was most common in fall, probably ingested as bears gathered seeds, nuts, and berries from trees, shrubs, and from the ground.

Effects of Elevation on Feeding Patterns

Because vegetation in the central Sierra tends to be arranged in belt-like zones according to elevation, we compared scat contents in 3 elevation classes: below 1,800 m; 1,800 to 2,400 m; and above 2,400 m. Black bears fed differently in these 3 zones (Table 2).

Below 1,800 m.—The lowest zone, which includes the heavily visited areas of Yosemite Valley, much of the region surrounding Hetch Hetchy Reservoir, and Wawona, was the only area where vegetative plant parts made up less than half of the scat volume (Table 2). Use of forbs was similar to that at the higher elevations, but bears ate only half as much grass and grass-like plant material. In contrast, fruits, nuts, and berries dominated the diet at low elevations. The most productive oaks, California black oak and canyon live oak (*Quercus chrysolepis*), and the most productive manzanita, whiteleaf manzanita (*Arctostaphylos viscida*), occur at less than 1,800 m, along with abandoned apple and pear trees in Yosemite Valley. Less animal food, particularly insect matter, was eaten. This low use of insects could be a consequence of the scarcity of dead and decaying wood where we sampled. Much dead wood is collected by visitors for fires, and dead and diseased trees are cut and removed near roads, trails, campgrounds and other areas by the Park Service. Human foods were eaten in amounts typical for the Park as a whole (Table 2). Visitors brought the largest quantity of food into this zone, but bear-resistant facilities were most abundant here and enforcement of food storage regulations was greatest.

Between 1,800 m and 2,400 m.—The mid-elevation zone provided principally herbage in the diet, most of it during the summer. Forbs were used heavily (13% volume, 30% frequency,) in this zone, especially yampah (*Perideridia gairdneri*) and lupines (*Lupinus* spp.).

Hatler (1972) reported use of lupine by black bears in Alaska. The roots of yampah were an important source of starch for Yosemite Indians, as were other local Umbelliferae including biscuit root (*Lomatium nudicale*) and lovage (*Ligusticum grayi*) (Niehaus 1974). Tisch (1961) reported spring use of *Lomatium* by black bears, and Boyer (1976) listed yampah as a spring food in southern California; neither indicated what part of the plant was used. Mealey (1980) found roots as well as herbaceous parts of yampah and biscuit root were used by grizzly bears in Yellowstone, but only above ground portions were detected in Yosemite scats, and we found no evidence of digging in stands of yampah where scats were usually found. Black bear claws are more designed for climbing than digging, and may be inadequate to excavate the most valuable parts of these plants. Less than half as many fruits, nuts and berries were eaten at mid-elevation than in the lower zone (Table 2). Manzanita berries, and particularly acorns, were much less abundant there, but they were common late summer and fall foods. This is the only zone were cherries were an important food source. Pears and apples were unavailable. Insects were heavily used, but human foods were less important at this elevation than at any other.

Above 2,400 m.—In the subalpine and alpine zone, diet is greatly simplified. Herbage comprised 60% of scat volume, with sedges, a few grass species, and lupine predominating. Fruits, nuts, and berries are scarce at this elevation, but more animal matter was eaten than at any other elevation. Ants and deer were the most common animal foods. Human foods also made up their largest proportion of the diet at the high elevations.

Use of this elevation zone by black bears usually was limited to June through October, based on scat and trapping evidence. Bears followed snow melt and sprouting vegetation upslope in June and retreated to lower elevations supplying berries and acorns beginning in September. Succulent herbage was supplemented by ants and deer (mostly young fawns and carrion from the summering herd) and berries, principally pinemat manzanita (*Arctostaphylos hevadensis*) and mountain gooseberry (*Ribes montigenum*). Black bear foods are scarcest in this high-elevation zone, but bears exploited the abundance of high-quality anthropogenic foods brought into the area by increasing numbers of hikers, backpackers, and other visitors.

Yearly Variation in Feeding Habits

Three factors altered the availability of foods used by black bears from 1974 through 1978. Production of fruits, nuts, and seeds, particularly of acorns, characteristically varies in a natural, unpredictable manner from year to year. Secondly, temperature and precipitation patterns departed considerably from long-term averages: there

was a hard frost in the spring of 1975, and there was a severe drought in 1976 and 1977 (NOAA Annual Climatological Summaries, 1974–1978). Although we collected no systematic food production data, we saw obvious differences in the periods of meadow succulence and the production of berries and acorns resulting from these weather differences. Thirdly, systematic efforts by the Park Service to reduce bear use of human foods began in 1974, and intensified greatly over the next 4 years (Harms 1977; W.B. Cella and J.A. Keay, unpubl. rep., Yosemite Natl. Park, 1979).

Nevertheless, there was a remarkable consistency in black bear feeding patterns during these 5 years (Table 2). The greatest variations occurred in 1975, 1976, and 1977, caused mostly by frost and drought. Fruit, nut, and berry crops and consequently their use fluctuated more than did other food items. In 1975 the frost reduced production of fruits, nuts, and berries, especially at lower elevations. Throughout the fall of 1975, bears were captured in Yosemite Valley and relocated to reduce property damage, leaving fewer bears to exploit the acorn crop. (Many of these acorns were eventually eaten during the following mild winter and spring.) Animal foods were used most heavily in 1976; a mild, dry winter probably permitted increased insect survival. In 1977, the drought lowered production and use of fruits, nuts, and seeds. That year the apple and pear crops in Yosemite Valley failed, and the acorn crop was scant. The drought also reduced herbage production, but the black bears ate proportionately more herbage in 1977 than in any other year. Apparently fruits, nuts, and seeds are limiting food resources, but herbage is not. Bears ate proportionately more herbage in seasons and years when other foods were scarce. Use of human foods declined from 1974 to 1976, and then began to increase. The increase at higher elevations was dramatic (Fig. 2).

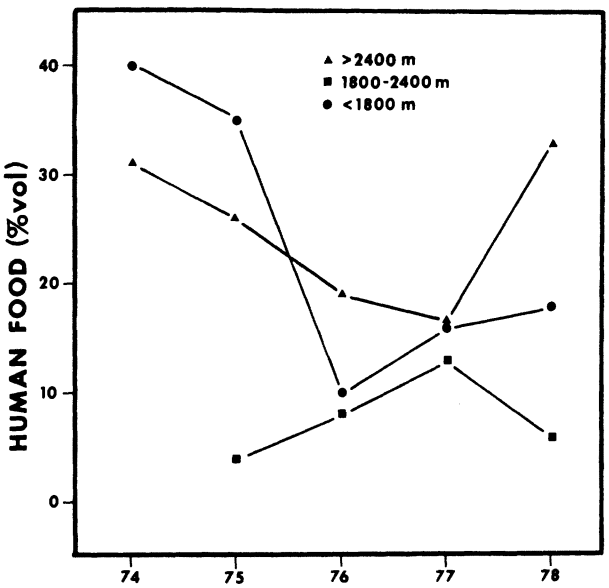

Fig. 2. Black bear use of human food over 5 years at 3 elevations in Yosemite National Park.

Management Implications

Yosemite Valley originally was an oak woodland inhabited by numerous California grizzly bears (Bunnell 1892); Hetch Hetchy Valley was much the same. It is uncertain whether black bears were sympatric there with grizzly bears. Today grizzly bears have been extirpated; Yosemite Valley is the most heavily developed and visited portion of the Park and Hetch Hechty is submerged behind a dam. What remains of this low-elevation zone in the western region of the Park appears to provide the richest black bear diet. No doubt the presence of California black oaks and the fruit orchards helps attract black bears to Yosemite Valley, and thence into conflict with park visitors.

Grinnell and Storer (1924) found black bears a rarity above 2,400 m; today bears are common during the summer in Tuolumne Meadows and other subalpine areas where people camp (Graber 1981). Our studies of marked animals showed that, while some individuals remained at low elevations (e.g., Yosemite Valley) all year, others moved to mid-elevations (e.g., Little Yosemite Valley) and high elevations (e.g., Tuolumne) in the summer. The input of human food at high elevations in Yosemite, in combination with native graminoid forage, appears now to provide an adequate diet for black bears during the summer. If spring and fall forage at lower elevations is not limiting, the carrying capacity of Yosemite may thus have been increased from pre-Park times in both the lowest elevations by the elimination of

grizzly bears, and in the high elevations by diet supplementation with rich anthropogenic foods. This means that there are almost certainly more bears in Yosemite, and that they have made important changes in their use of the landscape in response to a greatly modified nutritional regime.

Food Habits versus Nutrition.—Our food habits study was designed only to determine what black bears in Yosemite eat, and when and where they do so. Although scat analysis yields biased data concerning the relative quantities of food consumed (percent volume), we agree with Hatler (1972) that it provides an accurate assessment of their identities and how often they are taken.

Fecal remains represent what was *not* digested, which presents a crucial problem in relating scat contents to bear diet. Even when this problem can be overcome, as Mealey (1980) attempted to do with grizzly bear food habits, a second question arises. What is the contribution of each food item to black bear nutrition? Carbohydrates, fats, protein, vitamins, and minerals all must be available in sufficient quantities and at the right times; the insufficiency of 1 element may reduce the values of others (Crampton and Harris 1969). Food items consumed by black bears vary widely in their digestibility and in their chemical constituents. The principal class of food in Yosemite bear scats is herbage, which can be high in crude fiber. To our knowledge no data are published which show bears' ability to digest crude fiber.

Human foods, which tend to be highly digestible because of processing, may be grossly under-represented in our scat analysis. Often packaging was the only fecal element. The digestibility and large proportion of animal protein may mean that anthropogenic foods have had a significant impact on Yosemite black bear ecology. For example, Graber (1981) suggested that human foods are a factor in the rapid growth and large size of Yosemite bears. A small volume of human food in conjunction with large quantities of less digestible herbaceous matter may provide a balanced diet, and this may explain why scats collected at high elevations were nearly always found near camps, regardless of their contents.

LITERATURE CITED

ARNER, D.H. 1948. Fall food of the black bear in Pennsylvania. Pa. Game News 19(9):13.

BARMORE, W.J., AND D. STRADLEY. 1971. Predation by black bear on mature male elk. J. Mammal. 52:199 – 202.

BEEMAN, L.E., AND M.R. PELTON. 1980. Seasonal foods and feeding ecology of black bears in the Smoky Mountains. Int. Conf. Bear Res. and Manage. 4:141 – 147.

BENNETT, L.J., P.F. ENGLISH, AND R.L. WATTS. 1943. The food habits of the black bear in Pennsylvania. J. Mammal. 24:25 – 31.

BIGELOW, N.K. 1922. Insect food of the black bear (*Ursus americanus*). Can. Entomol. 54:49 – 50.

BOYER, K.B. 1976. Food habits of black bears (*Ursus americanus*) in the Banning Canyon area of San Bernardino National Forest. M.S. Thesis. California State Polytechnic Univ., Pomona. 63pp.

BUNNELL, L.H. 1892. Discovery of the Yosemite, and the Indian war of 1851, which led to that event. 3rd ed. F.H. Revell Co. New York. 338pp.

CHATELAIN, E.F. 1950. Bear-moose relationships on the Kenai Peninsula. Trans. North Am. Wildl. Conf. 15:224 – 234.

COWAN, I.McT. 1972. The status and conservation of bears (Ursidae) of the world 1970. Int. Conf. Bear Res. and Manage. 2:343 – 367.

CRAMPTON, E.W., AND L.E. HARRIS. 1969. Applied animal nutrition. 2nd ed. W.H. Freemman, San Francisco. 753pp.

DEWEESE, L.R., AND R.E. PILLMORE. 1972. Bird nests in an aspen tree robbed by black bear. Condor 74:488.

DIXON, J. 1927. Black bear tries to gnaw into a woodpecker's nest. Condor 29:271 – 272.

EAGLE, T.C. 1979. Foods of black bears in the Great Smoky Mountains National Park. M.S. Thesis. Univ. Tennessee, Knoxville. 104pp.

FRAME, G.W. 1974. Black bear predation on salmon at Olsen Creek, Alaska. Z. Tierpsychol. 35:23 – 38.

FRANZREB, K.E., AND A.E. HIGGINS. 1975. Possible bear predation on a yellow-bellied sapsucker nest. Auk 92:817.

GILLIAM, H. 1962. Weather of the San Francisco Bay region. Univ. California Press, Berkeley. 72pp.

GRABER, D.M. 1981. Ecology and management of black bears in Yosemite National Park. Ph.D. Thesis. Univ. California, Berkeley. 206pp.

GRINNELL, J., AND T.I. STORER. 1924. Animal life in the Yosemite. Univ. California Press, Berkeley. 375pp.

HARMS, D.R. 1977. Black bear management in Yosemite National Park. Proc. Conf. West. Assoc. State Game and Fish Comm. 57:159 – 181.

HATLER, D.F. 1972. Food habits of black bears in interior Alaska. Can. Field-Nat. 86:17 – 31.

HOWELL, A.B. 1921. The black bear as a destroyer of game. J. Mammal. 2:36.

KING, D.G. 1967. A black bear kills a fawn. Can. Field-Nat. 81:149 – 150.

KING, S. 1933. Wild life at Chinquapin. Yosemite Nat. Notes 12:86 – 87.

LEOPOLD, A.S., S.A. CAIN, D.M. COTTAM, I.N. GABRIELSON, AND T.L. KIMBALL. 1963. Wildlife management in the national parks. Trans. North Am. Wildl. and Nat. Res. Conf. 28:29 – 45.

LINDZEY, F.G., AND E.C. MESLOW. 1977. Home range and habitat use by black bears in southwestern Washington. J. Wildl. Manage. 41:413 – 425.

MCKELVEY, R.W., AND D.W. SMITH. 1979. A black bear in a bald eagle nest. Murrelet 60:106 – 107.

MEALEY, S.P. 1980. The natural food habits of grizzly bears in Yellowstone National Park, 1973 – 74. Int. Conf. Bear Res. and Manage. 4:281 – 292.

MUNZ, P.A., AND D.D. KECK. 1973. A California flora and supplement. Univ. California Press, Berkeley. 1,681pp + 224pp.

MURIE, A. 1937. Some food habits of the black bear. J. Mammal 18:238 – 240.

———. 1944. The wolves of Mount McKinley. U.S. Dep. Inter., Natl. Park Serv., Fauna Ser. 5. 238pp.

NIEHAUS, T.F. 1974. Sierra wildflowers: Mt. Lassen to Kern Canyon. Univ. California Press, Berkeley. 223pp.

PEDERSON, R.J., A.W. ADAMS, AND W. WILLIAMS. 1974. Black bear predation on an elk calf. Murrelet 55:28 – 29.

PIEKIELEK, W., AND T.S. BURTON. 1975. A black bear population study in northern California. Calif. Fish and Game 61:4 – 25.

POELKER, R.J., AND H.D. HARTWELL. 1973. Black bear of Washington. Wash. State Game Dep. Biol. Bull. 14. 180pp.

SCHWARTZ, J.E., II, AND G.E. MITCHELL. 1945. The Roosevelt elk on the Olympic Peninsula, Washington. J. Wildl. Manage. 9:295 – 319.

SMITH, W.W. 1955. Circumstantial evidence. Yosemite Nat. Notes 34:104 – 105.

SPENCER, H.E., JR. 1955. The black bear and its status in Maine. Maine Dep. Inland Fish. and Game. Game Div. Bull. 4. 55pp.

STORER, T.I., AND R.L. USINGER. 1963. Sierra Nevada natural history. Univ. California Press, Berkeley. 374pp.

TAVERNER, P.A. 1928. Bears and hawks. Condor 30:157.

THAXTER, B.A. 1933. Do bears attack deer? Yosemite Nat. Notes 12:72 – 73.

TISCH, E.L. 1961. Seasonal food habits of the black bear in the Whitefish Range of northwestern Montana. M.S. Thesis. Montana State Univ., Missoula. 108pp.

VAN WAGTENDONK, J.W. 1974. Refined burning prescriptions for Yosemite National Park. U.S. Dep. Inter., Natl. Park Serv. Occas. Pap. 2. 21pp.