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KENAI BLACK BEARS AND CRANBERRIES: BEAR FOOD HABITS AND DENSITIES

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KENAI BLACK BEARS AND CRANBERRIES:

BEAR FOOD HABITS AND DENSITIES

A

THESIS

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By

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Fairbanks, Alaska

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KENAI BLACK BEARS AND CRANBERRIES:

BEAR FOOD HABITS AND DENSITIES

RECOMMENDED:

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APPROVED:

Director of Graduate Programs

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ABSTRACT

Fecal droppings collected from 1979 through 1983 were analyzed to determine seasonal food habits of black bears (*Ursus americanus*) on the northwestern Kenai Peninsula, Alaska. Lowbush cranberries (*Vaccinium vitis-idaea*) were sampled in areas of different successional stage and habitat type to assess production levels. Methods for scat analysis and cranberry sampling were developed or improved upon, and evaluated. Berries, animal matter and green vegetation all formed major portions of the black bear diet. Lowbush cranberry was an important spring food overall and was important in both spring and fall where it was highly abundant. Black bears were more carnivorous and predatory than has been reported elsewhere. Cranberry yield from an area burned in 1947 was 8.2 times the yield from an area burned in 1969. Cranberry yields were quite variable as has been reported for other areas. Area-wide bear densities differed less than did area-wide cranberry densities.

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INTRODUCTION

The black bear (*Ursus americanus*) is a major component of the Kenai Peninsula predator-prey system and is highly valued for recreational purposes of hunting and viewing and as a food source. Black bear-moose interrelationships are of special importance as moose (*Alces alces*) receive even greater pressure than bear for both recreational and food purposes.

The Alaska Department of Fish and Game (ADF&G) and the U.S. Fish and Wildlife Service (USFWS) have conducted a cooperative, comprehensive predator-prey study on the Kenai Peninsula in southcentral Alaska since 1976. Studies have focussed on the habits and interrelationships of black bear, brown bear (*Ursus arctos*), wolf (*Canis lupus*), moose and caribou (*Rangifer tarandus*). My study, in conjunction with ongoing ADF&G research, was undertaken as a portion of the comprehensive predator-prey study.

On much of the Kenai Peninsula, vegetational succession has been, and continues to be, a particularly dynamic process as a result of a long history of fire (Lutz 1960, Spencer and Hakala 1964). Information on the seasonal food habits and population densities of black bears in areas of different successional stages was lacking prior to this study and recent ADF&G research (Schwartz et al. 1983*a* and *b*).

Early research indicates a long-standing scientific and public interest in the relationship between black bears and moose in many areas of the Kenai Peninsula (Culver 1923, Palmer 1939, Sarber 1944, Chatelain 1950). More recently, moose calf mortality studies on the northwestern Kenai Peninsula showed that 35% of neonatal calf deaths resulted from black bear predation, the highest single cause of mortality (Franzmann and Schwartz 1980, Franzmann et al. 1984). Details of the seasonal food habits of bears in areas of different successional stage help clarify the role of moose in the black bear diet in different areas. Such data are a valuable supplement to data on black bear predation on moose. In general, food habits information helps define the black bear's ecological niche in a particular area.

Hatler (1967) demonstrated that information gained through scat analysis, if properly interpreted, formed a sound basis for black bear food habits studies. Clark (1957), Tisch (1961), McIlroy (1970), Shaffer (1971) Poelker and Hartwell (1973), Mealey (1975), Lloyd and Fleck (1978), Zytaruk and Cartwright (1978), Landers et al. (1979), Beeman and Pelton (1980), Modafferi (1982), Grenfell and Brody (1983), Mace and Jonkel (1983) and Miller (1983) all used scat analysis either largely or entirely as the basis for food habits studies of bears.

The fruit and/or foliage of lowbush cranberry

(*Vaccinium vitis-idaea*) has been shown to be of dietary importance to black bear (Chatelain 1950, Hatler 1967), arctic hare (*Lepus arcticus*) (Pulliainen 1972), moose and caribou (Oldemeyer and Seemel 1976), spruce grouse (*Canachites canadensis*) (Weeden and Ellison 1968) and rock ptarmigan (*Lagopus mutus*) (Bossert 1976). General observations indicated that black bears on the northwestern Kenai rely heavily on the berry in both spring and fall (Schwartz et al. 1983*a*). The plant's range is circumpolar, and the species is found from sea level to altitudes of 2,400 m in some areas (Douglas 1974). Throughout Alaska, lowbush cranberry is common and generally abundant (Hultēn 1974, Holloway 1981). On the northwestern Kenai Peninsula, lowbush cranberry is very abundant (Oldemeyer and Seemel 1976).

Despite these facts, few detailed studies of lowbush cranberry have been conducted. Very little research has been done with the plant in North America, and even less has been done specifically concerning berry yields of the species. Hatler (1967) pointed out the need for good qualitative and quantitative berry studies within the framework of bear food habits studies. In Alaska, prior to this study, no large scale attempt had been made to evaluate lowbush cranberry fruit production.

Successional stage, habitat type and fire disturbance have profound effects on the abundance of lowbush cranberry in a particular area (Smith 1962, Friedman 1981, Hall and Shay 1981, Holloway 1981). Schwartz et al. (1983*b*) hypothesized that lowbush cranberry abundance was substantially lower in an area of the northwestern Kenai burned in 1969 than in a nearby area burned in 1947. Furthermore, it was suspected that these berries were of such great dietary importance to black bears that their abundance determined the overall abundance of black bears in an area. If the hypothesis was correct, then bear population densities in the 1947 burn area would be higher than those in the 1969 burn area, not just seasonally, but on an annual basis.

The Kenai Peninsula's wildlife and habitat are receiving increasing amounts of human use every year. The Peninsula's close proximity to Alaska's largest population center, Anchorage, as well as excellent road and trail access, ensures that this trend will continue. Information from this study can be used in management decisions intended to more effectively deal with increasing resource use.

Objectives

Three specific objectives were developed to approach the separate but related aspects of this study.

1) To determine the seasonal food habits of black bears in selected areas of the northwestern Kenai Peninsula, with emphasis on the role of lowbush cranberry in the diet.

2) To determine the abundance and density of lowbush cranberries in various habitats and successional stages within

the study site.

3) To evaluate the relationship between black bear population densities and lowbush cranberry densities.

STUDY SITE

The study site (Fig. 1) lies on the northern portion of the Kenai lowlands, on the northwestern Kenai Peninsula, almost wholly within the Kenai National Wildlife Refuge (KNWR) (formerly the Kenai National Moose Range, 1941-1981).

Located in southcentral Alaska between 59°-61° north latitude and 148°-152° west longitude, the 26,000 km^2 Kenai Peninsula is bounded by the waters of Prince William Sound to the east, the Gulf of Alaska to the south, and Cook Inlet to the west (Fig. 1). The Kenai Mountains, heavily glaciated and rising to 1,800 m, occupy most of the eastern two-thirds of the Peninsula. The Kenai lowlands, a gently rolling plain varying in elevation from 15 to 100 m, occupies most of the western one-third of the Peninsula. The lowlands are underlain with glacial deposits of varying texture overlain with silt loams, sands and gravels. Poorly drained areas covered with a layer of peat are common. There are over 5,000 lakes on the lowlands (Bangs and Bailey 1982).

A continental climate prevails on the study site. Precipitation averages 460 mm annually including 1.40 to 1.65 m of snow. Snow cover at low elevations generally extends from late October to late April. Snow depths rarely exceed 1 m, and brief thaws and rain are not uncommon during winter. Temperatures annually range from as low as $-30^{\circ}C$ to as high as $21^{\circ}C$.

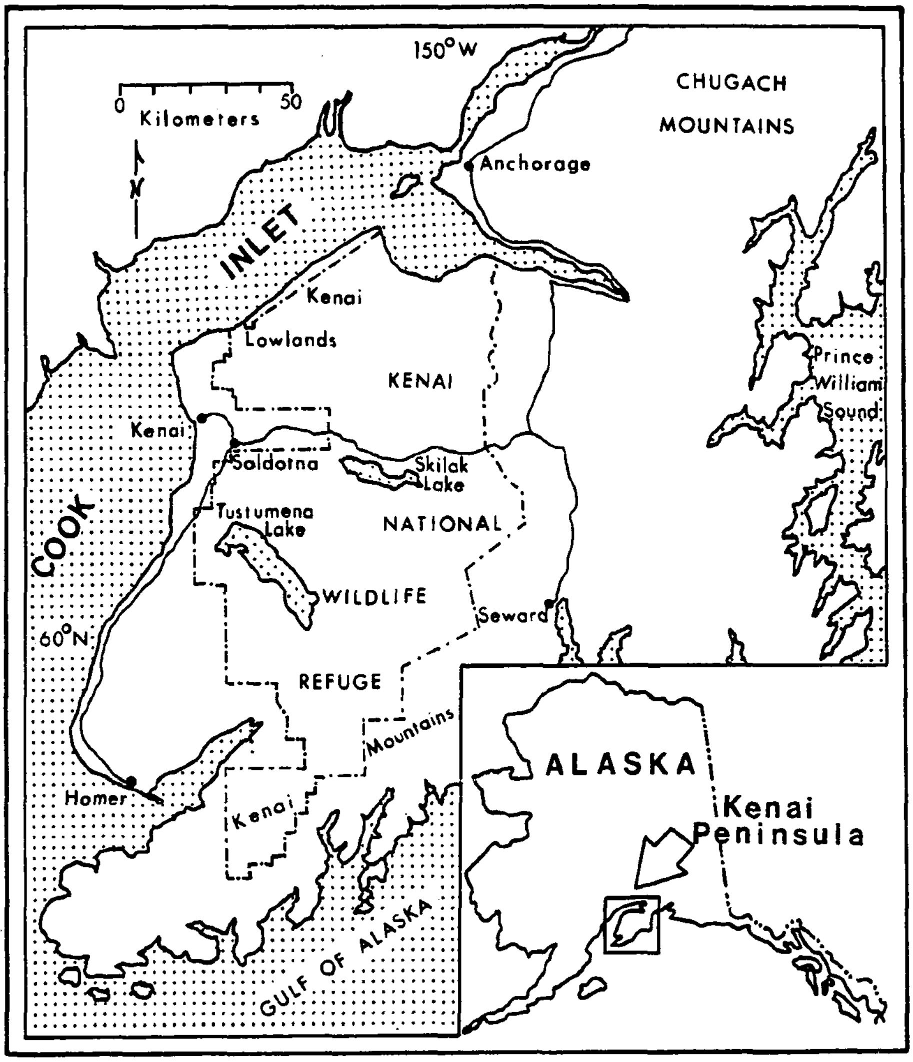


Fig. 1. Kenai Peninsula and study site; northern Kenai lowlands on the northwestern Kenai Peninsula, Alaska.

Mature, well-drained sites on the lowlands are dominated by white spruce (*Picea glauca*), paper birch (*Betula papyrifera*) and quaking aspen (*Populus tremuloides*). A few scattered stands of western hemlock (*Tsuga heterophylla*) also exist, some of which have been dated at over 400 years old (Lewandoski pers. commun.). Dominating more poorly drained sites are black spruce (*Picea mariana*), cottonwood (*Populus balsamifera*), alder (*Alnus* spp.) and willow (*Salix* spp.). Mosses, particularly sphagnum (*Sphagnumm* spp.), sedges (*Carex* spp.) and grasses, especially *Calamagrostis canadensis*, are abundant in and around the numerous muskegs and bogs of the lowland area (LeResche and Davis 1973).

A major influence on both plant and animal community composition on the Kenai has been fire. Major forest fires have been documented on the Peninsula since 1851 and have probably been occurring for as long as there have been forests (Lutz 1960). Two of the largest and more recent fires occurred on the northern Kenai lowlands in 1947 and 1969 (Fig. 2). Efforts were concentrated on selected study areas within these burns and on old growth forest areas adjacent to the burns, since these areas facilitate relatively easy comparison between different successional stages.

1947 Burn Study Area

During the summer of 1947, a fire, resulting from

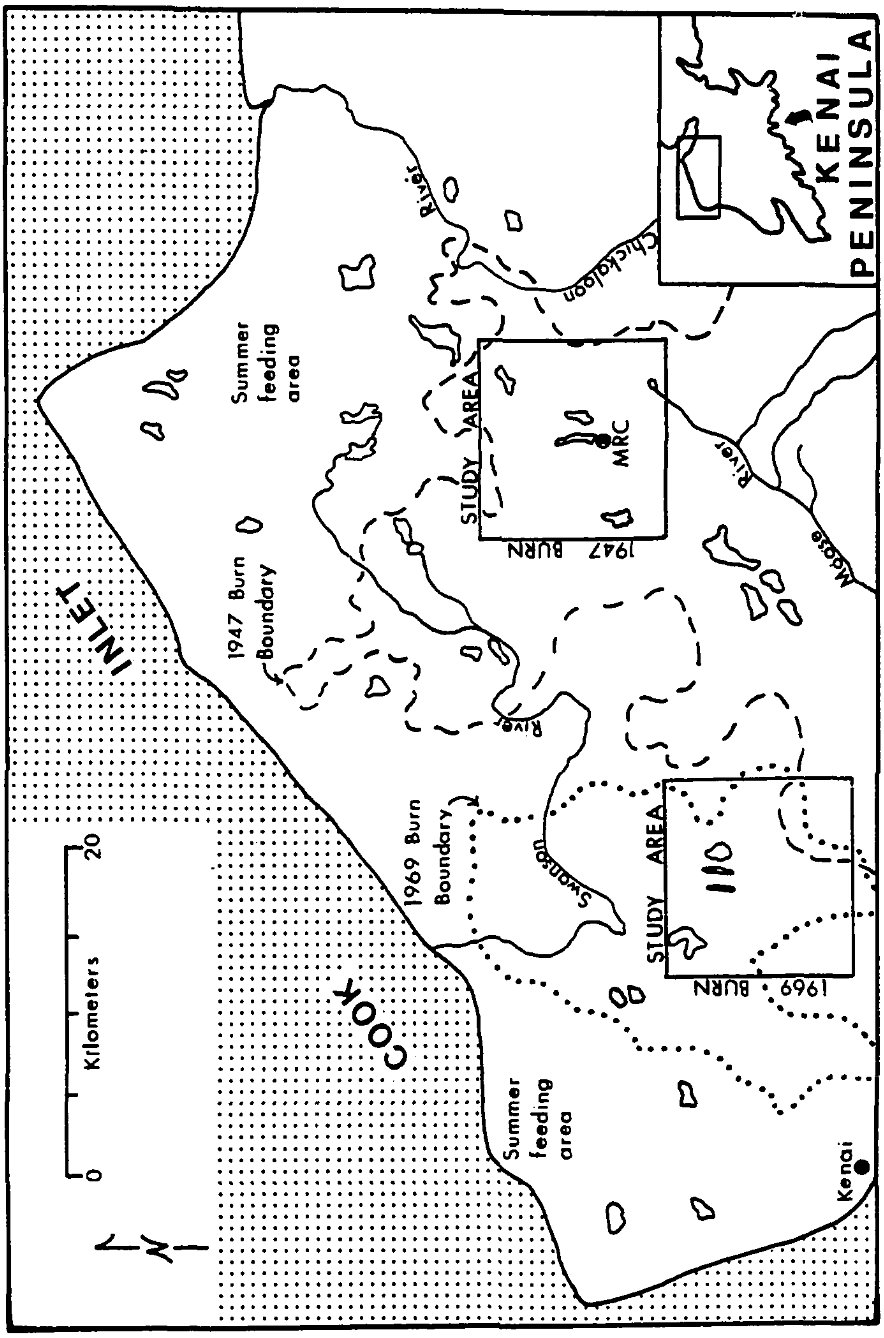


Fig. 2. Specific study areas, northwestern Kenai Peninsula, Alaska. (MRC = Moose Research Center.)

highway construction operations, spread over a 125,450 ha area in the center of the northern Kenai lowlands (Oldemeyer and Seemel 1976). However, due to topography and fuel source conditions, numerous unburned "islands" of mature timber were left within the outer limits of the fire resulting in large amounts of ecotone. Dramatic increases in moose numbers in this area were reported following the fire (Spencer and Hakala 1964), but carrying capacity for moose is now declining (Oldemeyer et al. 1977). Black bear densities in this area are high (Schwartz et al. 1983a). Schwartz and Franzmann (1980) established and described a 127 km^2 study area within the 1947 burn as part of their ongoing black bear research with ADF&G. These boundaries also served as my study area boundaries within the 1947 burn (Fig. 2). This study area surrounds the Moose Research Center (MRC), a cooperative research project of ADF&G and the USFWS. Total area was calculated for all habitat types within this study area (Table 1). Details of vegetation, shading and moisture conditions in the area were recorded during lowbush cranberry sampling (Appendix I). Bangs and Bailey (1982), LeResche and Davis (1973) and Oldemeyer et al. (1977) provide further descriptions of this area.

1969 Burn Study Area

In August of 1969, a campfire got out of control and over a period of several weeks an area of 35,000 ha burned.

Table 1. Total area of habitat types in the 1947 burn study area.

Habitat Type	Hectares
Mixed Regrowth	4,250
Mixed Mature	1,940
Mature Deciduous	1,620
Crushed	650
Spruce Regrowth	450
Mature Spruce	190
Alder[b]	80
Lakes and Streams[a,b]	1,780
Bogs/Muskeg[b]	1,740
Total[c]	12,700

[a]Includes 264 lakes ranging from <1/10 to 120 ha.

[b]Habitats not sampled, known not to produce cranberries.

[c]Approximately 52% of all dry area in regrowth from 1947 burn.

This area lies immediately west of the 1947 burn, and in some locations the two burns overlap (Fig. 2). Unlike the 1947 burn, however, the 1969 burn left very few remnant stands of mature timber and relatively little edge was developed. Those stands that did remain are generally very small, many <2 ha. Recently, moose numbers in this area have increased (Bangs et al. 1982). Studies to evaluate black bear densities in this area are ongoing (Schwartz et al. 1983b). Bear densities appear to be high. To obtain comparative information between the 1947 and 1969 burn areas, a 127 km^2 study area was also established within the 1969 burn (Fig. 2). Total area was calculated for all habitat types within this study area (Table 2). Details of vegetation, shading and moisture conditions in the area were recorded during lowbush cranberry sampling (Appendix II). Bangs and Bailey (1980 and 1982) discuss this area further.

Neither the 1947 nor the 1969 burn study area boundaries were based solely on physiographic features. For the purposes of this study and ongoing ADF&G research, boundaries were delineated to be large enough to encompass several bear home ranges, yet small enough to make studies logistically practical.

Old Growth Forest Areas

Tree ring counts and vegetation inventories from the

Table 2. Total area of habitat types in the 1969 burn study area.

Habitat Type	Hectares
Open Deciduous Regrowth	6,880
Closed Deciduous Regrowth[b]	1,620
Mixed Mature	490
Mature Deciduous	330
Mature Spruce	140
Alder[b]	40
Lakes and Streams[a,b]	1,420
Bogs/Muskeg[b]	1,780
Total[c]	12,700

[a]Includes 240 lakes ranging from <1/10 to 160 ha.

[b]Habitats not sampled, known not to produce cranberries.

[c]Approximately 90% of all dry area in regrowth from 1969 burn.

KNWR reveal that the majority of the area between and surrounding the 1947 and 1969 burns had not been burned for well over 100 years. Black bears from both burn areas occasionally travel into or through these old growth areas throughout the spring, summer and fall. Further, in late summer, bears regularly travel to 2 old growth areas in particular (Schwartz and Franzmann 1982, Schwartz et al. 1983a). One of these areas is north of the 1947 burn; the other is west of the 1969 burn. They are indicated as summer feeding areas in Fig. 2. Cottonwood, mature white and black spruce and some aspen and birch are common overstory species in these old growth areas. Devil's club (*Echinopanax horridum*), high bush cranberry (*Viburnum edule*), raspberry (*Rubus idaeus*), currants (*Ribes* spp.), rusty menziesia (*Menziesia ferruginea*), twisted-stalk (*Streptopus amplexifolius*) and red-berried elder (*Sambucus racemosa*) occur in the understory. Details of vegetation, shading and moisture conditions in the area were recorded during lowbush cranberry sampling (Appendix III). While bear scats were collected and lowbush cranberries sampled in some old growth areas, no formal study area boundaries were established in these areas. The intent was to obtain general information for comparison to the burned areas. Mulé (1982) further describes conditions in portions of the Kenai's old growth forests.

Vegetation on several areas of the study site, totalling approximately 2,700 ha was mechanically crushed between January 1975 and March 1978, using LeTourneau tree crushers, in an attempt to improve moose foraging conditions. These areas are now dominated by a mixture of birch, aspen, willow and spruce shrubs (Oldemeyer and Regelin 1980). No crushed habitat occurred within the boundaries of the 1969 burn study area.

With the exception of muskox (*Ovibos moschatus*), polar bear (*Ursus maritimus*) and arctic fox (*Alopex lagopus*), all native terrestrial furbearers and big game species found in Alaska occur on the Kenai Peninsula (Bangs et al. 1982).

METHODS: LOWBUSH CRANBERRY STUDY

Field Techniques

A two-stage sampling design was employed as the most practical and efficient method of determining levels of berry production. Study areas were subdivided into various habitat types (Tables 1 and 2). Distinction between habitat types was based on overstory composition, shade conditions, general soil and moisture characteristics, and time since last disturbance (fire, mechanical rehabilitation, etc.). Friedman's (1981), Hall's and Shay's (1981), Holloway's (1981) and my own observations indicated that these habitat characteristics are of primary influence on lowbush cranberry production.

Based on observations during travel throughout the study areas and on examination of aerial photos and vegetation maps, several locations in each habitat type were selected as potential sampling locations. These locations ranged from a few to several hundred hectares. Each location was assigned a number, and using a random number table, 2 different locations within each habitat type (except in old growth forest) were selected as sampling locations. Within the old growth forest area, only 1 sampling location per habitat type was selected.

At each sampling location, 2 first-stage sample units of dimensions 30x30 m were selected by laying a grid over an aerial photo of the location. The grid was oriented so that its borders ran in true north-south and east-west directions. The grid was scaled such that each square represented a 30x30 m area on the ground. Each square was assigned a number, and random selection of 2 numbers determined the sample units to be worked. During July and August, before berries ripened, the first-stage sample units were located as accurately as possible using compass bearings. Hemp twine tied between wooden stakes marked the unit boundaries. All units were oriented so that the borders ran in true north-south and east-west directions.

Each unit was then divided (on paper) into 900 plots of dimensions 0.5 x 2.0 m, the second-stage subdivisions of the 2-stage sampling design. Each m^2 plot was assigned a number, and selection by random number table was made of 20 of these m^2 plots in each first-stage unit. Each selected m^2 plot was marked on a grid sheet drawn to represent the first-stage unit and its component smaller plots. The grid sheet served as a "map" of each first-stage unit during sampling. By orientating the grid sheet so that its borders corresponded to the actual unit borders, the selected second-stage plots could be located using a compass and pacing off the appropriate distance from a corner or side of the first-stage unit boundary.

Sampling intensity at the first and second stages was based largely on the amount of time needed for the sampling. Ideally, all units should be sampled in 1 or 2 days to allow for accurate comparisons between units which would not be influenced by berry loss resulting from feeding by animals or harsh weather. This was not physically possible, however. Furthermore, the stage of ripeness of berries differed slightly between units, a factor which can influence weight measurements of berry samples. Therefore, a time constraint on sampling of 2 to 3 weeks seemed long enough to allow for adequate sampling, yet not so long that the degrees of berry loss or ripeness would vary too greatly. Based on "practice" sampling before the berries ripened and on rough calculations of travel time between locations, I decided on a sample of 20 second-stage plots in each first-stage unit throughout the study areas. The 1969 burn and old growth forest areas were sampled in 1982 only. The 1947 burn area was sampled in 1982 and 1983. The same first-stage units were sampled both years in the 1947 burn area, but the random selection of second-stage plots was redone (with replacement) in 1983.

Locations containing plots were visited throughout August to monitor the degree of berry ripeness. Berries were sampled when fully, but not overly, ripe. This was based on the assumption that this stage of ripeness would best represent the amount of berries available as a food base for bears. Sampling was scheduled among the habitat types and study areas so that all sampling was not completed in one particular area well before another; temporally distributing the sampling in that manner makes comparisons between areas more valid.

Collapsible frames having inside dimensions of 0.5 x 2.0 m and made of rigid plastic tubing, 12.7 mm in diameter, served as the borders for all second-stage plots. These frames were moved to the appropriate locations within the first-stage unit as previously described. All lowbush cranberries within the plastic frame were handpicked. Any cranberries lying directly on the north or west border of the frame were picked while any lying directly on the south or east border were not. Cranberries from each m^2 plot were placed in separate zip-lock plastic bags. Second-stage plots that contained lowbush cranberry plants, but no berries, were represented with blank paper tags. All berries and tags were triple bagged in plastic sacks with labels inside and out indicating study area, habitat type, sampling location and unit number. A typical unit might be represented by 9 bags of berries and 7 paper tags, indicating 9 m^2 plots contained cranberries, 7 m^2 plots contained cranberry plants but no berries, and 4 m^2 plots (20-(9+7)) contained neither cranberry plants nor berries. All berry samples were frozen at -25°C within 24 hours of picking and most within 12 hours.

Laboratory Techniques

After completely thawing at room temperature (about 2 hours), berries from 1 second-stage plot at a time were carefully spread out on paper towels. Since many plots were picked in rainy weather, some berries were wet when frozen. Thawing and blotting removed this water, thus reducing weighing errors. For the same reason, all dirt, stem and sepal remnants and leaves were carefully removed so that only the fruit itself was weighed. After cleaning, berries from each second-stage plot were counted, placed together in a petri dish, and weighed to the nearest 0.01 g on a Sartorius electric pan scale. The process was repeated for each second-stage plot and data recorded on the same form used in the field for the appropriate first-stage unit. All berries picked were counted and weighed.

Dry weight analysis was also made on samples of cranberries. Cranberries were air dried for 24 hours, then oven dried for 48 hours at $60^{\circ}C$. Dry weight analysis yielded information on percent water content of berries from different habitat types and study areas. If percent water content for all berries is similar, then fresh weights, which are easier to obtain, can serve as the basis for comparisons between habitat types and areas.

Separate estimates of lowbush cranberry abundance were made for each habitat type in each study area. After deriving an estimate in kg/ha for a particular habitat type, an estimate for total cranberry production for that habitat type was made by expanding the per-hectare value over the total amount of that habitat occurring in the study area. Study area-wide estimates of cranberry production were made by summing the different habitat totals within the study area. This approach is especially valuable in identifying which habitat types account for the most cranberry production. Cherkasov (1974) and Sautin et al. (1975) found this technique of estimating cranberry abundance superior to others in their work in the USSR.

METHODS: BLACK BEAR SCAT CONTENTS, FOOD HABITS AND FOOD RELATIONS

Field Techniques

Fecal droppings (scats) were collected along the few roads within the study areas and on the numerous seismic exploration trails throughout the study site. Scats were infrequently found while investigators hiked cross country; scats were harder to see off trails than scats on trails and bears frequently used trails for travel. In the 1947 burn area, related ADF&G black bear research involved capturing bears in barrel traps (Schwartz et al. 1983a). Scats could nearly always be collected at trap sites when bears were caught. In these cases, the sex and often the age of the bear leaving the scat were known and recorded. Scats suspected of being contaminated with bait were noted as such. Any bait foods found in such scats were not included in final results. ADF&G telemetry locations of radio-collared bears in the study areas often helped determine general locations where scats might be found. Collected scats were frozen in plastic bags at -25°C until analyzed. All scats were frozen within 36 hours of collection and most within 12 hours. Freezing is an easy, clean and efficient method of preserving scats and maintains the original condition of the scat contents.

In general, only scats that appeared to be <1 week old were collected. Although brown bears do inhabit the northwestern Kenai Peninsula, their densities are very low (Schwartz and Franzmann 1978). So, for the purposes of this study, all scats were considered to be from black bears. Shaffer (1971) and Mealey (1975) distinquished black and brown bear scats on the basis of diameter, but I agree with Hamer et al. (1981) that this is not a reliable method, particularly since many scats are formless and cannot be measured reliably. (Several scats known to be from trapped black bears in this study measured larger than the diameter that supposedly would classify them as brown bear scats.) I did not encounter any large groups of scats in a confined area, e.g. 10-20, as Hatler (1967) and Mealey (1975) described. Therefore, each scat was analyzed separately.

Scat deposition dates were estimated as accurately as possible. In some cases, either because a trail, road or area had been visited very recently, or because the scat was from a trapped bear, the time, to within a day, that the scat was deposited was easily determined. In other cases, the overall appearance and condition of the scat, including moisture content, color, presence of insects and/or fresh larvae, as well as the location of the scat (in open sun vs. shade), recent weather conditions and the date that the area was last visited (if at all), led to a reasonable estimate of when the scat was deposited. Date of collection alone is of no biological significance regarding when various foods are consumed. Therefore, even an estimated deposition date that may be a few days off is more meaningful than just the collection date.

In all cases I collected the majority of each scat, but intentionally did not attempt to pick up that portion touching the ground since leaves, sticks, moss, seeds and other debris from the ground unavoidably get mixed into the sample, complicating analysis. If samples were contaminated with debris, contamination was noted on a data tag which also included information on where the scat was collected, sex and age of the bear if known, and date deposited (known or estimated). Most collections weighed 120-150 g.

For seasonal analysis, scat collections were divided into 3 separate groups. Spring/early summer covered the period from den emergence through 30 June. Midsummer covered the period from 1 July through 15 August. Late summer/fall covered the period from 16 August to denning. These divisions were based on general observations of food availability including "greening up" of spring vegetation, moose calving and berry ripening.

Collections were made of many types of berries and green vegetation; calf and adult moose hair, hooves and teeth; snowshoe hare (Lepus americanus) hair, bones, claws and teeth; black bear hair; bird feathers; and, in general, anything that seemed likely to appear in scats based on the literature and personal communication with other researchers in the area. These samples later proved invaluable for reference during laboratory scat analysis.

Because the study site is flat and densely vegetated, direct observations of feeding activity were few. However, I frequently observed places where bears had been feeding and made note of and photographed these sites. Schwartz et al. (1983a and b) frequently observed, from the air, bears feeding in the study areas and provided this information to me.

Laboratory Techniques

In reviewing the literature, it became apparent that descriptions of methods for bear scat analysis are lacking in detail. All authors explain certain aspects of their procedures in some detail, but none present a truly in-depth, overall outline of their methods, or how or why they arrived at those methods. I found some methods to be very inadequate for accurate scat analysis. Therefore, I feel it appropriate to present here details of a laboratory procedure that provides for a thorough, systematic and consistent examination of bear scats along with explanation and evaluation of the methods. Several aspects of this procedure have been referred to by other authors, but the overall sequence of steps resulted from review and trial of many method variations during the early stages of this study.

A list of useful equipment for bear scat analysis includes the following:

Nested brass seives (Mesh sizes # 5, 25, 40 U.S.A. standard)

Lighted viewing lens or bright lamp

White enamel pans (400 x 250 x 60 mm)

Several types of forceps

Petri dishes

Dissecting microscope

Compound microscope

Metal and rubber spatulas

Hand-held fine mesh strainers

Graduated measuring cups or scoops

Stiff wire brush

Scalpel

Probes

Squirt bottles

Ordinary teaspoons

Glass vials (for storing unidentified or reference specimens)

Alcohol, formaldehyde or other preservatives

Bear Scat Analysis Procedure:

1. Thaw scats completely (in bag) if preserved by freezing.

2. Weigh scat in bag. (Subtract weight of bag later.)

3. Spread scat out in white enamel pan and grossly examine for large or obvious objects (such as bones, teeth, large flower parts, etc.) or single items that could be missed later. This step allows for easier identification of items that may break apart during washing of the scat contents (such as portions of a small mammal or bird vertebral column or a highly characteristic plant part).

4. Place scat in large beaker (1,000-2,000 ml). Add 3 ml of water for each g of scat. Gently stir and mix scat and water. Place a tag in each beaker used, identifying scat by number, date, etc. Let stand 30 minutes to several hours depending on consistency and condition of the scat. This step rehydrates scats that have become dry, separates individual food items and helps restore food items to their original shape and color making for easier identification. For my purposes, the ratio of 3:1, water:scat seemed easier to work with than other ratios. Having several scats soaking while others are being examined further speeds the analysis process.

5. Again, mix scat and water thoroughly by stirring and swirling in beaker.

6. While scat is uniformly mixed with the water, remove

180 ml of the mixture, using a 60 ml plastic scoop, remixing the solution frequently. One hundred eighty ml of mixture is approximately 135 g of water and 45 g of scat. Forty-five g of scat is roughly 1/3 of the average amount collected in this study.

7. Pour the 180 ml of scat/water mixture into nested sieves. Wash the scats thoroughly through the sieves using a spray nozzle. (Avoid overly high water pressure; it can break up food items making them harder to identify.) Using 3 mesh sizes was more efficient in segregating food items than using 1 or 2. Using more than 3 mesh sizes is cumbersome and overly time consuming. I used brass U.S.A. Standard Testing Sieves (W.S. Tyler Inc.) and recommend the following mesh sizes: No. 5 (4.0 mm mesh) for separating out large items such as wood chips, bone fragments and woody stems; No. 25 (0.71 mm mesh) for separating out berries, many seeds and most green vegetation, hair, feathers, etc.; No. 40 (0.42 mm mesh) for separating out small seeds such as those of Vaccinium spp., sand or dirt, if present, and any fragments from the larger items.

8. Using a spray nozzle, backwash the largest mesh sieve into a clean 250 x 400 x 60 mm white enamel pan. The white pan serves as a "screen" against which food items can be examined. At this point, the individual food items should appear "clean" and the water in the pan should be relatively clear. Examining the items in water proved to be superior

to spreading them out on paper or leaving them in the sieves because items remained separated making them easier to distinguish from one another.

9. Carefully examine all remains, removing them from the pan with forceps and placing all like items together in a petri dish. A bright light over the pan greatly helps in identifying and distinguishing between items. A lighted, spring-arm mounted viewing lens is even better. Often the majority of a scat may be composed of 1 food item. In such cases, it is easiest to remove other material with forceps and then simply pour all that remains through a fine mesh hand-held strainer.

10. Empty and clean the enamel pan and repeat step 9 for the next largest mesh sieve, then for the smallest mesh sieve. Certain food items, especially some berries, tend to stain the enamel fairly quickly. The pan should be kept as white as possible to provide a good viewing background.

11. Pour the remainder of the scat/water mixture from the beaker through the sieves and wash as described above, in steps 7-10. Examine the contents of each sieve but do not physically separate out and remove all items as before. The purpose of this step is to locate any items that were not found before and to determine if the remaining items that were already found are present in about the same proportions as previously encountered. If the amount of scat collected is very small, e.g. 30-60 g, pour all of the scat/water

mixture through the sieves initially and skip step 11.

12. Visually estimate what percent volume of the scat the various food items comprise, i.e., which percent volume category the items fall into. Percent volume categories of 0, Trace-5%, 6-25%, 26-50%, 51-75% and 76-100% were used in this study. This method is efficient, and the relatively broad classes make errors in estimating the correct volume unlikely. Tisch (1961), Hatler (1967), Mealey (1975) and many others used similar percent volume classifications.

13. Examine each sieve for any items remaining; then clean each sieve thoroughly with a stiff wire brush and a high-pressure stream of water. Cleaning the sieves between scats is especially important. Pieces of material left in the sieves from one scat might appear in subsequent samples as trace items thus decreasing the accuracy of final results.

14. Collect any unknown specimens from the sample and save for later identification. Also save those known specimens wanted for future reference. Preservation methods depend on the material being saved. Preserving seed specimens in an alcohol and formalin solution kept their original color, shape and texture better than drying did. A solution of approximately 2/3 95% ETOH and 1/3 10% formalin was used. Only about 1-5 ml/seed was needed, depending on seed size.

15. Record all data using separate forms for each scat. Appendices V and VI are samples of the scat analysis data form and scat analysis data codes used in this study.

Depending on content and size, 30-60 minutes were required to complete analysis of each scat.

This procedure is not a sampling procedure since the entire collected scat is examined. The initial 180 ml scat/water portion is just a part which is examined very intensively and physically separated. The intent of this procedure is to provide a systematic, thorough method of scat analysis that is faster than physically separating out every item and, at the same time, to avoid the inadequacies associated with sampling only portions of the scat.

During analysis, special note was made on the general condition of different food items. By noting the freshness of vegetation and the condition of insects and larvae in the scats, I attempted to differentiate between items eaten purposely, those ingested incidentally and those that may have actually entered the scat after it was on the ground. Vegetation that appeared old, brown and partially decayed, and occurred in low volumes in scats, was considered to be incidentally ingested. Plump, white maggots and whole "fleshy" insects were considered to have invaded the scat after it was deposited. Dry twigs and grass on or near the surface of a scat were considered to have been accidently collected with the scat. Other black bear food habits studies provided information on bear feeding behavior and foods commonly eaten by black bears in other areas. Such information provided clues to the likelihood that various foods were purposely ingested.

I found, as did Clark (1957), that certain foods give scats a very distinctive, characteristic odor. Some are rather aromatic while others are very foul. For example, scats containing large amounts of clover (*Trifolium* spp.) or devil's club berries, have a unique fragrant odor while those scats from bears eating meat have an offensive odor. This knowledge was sometimes particularly helpful in determining the contents of scats containing finely ground green vegetation (such as clover).

Most hair and feather specimens could be identified with the naked eye by comparison to reference samples, but all were checked under a dissecting microscope and many under a compound microscope at 100x magnification. Moore et al. (1974) proved to be an excellent aid in hair identification.

Color is sometimes not a reliable indicator for identification of certain food items, particularly berries. Passing through the digestive tract, being exposed to the elements and being washed in the lab can fade or completely change the color of food material. Furthermore, those items mixed in with large amounts of fresh berries often get heavily stained. For specific or generic identification, grass and sedge samples taken from scats were sent to the University of Alaska's Agricultural Experiment Station in Palmer. Hultén (1974) served as an excellent overall plant guide while the berry and seed descriptions in Viereck and Little (1972) were most useful.

Bangs (1979) found that small mammals on the northwestern Kenai Peninsula frequently ate fungus, particulary *Endogone* spp. He easily detected the presence of fungus in small mammal diets by observing fungal spores in the stomachs. To check for the presence of fungus in the black bear's diet, a few drops of the scat/water mixture from each scat were examined under a dissecting microscope at 33x magnification in an unsuccessful effort to find fungal spores.

By noting and recording the gross aspect and more obvious contents of each scat and then comparing these observations to final laboratory analysis results, I concluded that gross field examination of scats should be regarded as an unacceptable method of analysis for making any but the most general statements about bear food habits.

While almost any examining technique will reveal most items in scats, especially high volume items, close laboratory analysis prevents overlooking low volume or trace items. In this study, hair and feathers, for example, frequently fell into low volume categories. Had these items been overlooked, my results would have indicated a far less carnivorous diet than they do. (See page 57.)

Approach To Data Interpretation

In this study, scat analysis was regarded as a tool for determining the food habits (diet) of black bears. Raw data, particularly those on the volumes of different items in scats, were never interpreted as a direct indication of what bears actually consumed.

To interpret data from the various areas within the study site, data from the northern summer feeding area were grouped with data from the 1947 burn study area and data from the western summer feeding area were grouped with data from the 1969 burn study area. Schwartz et al. (1983a and b) showed that most bears from the 1947 burn area travel to the northern summer feeding area and most bears from the 1969 burn area travel to the western summer feeding area. In any case, virtually all bears that leave either the 1947 or 1969 burn areas go to 1 of the 2 summer feeding areas. Since data analysis showed that the diet in both summer feeding areas was nearly identical, grouping areas to provide a complete seasonal feeding picture for the 1947 and 1969 burn areas is valid.

METHODS: AREA BLACK BEAR POPULATION DENSITY ESTIMATES

Estimates of black bear population density within the 1947 burn area have been made for several years as part of ongoing ADF&G black bear studies (Schwartz et al. 1983 a). Similar research commenced in the 1969 burn study area in 1982 and provided general estimates of bear densities in that area (Schwartz et al. 1983b, 1984). These estimates were used in meeting the third objective of this study, evaluating the relationship between black bear population densities and lowbush cranberry densities.

RESULTS AND DISCUSSION: LOWBUSH CRANBERRY STUDY

To assess the abundance and density of lowbush cranberries in the 1947 and 1969 burn study areas, berry collections were made between 8 and 22 September 1982 in both areas and between 30 August and 8 September 1983 in the 1947 burn area. In addition, limited sampling was done in old growth forest areas adjacent to the 1969 and 1947 burn areas between 8 and 22 September 1982.

In all, 12,938 berries were collected in 1,280 randomly selected m^2 plots located in 6 different habitat types throughout the study areas. While accurate estimates of berry production were desirable, the main intent in this study was to compare the relative berry production of the 1947 and 1969 burn areas.

Dry matter analysis of berry samples showed that water content of berries from all areas was quite consistent (Table 3). Water content varied by a maximum of 5.7%, and 11 of 15 samples varied by <1.4%. Water content values were very similar to those reported from Alaska (Heller 1962), from Germany (Botticher 1977) and from Newfoundland (Stark et al. 1978). The lack of variability in berry water content indicates that production estimates based on fresh weights are legitimate and provide a sound basis for comparison of study areas.

Fresh weights for individual berries were also

Table 3. Percent dry matter and water of lowbush cranberries from KNWR, Alaska, 1982 and 1983. Values for combined data are $\bar{X}$ followed by SE, with n (number of habitats in sample) in parentheses.

Study area	Habitat type	Year	% Dry matter	% Water
1947 Burn	Mature Deciduous	1982	16.5	83.5
1947 Burn	Mixed Regrowth	1982	15.8	84.2
1947 Burn	Spruce Regrowth	1982	17.2	82.8
1947 Burn	Mature Spruce	1982	17.1	82.9
1969 Burn	Open Deciduous Regrowth	1982	14.9	85.1
1969 Burn	Mixed Mature	1982	14.8	85.2
1969 Burn	Mature Deciduous	1982	17.3	82.7
1969 Burn	Mature Spruce	1982	16.5	83.5
Old Growth Forest	Mixed Mature	1982	16.0	84.0
Old Growth Forest	Hemlock	1982	20.5	79.5
1947 Burn	Mature Deciduous	1983	15.8	84.2
1947 Burn	Mixed Regrowth	1983	16.3	83.7
1947 Burn	Spruce Regrowth	1983	16.5	83.5
1947 Burn	Mature Spruce	1983	17.0	83.0
1947 Burn	Crushed	1983	15.9	84.1
1947 Burn	All Combined	1982	16.7 :0.27(4)	83.3 :0.27(4)
1947 Burn	All Combined	1983	16.3 :0.20(5)	83.7 :0.20(5)
1969 Burn	All Combined	1982	15.9 :0.53(4)	84.1 :0.53(4)
Old Growth Forest	All Combined	1982	18.3 :1.61(2)	81.7 :1.61(2)
All Areas	All Combined	1982	16.7 :0.49(10)	83.4 :0.49(10)
All Areas	All Combined	All Years	16.5 :0.33(15)	83.5 :0.33(15)

consistent (Tables 4, 5, 6 and 7). Fresh weights for cranberries from interior Alaska (Hatler 1967 and Holloway 1981) were similar to values in this study. It appears that fruit size is related to the number of seeds per berry; therefore, large berries result from fertilization of many ovules. Furthermore, cross pollination results in greater berry size than self pollination (Pojar 1974). Holloway (1981) demonstrated that plants open to insect pollination produced significantly larger berries with greater numbers of seeds than did plants that were shielded from insects. Lehmushovi and Hiirsalmi (1973) noted increases in berry size with decreasing light intensity. However, average berry sizes in this study were relatively similar under all light regimes and, in fact, the largest berries came from one of the least shaded sites (Open Deciduous Regrowth).

During 1982, total cranberry production in the 1947 burn area was estimated at 8.2 times the level of production in the 1969 burn area. The 1983 berry production in the 1947 burn area decreased by 40% from the 1982 level, but the estimated yield was still approximately 5 times that of the 1969 burn area in 1982 (sampling was not done in the 1969 burn area during 1983). The opinion of several people working in the 1947 burn area was that the cranberry crop was "much better" in 1983 than 1982. Just the opposite was true. Rogers (1976) used visual observations to judge differences in berry crops that appeared to be great.

Table 4. Lowbush cranberry yields from the 1947 burn study area during 1982, KNWR, Alaska. Mean values are accompanied by SE (n[a] in parentheses).

Habitat type	Estimated total weight of berries (kg)	% of study area total yield	Mean kg/ha	Mean weight of individual berries (g)	% of stage-2 plots examined containing cranberry fruit	% of stage-2 plots examined containing cranberry plants
Mature Dedicuous	179,780	67.74	111.0 ± 51.38(4)	0.20 ± 0.01(4)	75.0	98.75
Mixed Regrowth	80,330	23.93	18.91 ± 3.64(4)	0.18 ± 0.004(4)	76.25	98.75
Spruce Regrowth	16,560	5.96	37.22 ±16.14(4)	0.18 ± 0.01(4)	81.25	100.00
Mature Spruce	640	0.23	3.40 ± 1.82(4)	0.18 ± 0.02(4)	18.75	91.25
Crushed	260	0.09	0.40 ± 0.21(4)	0.16 ± 0.03(4)	10.00	98.75
Mixed Mature	130	0.05	0.07 ± 0.04(4)	0.14 ± 0.004(4)	2.50	76.25
Study Area-Wide	277,700	100.00	28.53 ± 7.99(24)	0.17 ± 0.008(24)	43.96	93.96

[a]n = the number of stage-1 units sampled.

Table 5. Lowbush cranberry yields from the 1947 burn study area during 1983, KNWR, Alaska. Mean values are accompanied by SE (n[a] in parentheses).

Habitat type	Estimated total weight of berries (kg)	% of study area total yield	Mean kg/ha	Mean weight of individual berries (g)	% of stage-2 plots examined containing cranberry fruit	cranberry plants
Mature Deciduous	70,920	42.26	43.80 ±31.11(4)	0.17 ± 0.02(4)	57.50	100.00
Mixed Regrowth	79,770	47.53	18.77 ± 4.74(4)	0.19 ± 0.01(4)	61.25	98.75
Spruce Regrowth	14,640	8.72	32.97 ±10.34(4)	0.19 ± 0.01(4)	88.75	100.00
Mature Spruce	1,580	0.94	8.51 ± 6.02(4)	0.26 ± 0.00(2)	20.00	90.00
Crushed	920	0.55	1.42 ± 1.00(2)	0.15 ± 0.00(2)	15.00	90.00
Mixed Mature	0	0.00	0.00 ± 0.00(2)	0.00 ± 0.00(2)	0.00	87.50
Study Area-Wide	167,830	100.00	17.58 ± 6.62(18)	0.19 ± 0.02(18)	40.42	94.38

[a]n = the number of stage-1 units sampled.

Table 6. Lowbush cranberry yields from the 1969 burn study area during 1982, KNWR, Alaska. Mean values are accompanied by SE (n[a] in parentheses).

Habitat type	Estimated total weight of berries (kg)	% of study area total yield	Mean kg/ha	Mean weight of individual berries (g)	% of stage-2 plots examined containing cranberry fruit	% of stage-2 plots examined containing cranberry plants
Open Deciduous Regrowth	24,830	73.40	3.60 ± 2.16(4)	0.24 ± 0.04(4)	10.00	43.75
Mixed Mature	5,170	15.47	10.71 ± 5.25(4)	0.18 ± 0.01(4)	30.00	67.50
Mature Deciduous	2,380	7.02	7.30 ± 6.04(4)	0.20 ± 0.01(4)	17.50	86.25
Mature Spruce	1,460	4.31	10.12 ± 3.97(4)	0.18 ± 0.01(4)	37.50	81.25
Study Area-Wide	33,840	100.00	7.90 ± 2.40(16)	0.20 ± 0.01(16)	23.75	69.69

[a]n = the number of stage-1 units sampled.

Table 7. Lowbush cranberry yields in old growth forest area during 1982, KNWR, Alaska. Mean values are accompanied by SE (n[a] in parentheses).

Habitat type	Mean kg/ha	Mean weight of individual berries (g)	% of stage-2 plots examined containing cranberry fruit	% of stage-2 plots examined containing cranberry plants
Mixed Mature	24.81 ±17.54(2)	0.24 ± 0.0(2)	12.50	55.00
Hemlock	8.42 ± 5.95(2)	0.11 ± 0.0(2)	17.50	67.50
Mature Spruce	2.84 ± 1.96(2)	0.16 ± 0.02(2)	25.00	100.00
Study Area-Wide	12.02 ± 7.28(6)	0.17 ± 0.03(6)	18.33	74.17

[a]n = the number of stage-1 units sampled.

Hatler (1967) also reported visual observations. Such casual observations may not be reliable and should be used with caution.

Variability about the mean for production estimates was generally high. With few exceptions, production estimates varied greatly both within and between habitat types (Tables 4, 5, 6 and 7). While actual yields for cranberries reported in the literature differ widely, high variability of crops both between and within years appears universal. Hatler (1967) reported yields ranging from 33 to 74 kg/ha during 1 year in interior Alaska. Cherkasov (1974) and Sautin et al. (1975) estimated production at 6 to 257 kg/ha in natural habitats in Russia, and 41 to 246 kg/ha in tree plantation settings. Kolupaeva (1980) noted that under optimal conditions, cranberry crops varied from 220 kg/ha in average years to 296 kg/ha during best years, also in Russia. Yields have exceeded 1000 kg/ha on Tancook Island, Nova Scotia (Hall and Shay 1981). Yields in this study, where cranberries occurred, ranged from as low as 0.07 kg/ha (only about 500 berries/ha) to 111 kg/ha. It is interesting to note that methods in this study closely followed those used by Cherkosov (1974) and Sautin et al. (1975) and, in general, results were similar.

Despite attempts to stratify the study areas thoroughly according to habitat type, many factors influencing berry production could not be segregated. The stratification system used in this study basically separated areas of different shade conditions, soil and moisture characteristics and time since last disturbance. However, extremely cold, wet or dry weather can be detrimental to lowbush cranberry buds, flowers and immature fruit (Lehmushovi and Sako 1975). Holloway (1981) noted several diseases and insect pests that can adversely affect fruit production. A lack of insect pollinators is also likely to reduce fruit production.

In the 1947 burn area, 9 habitat types were identified. Six were sampled for cranberry production; the other 3 contained virtually no cranberry plants and were not sampled (Tables 4 and 5). In the 1969 burn area, 8 habitat types were identified of which 4 were sampled for berry production. Again, the remainder contained no cranberry plants (Table 6). In old growth forest areas 3 habitat types were sampled at 1/2 the intensity of the 2 burned areas for the sake of making general comparisons to the burned areas (Table 7). Both per-hectare production and total area combined determine the total production of a habitat type. Therefore, a type with relatively low berry density, but a very large area, can produce a large portion of a study area's total cranberry crop.

1947 Burn Study Area

Mature Deciduous Habitat - The total estimated yield of cranberries in this habitat type was nearly twice the combined yield of all other 1947 burn area habitat types during 1982. The yield/ha was approximately 4 times that of the average yield/ha in the 1947 burn area that year (Table 4). In 1983, total and per-hectare yields were less than half the 1982 level, but the yield/ha was still the highest in the 1947 burn area and for the entire study site. Total production in 1983, while less than that of the mixed regrowth habitat type, because of the large area occupied by mixed regrowth, was 4 times that of the remaining habitat types combined (Table 5).

Berry production estimates in stage-1 units in this habitat type ranged from approximately 6.7 to 281.6 kg/ha in 1982. During 1983, the stage-1 units ranged from approximately 1 to 151.3 kg/ha. Despite wide fluctuation on an absolute basis, production was consistent on a relative basis, i.e., the lowest unit in 1982 was also lowest in 1983, and the highest in 1982 was highest in 1983. Cranberry plants were present in virtually all stage-2 plots examined and berries were present in 76% and 57% of plots examined in 1982 and 1983 respectively. Smith (1962) found cranberry plants in Alberta in greatest abundance in areas of moderate shade as was present in the mature deciduous areas. Cranberry plants were robust looking and some stood 100-200 mm tall. Plant density was generally high.

The highest berry yields/ha by far occurred in this habitat type. However the very low production observed in some individual units of this habitat indicates that production will not necessarily be high in all mature deciduous stands. It appears that subtle differences in soil, light intensity, moisture, temperature, or other factors can result in large differences in the size of berry crops.

Mixed Regrowth Habitat - This habitat type occupies more than twice the area of any other type in the 1947 burn area. Due largely to this fact, the second highest total berry yield in 1982 and the highest total berry yield in 1983, in the 1947 burn area, came from mixed regrowth habitat. Berry production was relatively stable throughout this habitat type in both 1982 and 1983 (Tables 4 and 5). The estimated yield/ha was nearly the same for both years. Cranberry plants were present in all but 2 of 160 stage-2 plots examined. Berries occurred in slightly more plots of this type than even in mature deciduous habitat, but there were far fewer berries/plot overall. At the time of this study, mixed regrowth stands were approximately 35 years old. Trees were generally saplings but were large enough, and the density great enough, to provide moderate amounts of shade. Cranberry plants appeared generally healthy but were not as large as those in the mature deciduous habitat, nor did they occur in quite as high a density.

Spruce Regrowth Habitat - In both 1982 and 1983, the second highest berry yield/ha occurred in this habitat type. However, only 3.5% of the 1947 burn area is in spruce regrowth so total yields for the habitat ranked third each year (Tables 4 and 5). The yields each year were similar, and the ranking of stage-1 unit berry production was identical both years. Every stage-2 plot examined in this habitat type contained cranberry plants, and over 80% contained berries. Both figures are the highest for the entire study. However, both plants and berries, while evenly distributed, were only of moderate density. Nearly all of the cranberry plants in this habitat, although apparently healthy, were not robust and grew almost flat on the ground. The soil was relatively sandy, a type from which Sautin et al. (1975) reported high cranberry yields in Russia.

Mature Spruce Habitat - Less than 200 ha of pure mature spruce occur in the 1947 burn area. Most is a combination of black and white spruce. Cranberry plants occurred in approximately 90% of the stage-2 plots examined both years, but densities were generally low. Fruit occurred in only about 20% of the plots. Total production was low, particularly during 1982. Also, the 1983 estimate is based on a sample of only 2 stage-1 units. One of these units had no berries in either 1982 or 1983 while the other contained a total of 133 berries; the berries were relatively large (Tables 4 and 5). The lowest light levels of any habitat type, together with competition from dense mats of mosses and lichens, are probably major factors in the low plant and fruit production of lowbush cranberry in this habitat type.

Crushed Habitat - Cranberry production in habitats mechanically crushed 6-8 years prior to berry sampling was next to lowest in the entire study for 1982 and 1983 (Tables 4 and 5). The highest yield/ha, which occurred in 1983, was only 1% that of the mature deciduous habitat that year. While cranberry plants occurred in most stage-2 plots, densities were generally low. Cranberries occurred in only 10-20% of the stage-2 plots and also in low densities. Under cultivation, cranberry plants display maximum growth and dry matter accumulation in full sunlight such as occurs in the crushed habitat type (Holloway 1981). However, in natural situations, competition from other plants appears to reduce cranberry plant presence and size (Smith 1962 and personal observation). Apparently, the functional niche of lowbush cranberry is quite different than its realized niche. Plants in this habitat were small and displayed the most prostrate growth form observed in any habitat type.

Mixed Mature Habitat - Although the second most widespread habitat type in the 1947 burn area, total cranberry production from mixed mature areas was lowest of all habitats in both 1982 and 1983 (Tables 4 and 5). Yield/ha was extremely low (0 in 1983), and cranberry plant density was the lowest of all habitat types. Mixed mature areas were heavily shaded, but less so than mature spruce areas. Competition appeared low as the forest floor at most mixed mature sites was relatively bare except for leaf litter. Soil moisture was generally moderate. Soil nutrients may have been low, but so are the nutrient requirements of cranberry plants (Hall and Shay 1981). Perhaps the generally dense nature of the soil and poorly developed organic matter layer in these areas discouraged entry and spreading of cranberry plant rhizomes.

1969 Burn Study Area

Open Deciduous Regrowth Habitat - Although cranberry yield/ha was <1/2 of any other habitat in the 1969 burn area, the total area occupied by this habitat type was so great that total production was nearly 3 times that of the other habitat types within the 1969 burn area combined (Table 6). Estimates of production varied from 0 to 10.78 kg/ha. Variability between stage-1 units at the same sampling location was less (0 and 0.38 kg/ha for 1 location and 3.27 and 10.78 kg/ha for another location). Except for the crushed habitat type, open deciduous regrowth is the least shaded on the study site. As in the crushed areas, cranberry plant and berry densities were low. Only 44% of the stage-2 plots examined contained plants, the lowest value for the entire study. Large stumps and fallen trees resulting from the 1969 burn occupy much of the ground area in this habitat type. This fire debris is still quite solid, not having decayed to any great extent. Ironically, lowbush cranberry frequently occurs in great abundance atop older, more rotten logs and stumps commonly found in mature forest (Heller 1962, Viereck and Little 1972 and personal observation). It is likely that the same debris that contributed, in large part, to the low cranberry production in this area will, in the future, contribute to high production.

Mixed Mature Habitat - At 1 sampling location in this habitat type, the stage-1 units produced cranberry yields similar to those in the 1947 burn area mixed mature habitat (<1 g total for the location). However, yields from the stage-1 units of the other location were much higher and similar to one another (38.53 and 45.74 g respectively). These yields resulted in the highest yield/ha estimate for the 1969 burn area and the second highest total yield (Table 6). The dense soil and underdeveloped organic layer described in the mixed mature areas in the 1947 burn area were not factors in the 1969 burn area. Although cranberry plants occurred in only 68% of the stage-2 plots, the density of plants was high where they occurred. Berry densities were much greater than in the 1947 burn area mixed mature habitat area also. Despite the relatively high production level in this habitat type compared to other habitats in the 1969 burn area, the level is still <10% of the most productive habitat type in the 1947 burn area during 1982.

Mature Deciduous Habitat - As already mentioned, the fact that the highest overall berry yields in this study came from mature deciduous habitats does not in turn mean that all such areas will produce high yields of cranberries. At 1 location, the stage-1 mature deciduous units in the 1969 burn area contained no cranberries at all and at the other location, relatively small amounts (Table 6). Although the overstory and general appearance of this habitat type is similar to that found in the 1947 burn area, the understory appears different. Overall, cranberry plant density was low and grasses were more common than in 1947 burn area mature deciduous stands. Unlike many mature deciduous stands in the 1947 burn area, which may be dozens of hectares in area, no such stands exist in the 1969 burn area. They are all small, many <2 ha, and all surrounded by burned areas. Lowbush cranberry may have been outcompeted in these stands by plants such as grasses which invaded the stands from the surrounding burned areas.

Mature Spruce Habitat - As in the 1947 burn area, there is very little mature spruce habitat in the 1969 burn area. So, even though the berry yield/ha was relatively high for the 1969 burn area, the total yield was lowest (Table 6). Estimated yield/ha ranged from 0 to 22.24 kg/ha on the various stage-1 units. Berries were present in more stage-2 plots than in any other habitat type in the 1969 burn area, but density was low.

Old Growth Forest Areas

No area boundaries were established in old growth forest areas so no total yield values were calculated. Sampling was limited to 1 pair of stage-1 units in each of 3 habitat types. In each habitat, 1 of the stage-1 units produced no cranberries. Yield/ha estimates (Table 7) are probably not very accurate, but along with observations of the sampling locations, provide some basis for comparison with the 1947 and 1969 burn areas.

Mixed mature stands in the old growth forest appeared much older than those within the burn areas. Many large trees had fallen as a result of wind and decay, resulting in areas of moderate shading instead of heavy shading. The decayed trees also provided excellent growing substrate for cranberry, as already mentioned. Within these areas, dense clumps of fruiting lowbush cranberry frequently occurred. These semi-open areas accounted for virtually all of the cranberry production observed in this habitat type.

Hemlock stands on the study site are small (a few hectares or less) and rare. Shading was heavy and understory composition was similar to that in mature spruce stands. Also like mature spruce areas, cranberry production was variable but generally low.

The old growth area mature spruce stands visited appeared very similar to habitats of that type within the burn study areas. Cranberry plants were common but in low densities and cranberry production was low.

Cranberry Sampling Intensity

The time each year between berry ripening and potentially substantial berry loss (mainly resulting from animal feeding and harsh weather) restricts the amount of time available for obtaining a good sample of the cranberry crop. It is also likely that within 4-7 weeks of berry ripening, the ground will be snow-covered. Therefore, somewhere between 4 and 7 weeks is the absolute maximum time available for cranberry sampling, regardless of the degree of berry loss. The frequent occurrence of lowbush cranberry in bear scats in September indicates that 2-3 weeks is a more reasonable sampling period if the effects of berry loss on the accuracy of estimates are to be minimized.

The highly variable cranberry production encountered in this study indicates that no less than 2 locations, each with a pair of stage-1 units, should be sampled in each habitat type. Cherkasov (1974) recognized the high variability in the yielding capacity of cranberries, and recommended that 70 1-m^2 plots be sampled in each habitat type to obtain estimates that are within 25% of the actual crop. Sautin et al.(1975) made estimates of cranberry production with 19 1-m^2 plots in each habitat type. In this study, 80 1-m^2 plots were sampled in each 1947 and 1969 burn area habitat type. However, the high standard errors associated with yield estimates for most habitat types indicate that estimates are not highly precise (Tables 4, 5, 6 and 7). The number of habitat types an area is divided into, and how well those divisions segregate factors affecting berry production, will obviously affect the total number of plots sampled and the accuracy of the final yield estimate.

Summary

Total lowbush cranberry production was highly dependent upon study area ($P<0.001$). During 1982, the 1947 burn area lowbush cranberry crop was 8.2 times that of the 1969 burn area. Nearly 65% of the total 1947 burn area crop came from the mature deciduous habitat type, which, combined with the mixed regrowth and spruce regrowth habitat types, made up over 99% of the total yield. Over 73% of the 1969 burn area crop came from the open deciduous regrowth habitat type, not because of a high yield/ha but because of the large area occupied by this habitat type.

On a yield/ha basis, the 1947 burn area mature deciduous habitat type was the most productive of the entire study. However, not all mature deciduous areas were highly productive. Some produced no cranberries at all. Locations with the highest yields/ha are probably the most important to individual bears as feeding areas since more food can be obtained for every unit of effort.

Despite the high variability in cranberry yields encountered in this study, the relative comparisons of berry production between the 1969 and 1947 burn areas are valid. Sampling during 1983 revealed that the cranberry crop (in the 1947 burn area at least) varied substantially from one year to the next, but the production rankings for the various habitat types remained almost identical. Furthermore, the factors that affect cranberry production (particulary weather) should operate about equally in both study areas since the areas are quite close to each other. The magnitude of difference in cranberry crops in the 1947 and 1969 burn areas was great. Even if cranberry production in the 1947 burn area were halved and production in the 1969 burn area were simultaneously doubled over 1982 levels, the 1947 burn area would still produce more than twice as much lowbush cranberry as the 1969 burn area.

Cranberry crops in old growth forest habitats were not examined intensively, but appeared generally low as were the yields in the same habitat types within the burn study areas.

Cranberry sampling should be completed within 2-3 weeks after berry ripening. At least 2 stage-1 units at each of 2 different locations should be sampled in each habitat type.

RESULTS AND DISCUSSION: BLACK BEAR SCAT CONTENTS, FOOD HABITS AND FOOD RELATIONS

A total of 488 bear scats collected between 1 May 1979 and 31 August 1983 was analyzed to determine black bear seasonal food habits. Scats were collected as early as 28 April and as late as 3 October (Table 8). Nearly 1/2 of all scats (241) were from the spring/early summer season. The majority of scats (355) came from the 1947 burn area. Therefore, where data are combined, results may disproportionately weight the 1947 burn area and spring/early summer season. This effect has been largely eliminated by presenting most results on a seasonal and spatial (study area) basis.

Food habits data are presented in 3 ways: 1) On the basis of the percent of total occurrences each food type accounted for in different areas and seasons. 2) On the basis of percent frequency of occurrence of different food items. 3) On the basis of percent volume of different food items in each scat. Percent volume data are elaborated on in the text for each food item individually.

Fifty-one different items occurred a total of 3,086 times in all scats analyzed. Of these occurrences, 1,651 were determined to be occurrences of items purposely ingested (Table 9). Overall, scats contained an average 6.3 items (food and non-food) and 3.4 food items each. Sixteen

Table 8. Temporal and spatial distribution of black bear scats collected during 1979 - 1983 for food habits analysis, KNWR, Alaska.

	1947 Burn Study Area			1969 Burn Study Area			Old Growth and Summer Feeding Areas			Yearly Total
Year	Spring/ early summer	Mid-summer	Late summer/ fall	Spring/ early summer	Mid-summer	Late summer/ fall	Spring/ early summer	Mid-summer	Late summer/ fall	
1979	29	10	0	0	0	0	0	0	4	43
1980	61	35	25	0	0	0	0	0	0	121
1981	39	2	29	0	0	0	0	0	0	70
1982	42	30	0	26	10	14	0	24	48	194
1983	42	11	0	2	2	3	0	0	0	60
Total	213	88	54	28	12	17	0	24	52	488

Table 9. Total percent frequency of occurrence of food items[a] in all scats and percent frequency of occurrence of food items in each percent volume category. Scats collected 1979 - 1983 on the KNWR, Alaska. (All scats, n = 488.)

Scat Item	Total percent frequency of occurrence	Percent Volume Category				
		Tr-5	6-25	26-50	51-75	76-100
Fruits and Berries						
Lowbush Cranberry	58.6	22.1	15.0	9.2	4.3	8.0
Devil's Club	24.8	3.7	1.2	2.3	4.5	13.1
Twisted-Stalk	13.9	11.3	2.3	0.2	0.0	0.2
Cloudberry	3.5	2.9	0.6	0.0	0.0	0.0
Red Elderberry	2.7	2.7	0.0	0.0	0.0	0.0
Trailing Black Currant	0.4	0.2	0.2	0.0	0.0	0.0
Northern Black Currant	0.8	0.4	0.4	0.0	0.0	0.0
Red Currant	0.2	0.2	0.0	0.0	0.0	0.0
Highbush Cranberry	1.8	1.4	0.2	0.2	0.0	0.0
Rosehips	5.5	3.1	1.2	0.8	0.0	0.4
Raspberry	3.9	2.5	0.8	0.6	0.0	0.0
Cornus canadensis	1.6	1.0	0.4	0.2	0.0	0.0
Geocaulon lividum	0.4	0.2	0.0	0.2	0.0	0.0
Blueberry	0.8	0.2	0.4	0.2	0.0	0.0
Crowberry	0.8	0.6	0.0	0.2	0.0	0.0
Flowers						
Clover	7.8	5.5	1.6	0.6	0.0	0.0
Pedicularis spp.	1.4	0.6	0.4	0.4	0.0	0.0

Table 9 (cont.)

Scat Item	Total percent frequency of occurrence	Percent Volume Category Tr-5	6-25	26-50	51-75	76-100
Green Vegetation						
Equisetum spp.	46.1	11.5	6.1	8.0	7.2	13.3
Grass, Sedge	19.1	7.8	3.7	2.3	2.0	3.3
Clover leaves, stems	14.8	0.6	3.5	1.8	3.5	5.3
Spruce cambium	2.0	0.4	1.6	0.0	0.0	0.0
Menziesia leaves	3.9	3.3	0.4	0.2	0.0	0.0
Twisted-Stalk leaves	5.1	3.7	0.6	0.2	0.2	0.4
Moss	0.6	0.0	0.4	0.2	0.0	0.0
Pedicularis leaves	1.2	0.6	0.4	0.2	0.0	0.0
Cottonwood leaves	2.0	0.6	1.0	0.2	0.0	0.2
Animal						
Moose	35.9	18.4	9.4	4.3	1.2	2.5
Hare	11.9	9.0	1.6	0.4	0.6	0.2
Birds	8.8	5.7	2.0	0.6	0.2	0.2
Fish	2.7	1.8	0.8	0.0	0.0	0.0
Black Bear	1.6	0.8	0.0	0.0	0.2	0.6
Red-backed Vole	0.6	0.6	0.0	0.0	0.0	0.0
Insects	45.9	27.0	13.9	3.7	1.0	0.2
Insect larvae	6.6	6.1	0.2	0.2	0.0	0.0
Snail	0.2	0.2	0.0	0.0	0.0	0.0

[a]Includes only those items determined to be purposely ingested food items.

different items, including materials such as dirt and wood chips, were never counted as true food items, but were included in the overall listing of items found in the scats (Appendix IV). Another 5 items (grass/sedge, "moss", insects, insect larvae and black bear) were only counted as food in certain instances, the other occurrences being categorized as either incidental ingestion or accidental contamination from the ground during scat collection. The remaining 30 items were considered food in all scats where they occurred.

The same items consistently made up the most frequently occurring foods throughout all years of the study (Table 10). The volumes of various items in scats also remained relatively similar year after year. Therefore, comparisons were mainly directed between seasons and study areas.

For all scats combined, fruits and berries, animal matter and green vegetation, each accounted for approximately 1/3 of all food occurrences (Fig. 3). Seasonally, a partial shift away from both animal and green vegetable matter to fruits and berries as the year progressed, was evident (Fig. 4). Flowers accounted for few occurrences. During most seasons, 10 or fewer food items occurred in 10% or more of the scats.

Data from the 2 burn areas combined with their associated summer feeding areas were compared. All scats

Table 10. Seasonal frequency of occurrence of most frequently occurring individual food items in black bear scats collected from 1979 through 1983 on the KNWR, Alaska. All study areas and years combined. (Numbers rounded to nearest whole percent, n = 488.)

Spring/early summer		Midsummer		Late summer/fall	
Item	% Freq. Occur.	Item	% Freq. Occur.	Item	% Freq. Occur.
Lowbush Cranberry	78	Insects	62	Devil's Club berry	59
Equisetum spp.	66	*Equisetum* spp.	51	Lowbush Cranberry	43
Insects	54	Lowbush Cranberry	36	Twisted-Stalk berry	40
Moose	51	Devil's Club berry	35	Rosehips	18
Grass/Sedge	32	Clover leaves/ stems	31	*Menziesia* leaves	15
Snowshoe Hare	14	Moose	27	Moose	14
Clover leaves/ stems	12	Clover flowers	25	*Equisetum* spp.	13
Birds	12	Twisted-Stalk berry	15	Raspberry	12
Insect larvae	5	Snowshoe Hare	14	Insects	11
Cottonwood leaves	4	Twisted-Stalk leaves	8	Cloudberry	10
Remaining Foods	<3% each	Remaining Foods	<7% each	Remaining Foods	<9% each

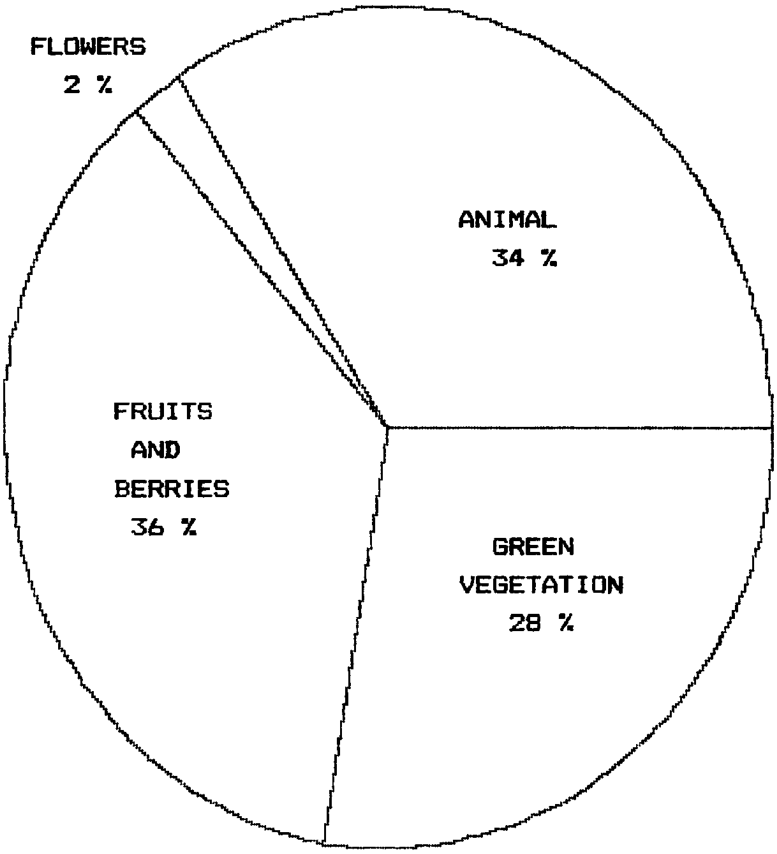


Fig. 3. Overall black bear food habits based on percent of total food occurrences in scats accounted for by each food type. All study areas, years and seasons combined. (Numbers rounded to nearest whole percent, n=488.) 1979 - 1983, KNWR, Alaska.

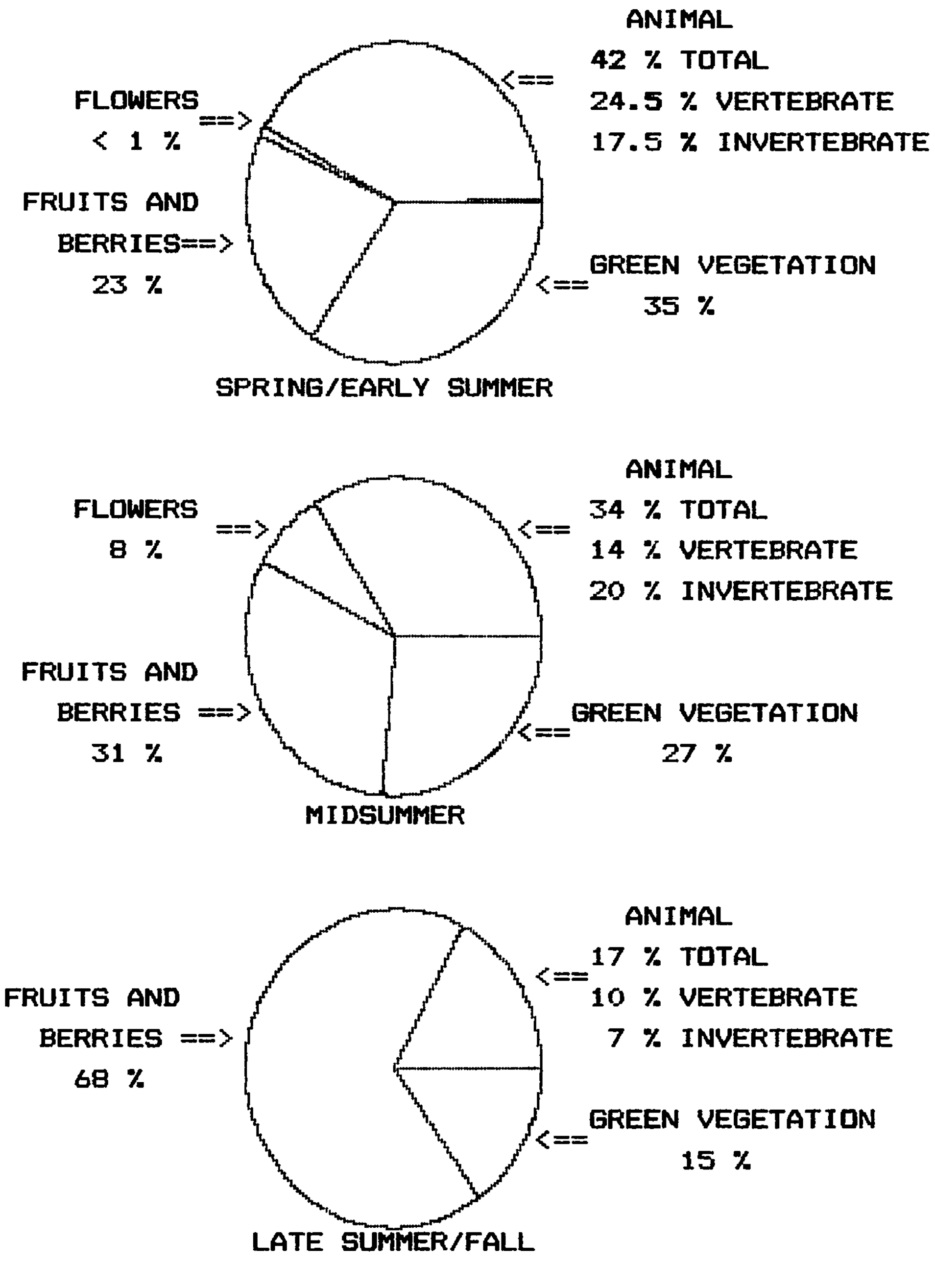


Fig. 4. Black bear seasonal food habits based on percent of total food occurrences in scats accounted for by each food type. All study areas and years combined. (Numbers rounded to nearest whole percent, n=488.) 1979 - 1983, KNWR, Alaska.

collected in the 1969 burn area were collected in 1982, except for 7 which were collected in 1983. These 7 were analyzed along with the 1982 scats from the 1969 burn area. For comparison, data are presented for the 1947 burn area for all years (Fig. 5) and for each burn area for 1982 only (Figs. 6 and 7). Very few differences between years occurred in the overall combined data. Also, food type occurrences for 1982 in the 1947 burn area (Fig. 6) were quite similar to food type occurrences for all years combined in that area (Fig. 5). As observed in the overall combined data, bears in both burn areas shifted from animal and green vegetable matter to fruits and berries between spring/early summer and late summer/fall.

Generally, the same food items, in the same or nearly the same order of frequency of occurrence, appeared in both the 1982 (Table 12) and overall data (Table 11) for the 1947 burn area. One exception is the absence of flowers in the 1982 scats.

Certain differences in the percent of occurrences accounted for by each food type and individual food items were evident between the 2 burn areas (Tables 11, 12 and 13). Most notable were differences during spring/early summer. For example, in 1982, green vegetation, principally Equisetum, made up over half of the total food occurrences in the 1969 burn area, 14% more than the proportion of green vegetation occurrences in the 1947 burn area while fruit and

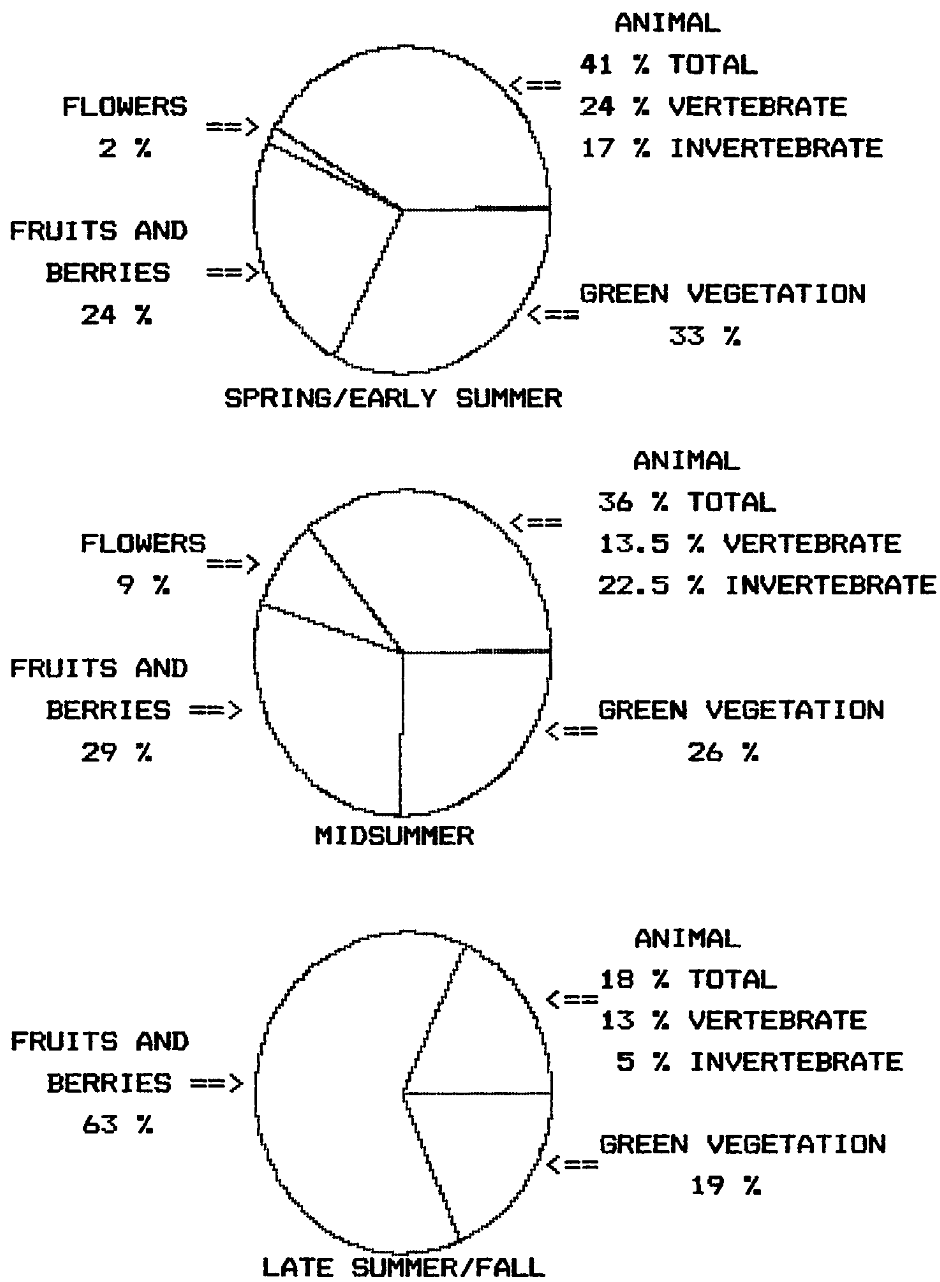
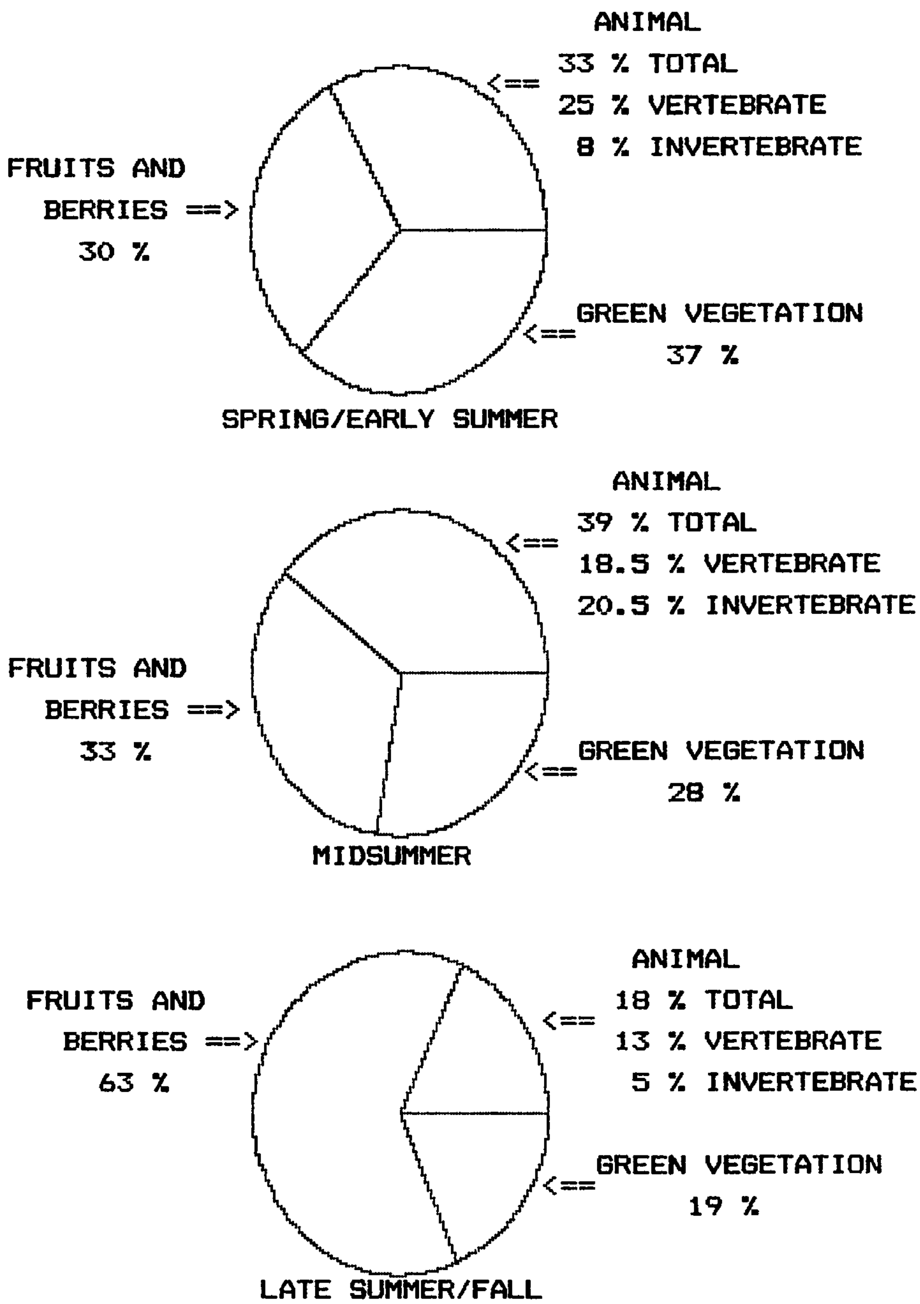


Fig. 5. Black bear seasonal food habits based on percent of total food occurrences in scats accounted for by each food type. 1947 burn study area, including summer feeding area, all years combined. (Numbers rounded to nearest whole percent, n=377.) 1979 - 1983, KNWR, Alaska.



(No scats were collected in this area during late summer/ fall in 1982. Combined data for other years for this area and season are presented for comparison to other areas.)

Fig. 6. Black bear seasonal food habits based on percent of total food occurrences in scats accounted for by each food type. 1947 burn study area, including summer feeding area, 1982 only. (Numbers rounded to nearest whole percent, n=90.)

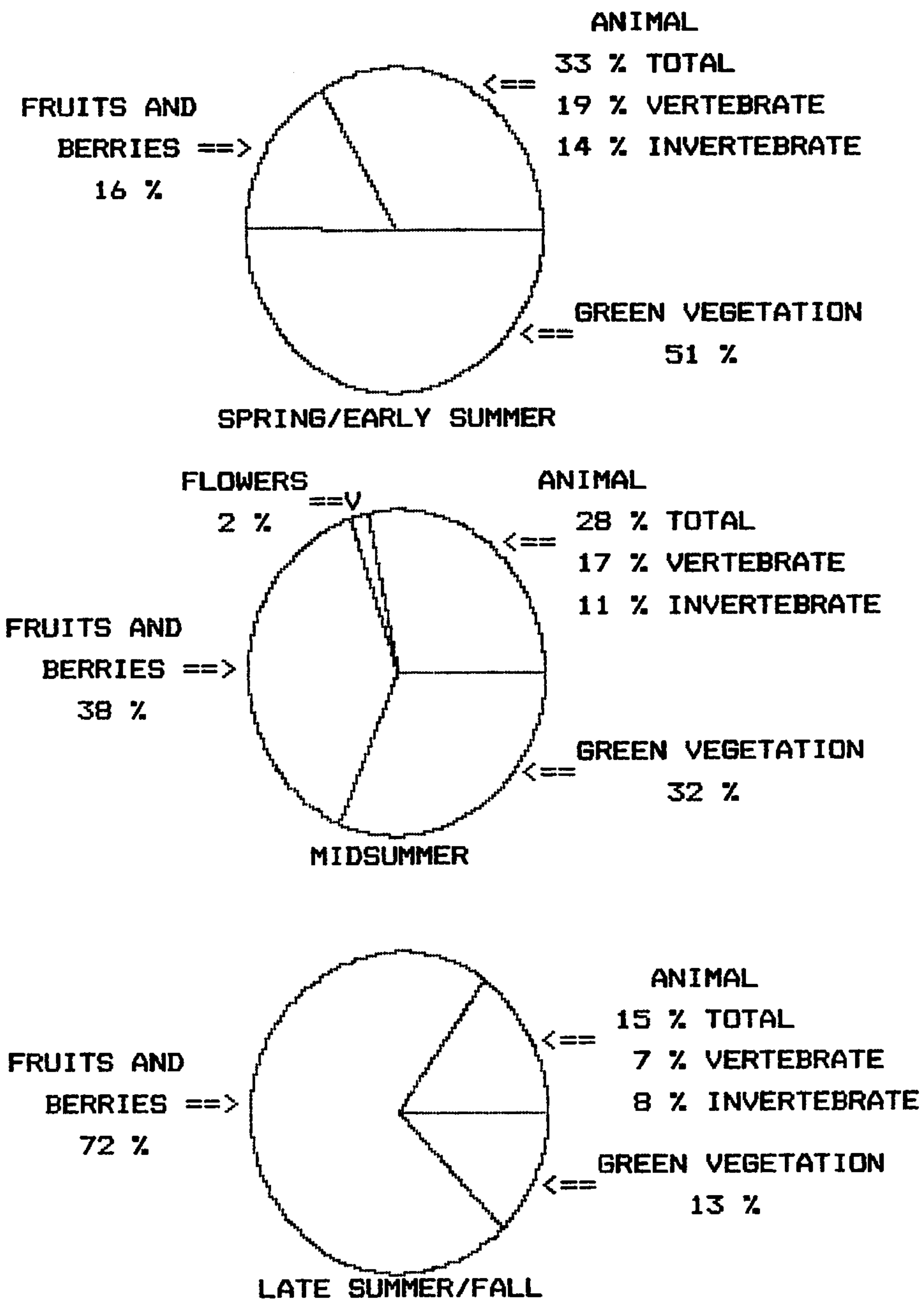


Fig. 7. Black bear seasonal food habits based on percent of total food occurrences in scats accounted for by each food type. 1969 burn study area, including summer feeding area, 1982 only. (Numbers rounded to nearest whole percent, n=106.) KNWR, Alaska.

Table 11. Seasonal frequency of occurrence of most frequently occurring individual food items in black bear scats collected from 1979 through 1983 on the KNWR, Alaska. 1947 burn study area, including summer feeding area, all years combined. (Numbers rounded to nearest whole percent, n = 377.)

Spring/early summer		Midsummer		Late summer/fall	
Item	% Freq. Occur.	Item	% Freq. Occur.	Item	% Freq. Occur.
Lowbush Cranberry	84	Insects	71	Lowbush Cranberry	88
Equisetum spp.	62	Lowbush Cranberry	41	*Menziesia* leaves	31
Insects	56	*Equisetum* spp.	37	Rosehips	29
Moose	53	Clover leaves/ stems	37	Moose	28
Grass/Sedge	33	Devil's Club berry	33	Devil's Club berry	16
Snowshoe Hare	15	Moose	31	*Cornus* berry	14
Clover leaves/ stems	14	Clover flowers	29	Raspberry	10
Birds	13	Twisted-Stalk berry	14	Cloudberry	10
Insect larvae	6	Snowshoe Hare	11	Birds	9
Cottonwood leaves	4	Twisted-Stalk leaves	8	*Equisetum* spp.	9
				Insect larvae	9
Remaining Foods <4% each		Remaining Foods <8% each		Remaining Foods <7% each	

Table 12. Seasonal frequency of occurrence of most frequently occurring individual food items in black bear scats collected on the KNWR, Alaska. 1947 burn study area, including summer feeding area, 1982 only. (Numbers rounded to nearest whole percent, n = 90.)

Spring/early summer		Midsummer		Late summer/fall[a]	
Item	% Freq. Occur.	Item	% Freq. Occur.	Item	% Freq. Occur.
Lowbush Cranberry	90	Insects	58	Lowbush Cranberry	88
Equisetum spp.	67	*Equisetum* spp.	56	*Menziesia* leaves	31
Moose	45	Devil's Club berry	40	Rosehips	29
Grass/Sedge	36	Moose	38	Moose	28
Snowshoe Hare	26	Lowbush Cranberry	27	Devil's Club berry	16
Insects	26	Twisted-Stalk berry	21	*Cornus* berry	14
Birds	7	Twisted-Stalk leaves	17	Raspberry	10
Twisted-Stalk leaves	5	Snowshoe Hare	15	Cloudberry	10
"Moss"	5	Grass/Sedge	10	Birds	9
Blueberry	2	Raspberry	6	*Equisetum* spp.	9
Pedicularis spp. leaves	2			Insect larvae	9
Remaining Foods	None	Remaining Foods	<5% each	Remaining Foods	<7% each

[a]No scats were collected in this area during the late summer/fall season in 1982. Combined data for all other years for this area and season are presented for comparison.

Table 13. Seasonal frequency of occurrence of most frequently occurring individual food items in black bear scats collected on the KNWR, Alaska. 1969 burn study area, including summer feeding area, 1982 only. (Numbers rounded to nearest whole percent, n = 106.)

Spring/early summer		Midsummer		Late summer/fall	
Item	% Freq. Occur.	Item	% Freq. Occur.	Item	% Freq. Occur.
Equisetum spp.	92	*Equisetum* spp.	71	Devils Club berry	98
Moose	38	Devil's Club berry	36	Twisted-Stalk berry	73
Lowbush Cranberry	35	Snowshoe Hare	29	Insects	19
Insects	31	Insects	21	*Equisetum* spp.	19
Grass/Sedge	19	Twisted-Stalk berry	21	Red Elderberry	15
Birds	4	Highbush Cranberry	21	Raspberry	14
		Spruce cambium	21	Fish	12
		Lowbush Cranberry	14	Cloudberry	8
		Northern Black Currant	14	Grass/Sedge	8
		Birds	14	Spruce cambium	8
		Insect larvae	14		
Remaining Foods	None	Remaining Foods	<7% each	Remaining Foods	<7% each

berry occurrence in the 1969 burn area was only about 1/2 that in the 1947 burn area. Animal occurrence though, was identical for both areas during spring/early summer 1982. Midsummer and late summer/fall in both areas were very similar on a food type occurrence basis.

During 1982, 5 scats were collected in areas adjacent to the 1947 and 1969 burn areas that were not part of the summer feeding areas. The small sample size didn't allow a separate analysis of these scats, but data from them were included with the overall combined study data (Table 9, Appendix IV). These scats contained only items which also occurred many times in other scats and were therefore not regarded as different or "unusual" in any way.

Most scats contained small amounts of 1 or more non-food items. These items, not regarded as dietary components, were often a clue to the animal's feeding behavior. One example was the frequent occurrence of wood chips in scats containing ants. Obviously, both were consumed when bears ingested ants from logs and stumps that the bears had torn apart.

Of the 35 items considered to be food, some occurred very rarely, and many others never occurred during certain seasons. Red currant (Ribes triste) occurred in only 1 scat throughout the entire study while lowbush cranberry appeared in 286 scats. In the 1969 burn area, during spring/early summer of 1982, only 6 different food items comprised the entire diet and only 4 occurred in more than 30% of the scats. On the other hand, during late summer/fall of the same year and area, 22 different foods occurred in scats (Table 13). Food items were grouped into 4 separate types. Non-food items were grouped into 3 separate types.

Fruits and Berries

Fruits and berries of 15 species comprised this type. All occurrences were considered food occurrences. Except for lowbush cranberry, devil's club berry and twisted-stalk berry, no species occurred in more than 5.5% of the scats (Table 9).

Virtually all black bear food habits studies have concluded that fruits and berries of some sort (and mast in some areas) are an important food, at least during certain seasons. Black bears lack a cecum and have acidic, simple stomachs which can't support microorganisms needed for cellulose digestion. Therefore, berries, which are relatively digestible, with concentrated nutrients, are a very desirable food (Rogers 1976).

In Alaska, Chatelain (1950), Erickson (1965), Hatler (1967), McIlroy (1970), Modafferi (1982) and Miller (1983) all reported high berry use by black bears, particularly in late summer and fall.

Lowbush Cranberry - In many areas, particularly certain mature deciduous stands, lowbush cranberries grow in lush carpets of thick clusters next to the ground, allowing bears to consume large quantities easily. The berries commonly persist through winter and some remain until the next crop ripens. Hatler (1967) reported that these berries are "quite durable throughout most of the berry season." Completely or nearly whole berries frequently occurred in scats and only rarely were the berries so altered by digestion that identification was difficult. Therefore, the amounts of lowbush cranberry in scats was a relatively good reflection of the amounts actually consumed.

Lowbush cranberry occurred in more scats than any other food item (286 of 488) (Table 9). In 37% of the scats where it occurred, >1/4 of the volume of the scat was lowbush cranberry, and in 21% of those scats >1/2 was lowbush cranberry. Lowbush cranberry accounted for 17% of all food occurrences during the entire study.

Lowbush cranberry was the only berry to occur above extremely low frequencies and volumes during spring/early summer (Tables 10, 11, 12 and 13). These berries probably play their most important dietary role during spring/early summer. They are available to bears immediately upon den emergence and provide a food base until other foods become available. Overall, lowbush cranberries appeared in 78% of the spring/early summer scats, and even in the 1969 burn area, where they are substantially less abundant, they occurred in 35% of the spring/early summer scats (Tables 10 and 13).

Schwartz et al. (1983a) speculated that little or no snow cover during the winter of 1980-81 left lowbush cranberries exposed to the elements and greatly reduced their availability during the spring/early summer of 1981. Indeed, vegetative damage to the plants was obvious and extensive throughout the study site that year. However, data show that 74% of the scats from spring/early summer of 1981 contained lowbush cranberry. This frequency is very similar to the overall frequency of occurrence for this food (Table 10).

Overall occurrences during midsummer dropped to <1/2 of spring/early summer levels in all areas, as other foods became more available. Scat volumes also decreased greatly, with 78% of the midsummer occurrences at the tr.-5% level (Table 10).

In the 1947 burn area, late summer/fall occurrences and volumes again rose as the year's lowbush cranberry crop ripened. Eighty-eight percent of all scats contained lowbush cranberry, with 62% of those occurrences at volumes >75% (Table 11). Yet, in the 1969 burn area, the berry occurred only once in 62 scats. Its dietary role in this particular season in the 1969 burn area was insignificant.

Chatelain (1950), Hatler (1967), McIlroy (1970), Rogers

(1976), Lloyd and Fleck (1978), Zytaruk and Cartwright (1978), Modafferi (1982), and Miller (1983) all refer to heavy use of berries of the genus Vaccinium by black bears. None, however, single out the species V. vitis-idaea as occurring more often than other species of the genus. In some cases, perhaps species within the genus were not differentiated from one another. In other cases, the abundance of V. vitus-idaea relative to other species of the genus may have been low. In this study, with the exception of 4 occurrences of blueberry (V. uliginosum), all occurrences of Vaccinium were V. vitis-idaea. Blueberry production on the northwestern Kenai Peninsula is both low and sporadic. Hatler (1967) speculated that the largest amount of nutrition per berry is derived from the juice, and therefore juicier berries such as blueberries, when available, will be chosen over lowbush cranberry.

Despite a high overall occurrence in scats, black bears did not seek out large amounts of lowbush cranberries where they were not particularly abundant. With the possible exception of the spring/early summer season, lowbush cranberry should not be considered an "essential" food item. In view of the great variety in the black bear diet, and the variety of flora and fauna throughout the black bear's extensive range in North America, there is probably no single food item that should be regarded as absolutely essential. In general, on the northwestern Kenai Peninsula, black bears made heavy use of lowbush cranberry where it was readily available. Where it was not readily available, black bears ate lesser amounts of it.

Devil's Club - Devil's club occurs in association with old growth forests, particularly large cottonwood stands. Black bears on the study site traveled as far as 34 km to such areas (Schwartz et al. 1983a), spending several weeks feeding on devil's club berries. The extreme density and spiny stems that characterize devil's club thickets did not appear to discourage black bears. An abundance of scats and numerous telemetry locations in these areas indicated feeding activity to be quite high.

Devil's club berries grow in a single cone-shaped cluster atop the plant's spiny stalk, usually 1-2 m above the ground. The uppermost portion of stalk, to which the berries are attached, is free of spines. It appeared that bears usually wrapped their mouths around this upper portion and stripped the entire cone of berries at once, efficiently collecting maximum food with minimum effort. Devil's club berries generally ripen between mid-July and mid-August, well before lowbush cranberry and most other berries on the study site. The berries on the top of the cone ripen first, and in many cases, black bears stripped only the top portion of the cone, leaving the unripened berries still on the plant. Devil's club berries are tough-skinned, pulpy and contain large seeds (2 per berry). Therefore, scat volumes are relatively good indicators of the volumes consumed.

Devil's club berry appeared in 1/4 of all scats examined with most occurrences concentrated in the latter part of midsummer and in late summer/fall. In both the 1947 and 1969 burn areas, the berry was among the top 5 most frequently occurring foods in both seasons (Tables 11 and 13). Scat volumes were also high (Table 9). In 71% of the occurrences, devil's club constituted >1/2 of the total scat volume.

Clark (1957) found that brown bears on Afognak Island made very high use of the berry, especially in August, noting that "bumper crops" of the berry were produced yearly. Poelker and Hartwell (1973) reported that devil's club berry was eaten by black bears in Washington. Black bears eat devil's club berry in coastal British Columbia (Lloyd and Fleck 1978). Black bears along the Susitna River in southcentral Alaska also make frequent use of the berry (Miller 1983).

Although their distribution is spotty, devil's club berries are usually extremely abundant where they do occur. The timing of devil's club berry availability and its abundance play an important role in providing black bears with a substantial food base.

Twisted-Stalk - Like devil's club berry, twisted-stalk berry is associated with old growth forest, and usually found in well-shaded areas. Unlike devil's club however, twisted-stalk is never found in high densities, and there are relatively few berries on each plant. Twisted-stalk berries dangle singly beneath the leaves of the plant, usually not more than 1 berry under each leaf. Many plants hold only a few berries, others perhaps 20 or more. This berry is not pulpy, has a very high water content, is thin-skinned and has small seeds. Therefore, digestive effects are great, and the low scat volumes are not correctly indicative of the volumes consumed.

Twisted-stalk berries occurred in 14% of all scats and 40% of all late summer/fall scats (Tables 9 and 10). Some use occurred in midsummer also, as many of the berries are ripe before mid-August. McIlroy (1970) reported bears feeding on this berry near Prince William Sound, Alaska. Twisted-stalk berry appeared in more 1969 burn area scats than 1947 burn area scats (Tables 11 and 13). Perhaps the berry was simply more abundant in the old growth areas visited by 1969 burn area bears. No sort of estimate was made as to the exact abundance of this berry. Scat volumes of this food were low. Virtually all occurrences accounted for <6% of total scat volume. The relative scarcity of this plant and the low number of berries on each require that more time and effort be expended by bears to obtain any sizeable amounts of the berries than are required for lowbush cranberries or devil's club berries. With the exception of these 2 species though, twisted-stalk berry occurred more frequently than any other berry. This berry was apparently taken whenever encountered, but its scarcity probably makes it more of a supplemental food than a staple.

Rosehips - Fruits of Rosa acicularis and R. nutkana are generally common throughout the 1947 burn and old growth areas by early in late summer/fall. This is not so in most of the 1969 burn area, especially those areas that actually burned. Rosehips are extremely pulpy with many large seeds and heavy skins. Digestive effects on volume are relatively small. The low scat volumes are a good indication of low volumes consumed. Overall, rosehips occurred in 5.5% of all scats (Table 9). They appeared in 29% of the 1947 burn area late summer/fall scats in 1982 and 18% of all late summer/ fall scats from the 1947 burn area. Rosehips occurred in <7% of 1969 burn area late summer/fall scats and only once in the other seasons combined (Tables 11, 12 and 13). Most volumes in scats were low (78% at <1/4 of total volume). As with twisted-stalk berry, rosehips probably serve as a supplement to the diet when and where available. Rosehips are far more common on the study site than are twisted-stalk berries, yet they were eaten less often, suggesting that black bears preferred twisted-stalk.

Raspberry - Ripening in August, Rubus idaeus is variably abundant within mature forests and particularly abundant on the edges of these forests. This species does not appear often in burned areas of the 1969 and 1947 burn areas. Scat volumes of this food were generally low. Actual consumption volumes were probably somewhat higher as the berries are very thin-skinned and juicy.

Overall, use of this berry was light. It occurred in only about 4% of all scats (Table 9). Seasonally it occurred in 12% of all late summer/fall scats and 14% of 1969 burn area late summer/fall scats (Tables 10 and 13). McIlroy (1970), Poelker and Hartwell (1973) and Beeman and Pelton (1980) all list species of the genus *Rubus* as black bear foods but also at relatively low frequency of occurrence and volume.

Cloudberry - Cloudberry, *Rubus chamaemorus*, was the only other member of the genus *Rubus* to occur in scats. While this species was common throughout moist, wooded areas of the study site, the berries themselves were never abundant. Ripening in late summer, cloudberries appeared in 8-10% of late summer/fall scats for all areas combined and for the 1969 and 1947 burn areas individually (Tables 10, 11 and 13). Scat volumes were nearly all at the tr.-5% level. Being similar to raspberries in structure, cloudberry scat volumes are below consumption volumes, but still, this berry does not appear to be of great dietary importance.

All Other Berries - Berries of all other species occurred in <3% of all scats and at scat volumes usually below 6% (Table 9). The highest occurrences of these remaining berries were red-berried elder (Sambucus racemosa), which occurred 13 times in 488 scats and highbush cranberry (Viburnum edule) which occurred 11 times. Elder berries also occurred in low frequency in Washington bear diets (Poelker and Hartwell 1973). Schwartz and Franzmann (1980 and 1981) speculated that highbush cranberry was a major food of black bears on the Kenai lowlands. The very infrequent occurrence of this berry in scates indicates that highbush cranberry was not a major food item, at least from 1979 through 1983.

Numerous authors, including Chatelain (1950), Tisch (1961), McIlroy (1970), Zytaruk and Cartwright (1978), Modafferi (1982), and Miller (1983) note blueberries as an important black bear food. Hatler (1967) in particular emphasized the important dietary role blueberries play in interior Alaska. Both Vaccinium ovalifolium (early blueberry) and V. uliginosum (alpine blueberry) occur on the northwestern Kenai Peninsula. However, in the 5 years that scats were collected on the study site, these berries appeared only 4 times. While the situation in alpine zones may be quite different, blueberry crops on the Kenai lowlands are generally very low. Good production of blueberries is sporadic, both spatially and temporally.

The berries of Cornus canadensis appeared in 8 scats during the study. These berries are very mealy and have a single large stone. Occurring most abundantly in mature deciduous stands, Cornus canadensis did not appear to be a very important food item.

Crowberry (Empetrum nigrum) is a commonly occurring item in the interior Alaska black bear diet (Hatler 1967), but in this study only 4 scats contained the berry, none at high volumes. The situation seems very similar to that of blueberries with abundance generally low in the lowlands.

Northern black currant (Ribes hudsonianum), trailing black currant (R. laxiflorum), northern red currant (R. triste) and timberberry (Geocaulon lividum) occurred 4, 2, 1 and 2 times respectively. These species are all relatively common throughout the study site but usually at low densities. They were eaten rarely by black bears and were of minimal importance in the diet.

Flowers

Overall, flowers formed a very small portion (2% of all food occurrences) of the black bear diet during this study. No flowers occurred in scats during 1982 in the 1947 burn area, and they only occurred in scats during midsummer of that year in the 1969 burn area. Flowers did not occur in any scats during late summer/fall. Only 2 species were represented in scats.

Clover - Clover (*Trifolium* spp.) is not native to Alaska (Hultén 1974). Within the study site, it has sometimes been used to revegetate roadside areas. Over 84% of all flower occurrences in scats in this study were clover. Twenty-four of those occurrences were during 1980. Clover flowers occurred in 7.8% of all scats (Table 9). Most occurrences (82%) were during midsummer and 18% were during spring/early summer. Most scats containing clover were found within the 1947 burn area (Table 11). No scats contained >50% clover and 71% of the occurrences of clover were at tr.-5% levels. At least some, and usually large amounts of, clover leaves and stems were present in scats containing clover flowers.

Spencer (1955) and Tisch (1961) reported clover flowers in summer black bear scats. Most scats in this study that contained these flowers were found on or near roads. Jonkel (1961) described a thirteenfold increase in black bear use of roadsides seeded with clover compared with non-seeded roadsides. Tisch (1961) also noted a relationship between clover and roadside feeding.

Why use of this food was so concentrated in time and area may simply be the result of a greater number of scats being collected in clover areas during 1980. Also, there are only very few, small areas containing clover within the study site. It is possible that a single bear happened to be occupying a specific clover-rich area one year, made heavy use of the food, left many scats and was not in the area other years. The seasonal concentration of bear use of clover may coincide with peak nectar production of the flowers.

Pedicularis - Several species of Pedicularis occur commonly within the study site. Although identification to the species level was not positive, it appeared that the scat remains were P. labradorica.

Pedicularis flowers occurred only 7 times in 488 scats, always in June (Table 9). In all but 1 case, stems and leaves were also present. Scat volumes were low.

Hatler (1967) noted small amounts of Pedicularis in black bear scats. Pedicularis flowers were a very minor part of the black bear diet during this study.

Green Vegetation

This type basically encompasses all non-flowering, non-fruit portions of plants. As is the case with berries, virtually all bear food habits studies show that green vegetation forms a large portion of the black bear diet, particularly in spring and early summer. Many studies including Hatler (1967), McIlroy (1970), Schaffer (1971), and Grenfell and Brody (1983) depict this food type as the overwhelming component of the black bear diet.

Green vegetation occurred often and, in many cases, in high scat volumes in this study (Table 9). However, data suggest that this group was not substantially more important than other food types (except flowers). Green vegetation did account for more food occurrences than any other type for spring/early summer in 1982 at both the 1947 and 1969 burn areas, but even these occurrences were less than those reported in other studies (Tables 12 and 13).

Green vegetation undergoes relatively little change in either volume or overall appearance as it passes through the black bear's digestive system (Hatler 1967). Therefore, volumes in scats fairly accurately reflect the volumes consumed, certainly more so than with any other food type.

Most green vegetation food items, especially early in the growing season, provide relatively high levels of protein and relatively low levels of non-structural carbohydrates and fats (Modafferi 1982). In addition, there are numerous items of this type that are widely abundant and readily available.

In this study, 21 green vegetation items occurred in scats. Of these, 11 were never counted as food. These were items which were taken incidentally by bears or things accidentally picked up by the collector during scat collection. Two other items were counted as food only in certain cases.

Equisetum spp. (Horsetail) - At least 7 species of this widespread genus occur within the study site. Perhaps the greatest value of Equisetum as a food is its wide distribution, early availability and abundance. Equisetum is very old evolutionarily (Curtis 1975) and is well adapted to a wide variety of habitats and conditions. Within the study site it is virtually everywhere. Also, it is one of the very first plants to sprout in the spring, many weeks before some plants.

While identification of Equisetum to the genus level was easy, identification to the species level was often difficult or not possible. E. fluviatile, E. palustre, E. silvaticum, E. pratense and E. arvense were all identified in at least some scats. E. arvense was the most common of those samples identified.

Equisetum is sometimes reported as part of "grass and sedge" foods or as a "grasslike" food item. Taxonomically, Equisetum and the grasses and sedges are only very remotely related (Hultén 1974). Outside of general outward appearance, Equisetum has little in common with grasses and sedges besides being a vascular plant. It is easy to differentiate this genus from grasses and sedges in scats, so Equisetum and grasses and sedges were recorded and are presented as different items.

Mealey (1975) calculated that Equisetum contained 15% protein with an apparent digestibility of 31%. Stelmock (1981) found 32 and 26% protein levels in Equisetum in samples from May and June respectively.

Equisetum occurred more often than any other green vegetation food (46.1% of all scats) and was second only to lowbush cranberry in overall food occurrences (Table 9).

Equisetum occurred in scats collected in all areas, and during all seasons. Its use was especially high during spring/early summer and in the 1969 burn area (Tables 10 and 13). Scat volumes were frequently high. Equisetum constituted >1/2 of the volume of 44% of the scats in which it occurred (Table 9).

As a bear food, Equisetum is most commonly reported in the northern and western sections of North America. Chatelain (1950), Tisch (1961), Hatler (1967), McIlroy (1970), Shaffer (1971), Zytaruk and Cartwright (1978), Modafferi (1982), and Miller (1983) found that Equisetum occurred very commonly in the black bear diet, especially before midsummer.

Grasses and Sedges - Members of the Graminae and Cyperaceae appear to be the most universally used of all foods throughout the black bear's range. Like Equisetum, grasses and sedges are widely abundant on the northwestern Kenai.

Grasses and sedges were the second most frequently occurring green vegetation food item in this study (19.1% of all scats) although many other foods occurred more often and in greater volumes in overall study data (Table 9). Not all occurrences of grasses and sedges in scats were counted as food. Twenty-seven percent were classified as incidentally ingested items or as items accidentally collected with scats. Based on microhistological analysis, Calamagrostis canadensis accounted for 76% of the grass and sedge occurences in scats. Festuca altaica and Hierochloe spp. each represented 5% of the occurrences. Carex spp. represented 14%. Scat volumes of grasses and sedges were relatively evenly distributed among the 5 scat volume levels with tr.-5% being the most common volume.

Although grasses and sedges appeared relatively often in scats collected throughout the study site, especially in spring/early summer (81% of grass and sedge occurrences), other studies showed grasses and sedges to account for much more of the black bear's diet. Frequencies of occurrence for grasses and sedges 2 to 4 times higher than in this study were reported by Tisch (1961), Hatler (1967), Zytaruk and Cartwright (1978), and Grenfell and Brody (1983). The equal or greater abundance of other, perhaps higher quality, foods appears to restrict this food's use mainly to spring/early summer and to levels lower than observed in many other studies.

Clover Leaves and Stems - Overall, 14.8% of the scats contained this food, approximately twice as many as contained clover leaves and stems along with clover flowers (Table 9). If flowers were present, they were consumed with the rest of the plant; if not, the non-flowering portion was eaten alone. The difference in the number of occurrences in flowering and non-flowering portions is apparently just a function of fewer plants having flowers when bears in this study were feeding on them.

Clover constituted >1/2 of the volume of 43 of the 72 scats in which it occurred. Differences in flower and non-flower volumes are probably a function of a greater portion of each plant being composed of non-flowering structures. Besides the differences noted above, the discussion on clover flowers as a food (page 84) applies here.

<u>Twisted-Stalk Leaves</u> - The young shoots and leaves of twisted-stalk, available mainly in midsummer, are tender and have an excellent cucumber-like flavor (Heller 1962 and personal observation). Unlike use of twisted-stalk berries, which occurred mainly in late summer/fall, most black bear use of the leaves occurred during midsummer and was not associated with berry use.

This food occurred 18, 3, 1, 1, and 2 times respectively in the different percent volume categories (from lowest to highest) (Table 9). This totals <1/2 of the berry occurrences in scats for this species. More berries occurred in scats from the 1969 burn area than from the 1947 burn area, but nearly all leaf occurrences were in scats from the 1947 burn area (Tables 11 and 13).

McIlroy (1970) detected no difference in berry and foliage use of this species by black bears in Prince William Sound, Alaska.

Twisted-stalk leaves were not an extremely important food by themselves in this study, but along with other foods which did not occur extremely often or in high volumes, they helped supplement the overall diet before fall berry crops became available.

Menziesia Leaves - This species occupies a narrow range in southcentral and southeastern Alaska and northwestern Canada. Unlike some other members of the Ericaceae, the leaves of *Menziesia ferruginea* are thin and tender.

Leaves of *Menziesia ferruginea* appeared in 19 (3.9%) scats (Table 9). All occurrences were from the 1947 burn area, and except for 1 occurrence in spring/early summer, all were from late summer/fall. No flowers or fruits of this species occurred in scats. While volumes of these leaves in scats were generally low, enough leaves were present in the scats to indicate that they were not ingested incidentally. They had also obviously been chewed and appeared fresh, indicating they had been picked directly from the bush.

M. ferruginea glabella, a Rocky Mountain variety of the species (Hultén 1974) was eaten infrequently by black bears in northwestern Montana (Tisch 1961). However, that use involved only blossoms, which did not occur in scats in this study. It apparently is eaten as a supplement to major foods.

Spruce Cambium - In other areas of the black bear's range, bears feeding on the cambium of coniferous trees has led to serious forest depredation problems (Levin 1954, Poelker and Hartwell 1973). Tisch (1961) discussed cambium feeding at length. Within my study site, Lutz (1951) reported that he "repeatedly encountered" white spruce and aspen trees that had been fed upon by bears. In white spruce habitat, he found that 25 to 50 trees per ha had been partially stripped of the lower bark and portions of the cambium scraped away, as evidenced by teeth grooves in the soft plant tissue. In some localized areas, he reported "much higher" occurrences of such feeding. I noted both white and black spruce stripped of bark and fed upon.

Wood fibers composed very high proportions of both scats and stomach contents in certain areas of Washington (Poelker and Hartwell 1973).

Spruce cambium occurred in only 2% of all scats (Table 9) and never composed more than 1/4 of the scat volume in this study. Spruce cambium occurred in scats from all areas and during all seasons.

Cottonwood Leaves - Leaves and buds of *Populus balsamifera* occurred in only 2% of all scats (Table 9). This item is apparently very desirable to some bears though. Schwartz, Spraker and local hunters (pers. commun.) have reported black bears far out on the upper limbs of cottonwood trees feeding on the waxy buds and young leaves of this tree, especially in May and June when 9 of the 10 occurrences in this study took place. One scat contained more than 75% cottonwood leaves by volume. All other occurrences were below 50% volume.

Pedicularis Leaves - The discussion of *Pedicularis* flowers (page 85) applies essentially verbatum here.

"Moss" - Trace levels of *Sphagnum* spp., club mosses, and feather mosses occurred in over 11% of all scats (Appendix IV). These were often wilted fragments and were not counted as food. However, 3 occurrences of *Sphagnum* moss, 2 in June and 1 in July, represented items that appeared intentionally consumed. Large clumps of fresh moss that appeared to have been uprooted were present in these scats. The moss was relatively unaffected by digestion and perhaps simply provided some "roughage" in the diet.

Lowbush Cranberry Leaves - Lowbush cranberry leaves were never counted as food although they occurred in more scats than any other single item in the entire study (60.2% of all scats) (Appendix IV). Ninety percent of the occurrences were at scat volumes <25% and none of the small, thick leaves ever appeared to be even partially digested. Most of the leaves were brown, some partially decayed, indicating they were inadvertently picked from the ground by the bear or the scat collector. One point of interest is the difference in the frequency of occurrence of these leaves in spring/early summer compared to late summer/fall scats. Most lowbush cranberry consumption occurred during these 2 seasons. In spring/early summer, overall, 84% of all scats contained lowbush cranberry leaves, but overall during late summer/fall, these leaves appeared in only 35% of all scats. Apparently bears can gather up meals of newly ripened fall berries much more efficiently than leftover spring berries. It appears that bears have to "scrounge" more for a berry meal during spring/early summer. The crop will obviously be somewhat less abundant during spring and early summer, and many berries may be lying on the ground by then.

Devil's Club Leaves and Stems - Despite the spiny structure of devil's club leaves and stems, small amounts often appeared in scats along with the berries. Their consumption was classified as incidental to taking devil's club berry, and no occurrences were counted as food.

All Other Green Vegetation Items - Ten other items occurred which were never counted as food items. Hatler (1967) and McIlroy (1970) also encountered many items in scats which they did not count as food items. Although spruce needles occurred in 50.6% of all scats, the needles were nearly always brown, indicating they had been picked up from the ground. The only scat volumes above tr.-5% occurred in scats which also contained spruce cambium and were probably incidentally ingested as bears licked the inner portion of stripped bark which was lying on the ground.

The leaves of Labrador tea (Ledum palustre), birch, willow, Cornus canadensis, alder, twinflower (Linnaea borealis), and Geocaulon lividum occurred in very low volumes and most, very infrequently. Again, the leaves were unusually brown and often partially decomposed.

Small fragments of ferns (Pteridophyta) and lichens also appeared in trace quantities in a few scats.

Animal

The incidence of animal matter in scats, particularly vertebrates, from this study is far greater than has been previously observed in other black bear food habits studies. There were 300 vertebrate occurrences alone in 488 scats, along with 256 invertebrate occurrences. Twenty-five scats contained both mammal and bird remains, 3 contained both mammal and fish remains and in 1 instance, mammal, bird and fish remains all occurred in the same scat. Animal matter accounted for 34% of all food item occurrences and 42% of all spring/early summer food item occurrences. Hatler (1967) concluded that bears prefer meat over anything else but that they cannot obtain it consistently. In this study, animal matter appeared regularly in black bear scats, and particularly often during spring/early summer. Animal matter certainly is the most concentrated protein source available to bears.

Digestive reduction of volume between ingestion and scat is greater for animal matter than for any other food type. Volumes of animal matter in scats are often far less than volumes consumed (Hatler 1967). In grizzlies, digestibilities for protein and fat have been shown to be 92.2% and 91.8% respectively (Bunnell et al. 1978). The volume changes in vertebrate food items are especially pronounced. A dozen hairs in the scat can potentially represent several kilograms of consumed meat. Fortunately, hair, claws, hooves, chitin and to some extent bones are resistant, and their appearance in scats allows identification to be made. The scat volumes though are generally a very inaccurate reflection of volumes consumed.

The animal matter food type is comprised of 9 different items. Only some occurrences of 3 items (insects, insect larvae and black bear) were counted as food.

<u>Moose</u> - Moose densities on the northwestern Kenai Peninsula are very high. Twinning rates among cows are also high, especially in the 1969 burn area (Bangs and Bailey 1980, Franzmann et al. 1984).

Moose occurred in 175 (35.9%) of the scats. It was the fourth most frequently occurring food item during the entire study (Table 9). Of all occurrences in scats, 109 were calves, 49 were adults and 17 were of undetermined age. Moose occurrence was consistently highest during spring/ early summer in all areas, although moose did appear in scats during all seasons. In the 1947 burn area, 53% of all spring/early summer scats contained moose (Table 11). Moose appeared less often in the 1969 burn area scats. Still, it occurred in 38% of spring/early summer scats there, and was the second-most frequently occurring food item in that season (Table 13). The majority (78%) of moose occurrences were at scat volumes below 25%. As mentioned above though, the actual volumes consumed were undoubtedly far greater than scat volumes would indicate.

Moose occurrence in scats declined after spring/early summer, but 27% of midsummer scats still contained moose, most of which was non-carrion calf. Most late summer/fall occurrences, which totalled 15 in 123 scats, appeared to be from "clean up" activities during and after the September moose hunting season. These scats contained many short, stiff hairs such as grow on the moose's head and lower legs which hunters normally leave with the entrails.

On the Kenai Peninsula, Culver (1923), Palmer (1939), Sarber (1944) and Chatelain (1950) all reported moose remains as common in black bear scats, especially in May and June. Cooney (1943) described black bears in Montana as common moose predators. Hatler (1967) reported a few occurrences of moose in scats from interior Alaska, but determined them to be from carrion. On the contrary, more moose occurrences in this study were non-carrion than carrion. In this study, 59 moose occurrences were determined to be carrion, based mainly on the presence of maggots and/or the presence of long winter guard hairs in midsummer or later scats, indicating that the moose had to have died earlier in the year. Another 17 occurrences were of unknown status. Ninety-nine scats contained moose calf remains with no signs that these were carrion. Even if all 17 undetermined occurrences are counted as carrion, the non-carrion total is still over 30% greater than the carrion total.

In other studies, determination of whether or not moose in scats was carrion rested partly on the appearance of the item, e.g., accompanied by maggots, and partly on speculation. The role of speculation was greatly reduced in this study by results of moose calf mortality studies conducted throughout the study site (Franzmann et al. 1980, 1984; also see Predation section, page 113). In both the 1947 and 1969 burn areas, black bears killed approximately 35% of the annual moose calf crop, with predation being heaviest within approximately 1 month of calving. The high incidence of moose calf remains in spring/early summer scats coincides well with heavy predation during this period. Also, winters since 1978-79 on the study site have been mild, with low precipitation and no extended periods of cold temperatures. These conditions have contributed to excellent winter moose survival and low numbers of winter-killed carcasses available in spring, further reducing the probability that moose remains in scats were from carrion. Observations by Franzmann et al. (1984) indicate that dead moose are frequently left untouched by black bears.

If results of other studies are accurate, then black bears on the northwestern Kenai Peninsula are unique both in the amount of big game meat eaten and in the way it is obtained. Moose is a major contributor to the high number of occurrences of animal matter in the spring/early summer diet and provides large amounts of highly digestible protein whenever eaten.

Snowshoe Hare - When abundant, snowshoe hares (*Lepus americanus*) can and do provide a source of high protein for black bears. Female hares commonly produce 2 litters per year and populations can grow rapidly (Rearden 1981).

The cyclical nature of Alaskan snowshoe hare populations is reflected in the occurrences of this food item in bear scats. One of the very few notable differences in year-to-year food consumption involves snowshoe hares. While hares occurred in 11.9% of all scats, only 4.7%, 3.3% and 8.6% of scats from 1979, 1980 and 1981 respectively, contained hare. Then in 1982, the level rose to 14.4% and in 1983 to 30% (Tables 11, 12 and 13). Over this same 5-year period, increasing numbers of hares could be observed in all areas of the study site, and the number of hare pellets and browsed twigs also appeared to rise sharply.

Hares occurred in scats during all seasons in all areas, although during spring/early summer they occurred most often in the 1947 burn area (Tables 11 and 12). Snowshoe hare constituted only tr.-5% of total scat volume in 76% of the scats in which it occurred. Consumption levels are greater than scat volumes, but the difference is not as pronounced as with moose since the amount of digestible meat relative to undigestible material in each hare is less than with moose.

Hatler (1967) reported that hares were common in the diet of bears in interior Alaska. He also noted that there was little evidence in scats as to whether or not the hares were carrion, but he suspected they were. R.D. Guthrie (pers. commun.) noted that red fox (*Vulpes vulpes*) sometimes cache large numbers of hares, and bears may happen across these caches. However, there are virtually no red fox within or near the study site (Bailey 1981). If scats for this study had been collected between 1975 and 1979 instead of 1979-1983, it might have been tempting to conclude that black bears rarely or never feed on hares when, in fact, their absence in the diet would have been a function of their scarcity in the community.

Birds - This food item includes feathers, feet, eggshells and egg contents. Because most (88%) of the bird occurrences formed <25% of the scat volume (Table 9) and remains were always fragmented, identification even to the genus level was not always possible. Of the 43 total bird occurrences, 13 were identified as spruce grouse (*Canachites canadensis*) chicks, 4 as spruce grouse adults, 5 each of adult and chick of unknown species and 7 of unknown age or species. A scat from a very old male black bear captured in the 1947 burn area on 2 June 1983 contained unspotted, white eggshell fragments, portions of shell membrane, and yolk. The curvature of the shell fragments indicated that the egg(s) had been large. The scat also contained several white adult breast feathers. Apparently, this bear had raided the nest of a trumpeter swan (*Olor buccinator*), relatively common on the study site. The adult feathers were probably part of the nest lining. Eight other scats, all from spring/early summer, contained shell fragments very similar to those found in this scat and were quite possibly swan also. Bears may have to swim to swan nests since swans often nest on small islands.

Over 60% of the scats with birds contained positively identified chick remains, eggshells or both. Sixty-eight percent of the occurrences were during spring/early summer.

These high proportions suggest that nesting birds comprise the largest source of this food item. In addition, spruce grouse are ground nesters making them all the more available. During June, I observed spruce grouse hens with broods of chicks almost daily.

Hatler (1967) reported that black bear predation of waterfowl eggs was quite common in interior Alaska. Rowan (1928) reported similar findings in northern Alberta. Tisch (1961) and Shaffer (1971) reported practically no bird remains in scats from northwestern Montana.

The high nutritional value of birds and their eggs apparently makes it worthwhile for bears to seek them out. However, the total amount of food available in small chicks, in particular, is low, and the availability of this food relative to many other food items is low.

Fish - Only a few streams on the study site receive runs of salmon (*Oncorhyncus* spp.), and these runs are relatively small. Only 9 scats contained salmon, 7 of which were collected during late summer/fall near a creek in the 1969 burn area which receives a small run of red salmon (*O. nerka*). The other 2 salmon occurrences took place in spring/early summer, also in the 1969 burn area, but it couldn't be determined which stream they may have come from (Table 13). Of the remaining 4 fish occurrences, 1 appeared to be sucker (*Catostomus* spp.) and the other 3 possibly Dolly Varden

(Salvelinus malma) or arctic char (S. alpinus), all 3 of which occur commonly within the study site.

Volumes of fish in scats were always low but are a very poor indication of volume consumed. Only rarely did anything except bones appear in the scat, and when meat type residue did occur it was in the form of "organic mud" (McIlroy 1970 and personal observation) which easily washed through even the smallest sieve.

In many coastal areas such as Prince William Sound, Alaska (McIlroy 1970, Modafferi 1982), and western British Columbia (Lloyd and Fleck 1978), fish make up a large portion of the black bear diet. Salmon are the most frequently reported fish.

Although fish, especially salmon, are an excellent source of both protein and fat, they are not available enough or are not used enough within the study site to be considered more than a "minor" food item.

Black Bear - Black bear hair occurred in 22.7% of all scats, nearly always in low volumes and, presumably, as a result of grooming (Appendix IV). Wright (1910) described black bears intentionally burying their forepaws in ant hills, then removing them and licking the ants out from among the hair of the paws. This behavior could result in the ingestion of hair.

In 8 cases, the volume of black bear hair in scats was high, and substantial amounts of bone and tissue were also present. These 8 scats were collected from the general vicinity of the carcass of a yearling male black bear which, all evidence indicated, had been killed by another black bear (Schwartz et al. 1983a). The yearling wore a radio collar and had been located 5 times before he died in 1980. He had appeared to be in good condition.

In June 1983, Schwartz (pers. commun.) located a radio-collared mature female black bear (with cubs), feeding on buds and leaves in a cottonwood tree. She was in good condition. Three days later, he located this bear again, this time several hundred meters from the previous location. She was dead and was being fed upon by a radio-collared mature male black bear who had apparently killed her. All evidence suggested that the female had not died in a fall from the tree she had been seen in.

Seton (1929) described cases of black bears killing and eating one another but stated that this practice was nearly as rare as cannibalism among humans. He didn't provide any evidence as to how he reached that conclusion though. Palmer (1939) mentioned cannibalism among Kenai black bears but implied that the bears themselves didn't do the actual killing. The killing and eating of cubs is noted by Erickson (1965).

Intraspecific killing is quite likely more of a socially related behavior than a feeding behavior, but making use of the large amounts of protein in the few available carcasses is a wise feeding strategy.

Red-backed Vole - Three occurrences of red-backed vole (Clethrionomys rutilus), all at trace scat volumes, occurred during the study (Table 9). All 3 occurrences took place during spring/early summer in the 1947 burn area. One of the best places to find red-backed voles is near old logs (Rearden 1981). Perhaps bears sometimes encountered voles when searching out insects in decaying wood. In any case, they appear to be of very minor importance as a bear food within the study site.

Insects - More than 95% of all insect occurrences were carpenter ants (Camponotus herculeanus) or field ants (Lasius spp.). A few occurrences each of beetles (Tenebrionidae), bees (Vespidae) and flies (Diptera) also occurred. Insects actually occurred in 257 (52.7%) of the scats; but only 224 occurrences were considered as food, the others appearing to have invaded the scat while it was on the ground. Scat volumes of this item tended to be low. Only 11% of the occurrences formed more than 25% of the scat (Table 9).

Insects occurred in scats from all areas and during all seasons, although midsummer, and July in particular, showed the highest level of occurrence. On an occurrence basis, insects were the highest ranking midsummer food for all areas combined and for the 1947 burn area (Tables 10 and 11). In the 1969 burn area they ranked fourth during that season (Table 13). The slightly higher occurrence in the 1947 burn area may be related to the time since the area was burned. Trees killed in the 1947 burn, of which there are many, are now in the proper stage of decay to house large colonies of ants. Most trees killed in the 1969 burn are still quite solid and fewer "ant homes" are available in the area. In addition, black bears can tear open older logs more easily.

Volumes of ants in scats, also highest during midsummer, were mostly below 25%. Even low volumes, though, are often composed of very large numbers of ants. Of the major animal foods, insects seem to undergo the least amount of volume reduction during digestion. Their chitinous exoskeletons pass through the gut relatively unchanged, although often fragmented. Ants in scats often appeared identical to live ants but close examination revealed that internal structures had been digested.

Insects have been reported as a common black bear food in Maine (Spencer 1955), New Brunswick (Zytaruk and Cartwright 1978), North Carolina (Landers et al. 1979), Tennessee (Beeman and Pelton 1980), Minnesota (Rogers 1976), Montana (Tisch 1961, Shaffer 1971), Colorado (Gilbert 1951), California (Grenfell and Brody 1983), Washington (Poelker and Hartwell 1973), and Alaska (Chatelain 1950, Hatler 1967, Miller 1983). Insects apparently were not important foods in Quebec (Juniper 1978), western British Columbia (Lloyd and Fleck 1978) or Prince William Sound, Alaska (McIlroy 1970, Modafferi 1982). Hatler (1967) interpreted the high number of ants, which are colonial, in scats where they occurred as meaning that high concentrations of insects are a prerequisite to use by bears. On the other hand, Wright (1910) and Tisch (1961) concluded that bears "relish" the flavor of ants, perhaps because of their formic acid content, and will expend effort to obtain just one. Rogers (1976) observed that 1 Minnesota bear spent 3/4 of its midsummer foraging time seeking out ants.

Ants are a very important food item on the study site. Ants are an especially valuable food because they are abundant when the availability of young moose calves and overwintered berries is decreasing and fall berries have not yet ripened.

Insect Larvae - Diptera larvae was the sole component of this item and occurred in 15.6% (76) of the scats (Table 9 and Appendix IV). However, in all but 32 cases, it was obvious that the plump, white larvae had not been consumed but had hatched in the scat. All food occurrences of this item appeared to be part of a carrion meal, and except for 2 instances, all scat volumes of larvae were at tr.-5%. The soft larvae were reduced in volume by digestion though, meaning that consumption volumes were somewhat higher. Entire nests of Vespid larvae, providing substantial amounts of animal protein, were consumed by bears in interior Alaska (Hatler 1967). In this study, larvae played a rather minor dietary role.

Snail - A single ingested snail was found in a scat from 10 September 1981. The scat also contained lowbush cranberry and Cornus berry. Obviously of no dietary importance in this study, the occurrence is reported just for the record.

Parasites - One occurrence of Toxascaris (Baylisascaris) spp., involving 3 individuals of this genus of nematode, was recorded for a scat from 16 August 1979. Rausch (1961) noted that this intestinal parasite was particularly common in late summer and fall. This scat also contained devil's club berry.

Sprent (1968) reclassified members of the genera Ascaris and Toxascaris in a new genus, Baylisascaris. Members of this genus have been reported in black bears from Ontario, Wyoming, Minnesota, Montana and Alaska (Rogers and Rogers 1976). Hatler (1967) found members of this genus, some of which were 150-180 mm long, in 9 bears. The occurrence in this study involved worms 80-100 mm long.

Miscellaneous Vegetation Fragments

This type included small fragments of leaves, twigs, roots and bark. Such fragments occurred in 34.6% of all scats (Appendix IV). Virtually all volumes of these items in scats were <6% of the total scat volume. Nearly always, these items appeared to be incidentally ingested or picked up accidentally at scat collection. At times they were probably minute portions of already identified items. No items of this type were considered food.

Debris

Wood chips and sand, dirt and gravel comprised this type. In all, 40.6% of all scats contained some or all of the above items (Table 9). All occurrences of wood chips, ranging from small slivers to chunks of about 1 cm^3, were in scats containing ants. This resulted from logs and stumps being torn apart by bears and partially eaten along with the ants in them. Soil of various sizes occurred sporadically and never appeared to have been ingested intentionally. No items of this type were considered food.

Bear Densities vs. Cranberry Densities

Estimated black bear densities within the 1947 burn area, range from 1 bear/3.9 to 1 bear/7.5 km^2; these densities are high compared to those reported from other areas in North America (Schwartz et al. 1983a). No formal density estimates currently exist for the 1969 burn area. However, indications are that the density of black bears there is similarly high. During the first 2 months of study in the 1969 burn area (spring 1982), 19 black bears were captured (Schwartz et al. 1983b). By March 1984 a total of 56 bears had been captured. Reproductive rates among the 1969 burn area population were high (Schwartz et al. 1984).

Black bear densities do not appear to be related solely to lowbush cranberry densities, on a study-area basis. Any differences in bear densities that may exist between the 1947 and the 1969 burn areas are certainly nowhere near the magnitude of difference in the lowbush cranberry crops in those areas. Food habits data indicate that bears simply eat less lowbush cranberry where it is not abundant, as in the 1969 burn area, but make very heavy use of lowbush cranberry where it is abundant, as in the 1947 burn area. It does seem reasonable that localized concentrations of lowbush cranberry, which occur to some degree even in the 1969 burn area (in some unburned stands), would result in relatively high bear densities for short periods of time, in that particular localized area. It appears that black bears do, in fact, spend a very high proportion of their time in unburned stands within the 1969 burn area (Schwartz et al. 1984).

Their overall generalist feeding behavior allows black bears to thrive in a wide variety of habitats throughout their range. Perhaps no single food item is of such importance to black bears that it alone determines their density.

Anal Plugs and Winter Activity

Craighead et al. (1972) discussed the presence and appearance of what have been described as "plugs" in the denning bear's rectum. These plugs have been described as dense, heavy and containing large amounts of bear hair, usually mixed with some vegetation fragments and/or sand and dirt. During this study, 8 such plugs were analyzed. They contained 25-75% black bear hair, fragments of partially decayed vegetation, and approximately 10-25% sand and dirt. The vegetation consisted of birch leaves, mosses, grass, twigs and, in general, items that commonly made up the den nest material. These plugs were very dense and had a very sticky, almost tar-like consistency. They would not dissolve or break apart in water (hot or cold) even when soaked for many hours.

Exactly when bears pass these plugs is unknown. Craighead et al. (1972) stated that such plugs were apparently passed several days after leaving the den in the spring. This was not always the case in this study as several plugs were found either inside of, or at the immediate entrance to dens during the winter. Three fresh plugs were found inside of dens in early March, at least 6-8 weeks before final den emergence.

Folk (1972, 1976, 1980) concluded that bears do not eat, drink, urinate or defecate during the entire denning period. However, Schwartz (pers. commun.) reported that large scats were present at the entrance of 6 different dens of radio-collared bears visited in February 1983 and several dens visited in March 1984. These scats appeared "loose" and not at all like anal plugs and were not regurgitations. Some were atop fresh snow, others were inside of dens, indicating they were not deposited before denning. They were not examined further. In 5 of the 1983 cases, a sow with newborn cubs occupied the den. The scats were far too large to have come from the cubs. The sixth case involved a mature female without cubs. In this case, both feces and urine were present atop fresh snow immediately outside the den. Bear tracks were also in the snow just outside of the den indicating that the bear had come out, milled around the entrance, and returned to the den. None of the bears in these cases were startled or especially aroused when the dens were visited.

It's interesting to note that in examining 49 dens, following their use, throughout the study site (Schwartz et al. 1983a) no evidence was ever found of placental material, a dead cub, feces from nursing cubs or any other such material. I visited many of these dens during the spring and summer following their use and found them consistently clean, dry and free of odor. It seems reasonable that the materials mentioned above might be eaten by the female. This could account for at least 5 of the winter scats found during this study and would indicate that the black bear's digestive system is capable of functioning to some degree in winter.

Predation

The general consensus presented in the literature is that black bears play a minor role as a predator. Seton (1929) described black bears displaying predatory behavior as "strange perverts" among the bear population as a whole. Erickson (1965) stated that black bears were of little consequence as predators. Bradt (1946) and Chatelain (1950) concluded that black bears are physically incapable of being consistently successful predators. Animal remains, especially remains of vertebrates, in black bear scats are regularly presumed to be carrion, even though often no special evidence is cited to support the presumption. Hatler (1967) presented a detailed analysis of black bear predation throughout Alaska and, based on the evidence available, reached conclusions similar to those of the authors above.

While the objectives of this study did not directly address predation, findings related to the topic are so contrary to most other food habits studies that some mention is warranted.

Physically, black bears possess a strong musculature, speed and quickness, large canines and claws and forward facing eyes, all characteristics of a predator. Their reflexes and movements can be amazingly fast. Such characteristics alone do not conclusively reveal that black bears are predatory. However, predator-prey studies conducted throughout the study site do. Franzmann et al. (1980,1984) found that over 1/2 of all non-winter moose calf mortality on the study site resulted from black bear predation.

Black bears appeared to pursue moose calves whenever encountered (Schwartz et al. 1983a). Johnson (pers. commun.) and Schwartz et al. (1983a) observed bears actually killing calves on the study site. Both incidents took place on lake shores while the cow's attention was temporarily turned away from the calf. Although certain areas of the study site (the 1969 burn area especially) showed very high twinning rates among moose, single calves did not appear any less susceptible to predation than were twins, as Le Resche (1966) implied (Franzmann et al. 1984).

Early researchers (Culver 1923, Palmer 1939, Sarber 1944) concluded that black bears on the Kenai Peninsula preyed heavily upon moose calves, but their data and length of study were quite limited. Many of their observations were very casual.

Snowshoe hares and birds comprised the bulk of remaining vertebrate foods in this study. Some of these items were surely taken as carrion, but it is reasonable to assume others were preyed upon. For much of the bear's active season, the young of both hares and birds are available. I have caught young hares and birds with my hands and have observed domestic dogs catching many in a few hours' time. In light of this, it is not unlikely that bears could be fairly successful in catching them, especially in years of great abundance.

Hatler's (1967) argument that Alaskan black bears are rarely predatory was thorough and logical, but wrong, at least when applied to the northwestern Kenai Peninsula. In fact, the speculation of early researchers that black bears are a major moose predator in this area was quite accurate. However, the overall effect such predation has on moose populations, relative to other factors that can regulate populations, such as food quantity and quality, was misunderstood by them. They believed that black bear predation alone was responsible for the decline of moose populations on the Kenai during the first half of this century. Today moose populations are high on the northwestern Kenai, especially in the 1969 burn area, despite the high incidence of predation.

It is possible that the predatory behavior of Kenai black bears is a rare and localized thing. Cowan (1972) noted that grizzlies frequently killed big game in Jasper National Park but that such events were rare in nearby Banff National Park in Alberta. It is also possible that most bears, if placed in a setting rich with potential prey, such as the northwestern Kenai, would display highly predatory habits.

Scat Volume Data and Food Importance

The use and interpretation of scat volume data for various foods in this and other studies deserves comment. Hatler's (1972) work evaluating various food habits techniques is frequently cited. He concluded, with certain restrictions, that it was legitimate to use scat analysis as the basis for bear food habits studies. He noted that frequency of occurrence data from scat analysis was very close to that from stomach analysis. However, he also noted that the same cannot be said for volume data. All foods undergo some reduction in volume as they pass through the gut. More importantly, different food items undergo different changes in volume. Only if the volume of every type of food item consumed remains unchanged between mouth and scat, or if any volume changes that do occur are equal for all foods or are known, can the percent volumes of foods in scats be an accurate reflection of the percent volumes of foods consumed. Since this is never true, percent volume totals should never be directly presented as data showing quantities consumed. In this study, percent volume data were evaluated separately in light of the nature of each food item. They were never presented as volume consumed, but served only to supplement frequency of occurrence data. Volume data can be especially useful for comparing the dietary role of the same food item in different areas or seasons. In contrast, Mealey (1975) and Beeman and Pelton (1980) presented volumes of food items found in scats as volumes consumed and Beeman and Pelton (1980) presented much of their data on a volume basis alone.

In an effort to account for differences in volumes of different food items due to digestion, some authors (Mealey 1975, Bunnell 1983, Grenfell and Brody 1983) mathematically "combined" or "averaged" percent frequency and percent volume values. The resulting indices were intended to represent the "importance" of various food items more accurately than either frequency or volume measures alone could. However, scat volume data remain a poor reflection of volumes consumed whether combined with frequency data or not. In addition, ironically, foods which are the most indigestible, depending on how often they occur, can be ranked as the most important using a "combined index". At the same time, very digestible foods, such as vertebrates, could be represented as less important than they really are. This would be a particular problem in this study because of the high incidence of vertebrate foods.

Another bothersome aspect of the use of scat volume data involves the nature of these data. In most studies, including this one, the volume of the scat that a particular food occupies is simply visually estimated within some range or class of values, e.g., 26-50%. (This practice is justifiable and is far quicker than using water displacement methods, etc.) The data thus obtained are ordinal. Ordinal scale data convey less information than ratio or interval scale data because only relative magnitudes are known (Zar 1974). Nevertheless, such data are useful and practical to obtain. But in order to calculate various "importance indices" some authors (Mealey 1975, Beeman and Pelton 1980, Beecham pers. commun.) "converted" ordinal data to ratio or interval data, apparently by taking mid-points of volume classes or assigning one specific value to each class. Other authors (Poelker and Hartwell 1973, Grenfell and Brody 1983) made ocular estimates of the exact percent volumes to obtain ratio or interval scale data. In my experience, it would be impossible to do this with any degree of accuracy. While the above methods may yield "neat packages" of numerical data, they do not necessarily yield "better" data and may often be misleading. Unless exact digestibilities of all foods are known, emphasis should be placed on frequency of occurrence data. Volume data should be evaluated "subjectively" if necessary, with regard to the structure of each food and used as a supplement to frequency of occurrence data.

Summary

Fruits and berries, green vegetation and animal matter all formed major portions of the black bear diet in this study. A gradual switch from a diet consisting mainly of animal matter (including large amounts of vertebrate matter) and green vegetation in spring to mainly fruits and berries in fall was observed. Lowbush cranberry occurred more often than any other food during the entire study. Lowbush cranberry occurred often in the diet during spring in the 1969 burn area, and in both spring and fall in the 1947 burn area, frequently in high volumes. It is probably of more dietary importance in spring since it is one of the only foods available in any quantity when bears emerge from their dens. However, where cranberries were not particularly abundant, fewer were eaten. Devil's club berry also occurred frequently and in high volumes, almost entirely in late summer and fall.

Equisetum was by far the most heavily used green vegetation food item, especially in spring and in the 1969 burn area, where fewer lowbush cranberries were available.

Black bears on the northwestern Kenai Peninsula are more carnivorous and predatory than is reported for black bears elsewhere. Vertebrates, particularly moose calves, were a major item in the diet, especially in spring. Ants occurred very often in midsummer.

Many food items occurred only infrequently and/or in low volumes. Individually, such items appear to be of minor importance but, in aggregate, they form a substantial part of the diet. Overall, annual and spatial differences in food habits throughout the study were few and/or small.

Differences between lowbush cranberry crops in the 1947 and 1969 burn areas did not result in large differences in black bear densities between the 2 areas. Any differences in black bear densities that may exist are not of the same magnitude as the differences in lowbush cranberry densities.

Because scat percent volume data are poor reflections of volumes of food consumed, data were presented with emphasis on frequency of occurrence. Volume data should be evaluated with regard to the structure of each food and used as a supplement to occurrence data.

CONCLUSIONS AND RECOMMENDATIONS

All objectives of this study were met. In meeting those objectives, many conclusions were reached, and many recommendations evolved for obtaining and interpreting information from similar studies.

1) Despite high variability in lowbush cranberry production within and between habitat types, study areas and years (as noted in other studies), changes in production between the 1947 and 1969 burn areas are probably proportionate since many factors governing production operate similarly in both areas. Furthermore, the magnitude of difference in cranberry production between the 2 areas was great. Even if the 1982 cranberry production level in the 1947 burn area were cut in half, and the 1982 production level in the 1969 burn area were simultaneously doubled, the 1947 burn area would still produce more than twice as much cranberry as the 1969 burn area.

The fact that the highest yield of cranberries/ha came from mature deciduous forest in the 1947 burn area does not in turn mean that all mature deciduous stands are highly productive. Some produced no cranberries. The majority of the 1969 burn area is occupied by open deciduous regrowth which produced very low cranberry yields/ha.

Locations with the highest lowbush cranberry yields/ha, even if they do not contribute large amounts to the study area total production, are probably of greatest importance to individual black bears in terms of providing berry foods. Bears can obtain more food per unit of effort in such habitats.

2) Sampling of lowbush cranberries should be completed within 2-3 weeks after berry ripening to reduce the effect that berry loss might have on production estimates. At least 2 stage-1 units at each of 2 locations should be sampled in every habitat type.

Visual estimates of berry production can be quite inaccurate. They should not be heavily relied on, even for relative comparison of crops from year to year.

3) Black bears on the northwestern Kenai Peninsula are highly carnivorous and highly predatory, more than has been previously reported of other black bears. Moose, particularly calves, were a major vertebrate food. Snowshoe hares and various birds were also eaten regularly. Increasing occurrences of snowshoe hares coincided with increases in the hare population. The cyclic nature of hare populations or any potential prey should be considered in food habits studies.

The implications of the highly carnivorous and predatory habits of black bears in this study go beyond diet. The ecological niche occupied by bears in this study is different than that reported for other bears. This difference should be acknowledged in any management decisions that affect either black bears, their prey or potential competitors.

The highly carnivorous food habits of black bears on the northwestern Kenai Peninsula may represent a unique, localized situation. Their food habits may also simply reflect an abundance of prey. In any case, indications are that the food habits of different black bear populations can vary substantially. The food habits of any black bear population should never be assumed to be similar to another population before careful study is made.

4) Lowbush cranberry occurred in scats more often than any other food item, often in high volumes, during the entire study. This food is most important in spring because over-wintered berries form an abundant food base, available immediately after bears emerge from their dens. Bears make especially heavy use of cranberries in areas where the berries are very abundant. Bears in the 1969 burn area, where cranberries were far less abundant, ate far less of the berry than in the 1947 burn area where cranberries were more abundant.

5) Equisetum was the most important type of green vegetation food in this study. It is extremely abundant throughout the study site and among the very first vegetation to "green up" in the spring.

6) Evidence of black bear winter activity, including fresh scats, urine and tracks atop fresh snow at den entrances

during midwinter was found during this study. Dens were noted as being clean, dry and free of placental material, cub feces and dead cub remains indicating that such materials may be consumed and passed by denning adult female bears. Scats and urine were also found at dens without cubs.

7) Gross field examination of scats is an unacceptable analysis technique for making any but very general statements about bear food habits. Unless scats are washed through several sizes of sieves, and preferably examined in water against a white background, many items, especially hair and feathers, can be overlooked.

The food habits of black bears in this and other studies changed enough seasonally to indicate that scat samples should be collected throughout all seasons, including very early and late in the year.

Percent volume estimates for foods in scats are not an accurate reflection of the volumes of foods consumed. Percent volume data should be evaluated separately for each food item since digestive reduction in volume varies for different foods. Such data should be used only to supplement percent frequency of occurrence data.

8) Cranberry densities in the 1947 and 1969 burn areas did not have a major influence on the overall black bear densities in those areas. Any differences in bear densities that may exist are far smaller than differences in cranberry density.

9) No single food item appears to be of such great importance to the omnivorous black bear that that food alone determines black bear density on regional and annual bases. However, the availability of certain food types or groups as a whole, such as fruits and berries in general, undoubtedly does play a role in determining densities. Furthermore, the seasonal abundance of certain food items can result in short-term, localized concentrations of bears within a region.

Appendix I. Detailed description of habitats sampled for lowbush cranberry production in the 1947 burn study area during 1982 and 1983 on the KNWR, Alaska.

Habitat Type	Overstory Species Present	Understory Species[a] Present	Shading	Soil Moisture
Mature Deciduous	Birch, Aspen, occasional White or Black Spruce	Lowbush Cranberry, *Cornus canadensis*, Labrador Tea (*Ledum palustre*), Rose, Fireweed (*Epilobium* spp.), Highbush Cranberry, Ferns, Mosses, Lichens	Uniformly moderate	Uniformly moderate
Mixed Regrowth	Birch, Aspen, White and Black Spruce, generally about 1/2 deciduous, 1/2 coniferous	Lowbush Cranberry, Labrador tea, Rose, Fireweed, Twinflower (*Linnaea borealis*), Mosses, Lichens	Moderate to heavy	Generally dry, well drained
Spruce Regrowth	Spruce, >75% Black, <25% White	Lowbush Cranberry, *Cornus candadensis*, Labrador tea, Rose, Fireweed, Twinflower, Grasses, Lupine (*Lupinus* spp.), Mosses, Lichens	Generally moderate, heavy in spots	Dry to moderate

[a]Order of listing is not intended to indicate relative abundance.

Appendix I (cont.)

Habitat Type	Overstory Species Present	Understory Species[a] Present	Shading	Soil Moisture
Mature Spruce	Spruce, generally 75-100% Black, 0-25% White	Lowbush Cranberry, *Cornus canadensis*, Rose, Highbush Cranberry, *Menziesia ferruginea*, Crowberry, Mosses, Lichens	Uniformly heavy	Uniformly moderate
Crushed	None	Lowbush Cranberry, *Cornus canadensis*, Fireweed, Rose, Twin-flower, Grasses, *Equisitum* spp., Mosses, Lichens	None	Uniformly dry
Mixed Mature	Birch, Aspen, White and Black Spruce, totalling about 1/2 deciduous and 1/2 coniferous	Lowbush Cranberry, *Cornus Canadensis*, Highbush Cranberry, Rose, Twinflower, Ferns, Grasses, Mosses, Lichens	Uniformly heavy	Uniformly moderate

[a]Order of listing is not intended to indicate relative abundance.

Appendix II. Detailed description of habitats sampled for lowbush cranberry production in the 1969 burn study area during 1982 on the KNWR, Alaska.

Habitat Type	Overstory Species Present	Understory Species[a] Present	Shading	Soil Moisture
Open Deciduous Regrowth	Little true overstory. Birch and Aspen regrowth in low to moderate density, 1-2 m high.	Lowbush Cranberry, *Cornus canadensis*, Fireweed, Twinflower, Highbush Cranberry, Cloudberry, Grasses, Mosses, Lichens	Almost none	Uniformly moderate
Mixed Mature	Birch, Aspen, White and Black Spruce, totalling about 1/2 deciduous, 1/2 coniferous	Lowbush Cranberry, *Cornus canadensis*, Rose, Fireweed, Highbush Cranberry, Twinflower, Crowberry, Blueberry, Grasses, Mosses, Lichens	Moderate to heavy	Uniformly moderate
Mature Deciduous	Birch, Aspen, Occasional White or Black Spruce	Lowbush Cranberry, *Cornus canadensis*, Fireweed, Highbush Cranberry, Twinflower, Grasses, Ferns, Mosses, Lichens	Uniformly moderate	Uniformly moderate

[a]Order of listing is not intended to indicate relative abundance.

Appendix II (cont.)

Habitat Type	Overstory Species Present	Understory Species Present[a]	Shading	Soil Moisture
Mature Spruce	Spruce, >75% Black, occasional Birch or Aspen	Lowbush Cranberry, *Cornus canadensis*, Cloudberry, *Oxycoccus microcarpus*, Devil's Club, Twisted-Stalk, Highbush Cranberry, *Equisetum* spp., *Menziesia ferruginea*, Crowberry, Grasses, Mosses, Lichens	Generally heavy, some moderate areas	Moderate to wet

[a]Order of listing is not intended to indicate relative abundance.

Appendix III. Detailed description of habitats sampled for lowbush cranberry production in old growth forest areas during 1982 on the KNWR, Alaska.

Habitat Type	Overstory Species Present	Understory Species[a] Present	Shading	Soil Moisture
Mixed Mature	Birch, White and Black Spruce totalling about 1/2 deciduous, 1/2 coniferous	Lowbush Cranberry, *Cornus canadensis*, Rose, Twinflower, Crowberry, Raspberry, *Equisetum* spp., Ferns, Grasses, Mosses, Lichens	Generally heavy with scattered semi-open areas of moderate shading	Moderate to wet
Hemlock	Nearly all mature Hemlock, scattered mature Birch	Lowbush Cranberry, *Menziesia ferruginea*, Mosses, Lichens	Generally heavy, with few small areas of moderate shading	Uniformly moderate
Mature Spruce	Spruce, >75% Black, occasional Birch or Aspen	Lowbush Cranberry, *Cornus canadensis*, Cloudberry, *Oxycoccus microcarpus*, Devil's Club, Twisted-Stalk, Highbush Cranberry, *Equisetum* spp., *Menziesia ferruginea*, Crowberry, Grasses, Mosses, Lichens	Generally heavy, some moderate areas	Moderate to wet

[a]Order of listing is not intended to indicate relative abundance.

Appendix IV. Total percent frequency of occurrence of scat items[a] in all scats and percent frequency of occurence of scat items in each percent volume category. Scats collected 1979 - 1983 on the KNWR, Alaska. (All scats, n = 488.)

Scat Item	Total percent frequency of occurrence	Percent Volume Category				
		Tr-5	6-25	26-50	51-75	76-100
Fruits and Berries						
Lowbush Cranberry	58.6	22.1	15.0	9.2	4.3	8.0
Devil's Club	24.8	3.7	1.2	2.3	4.5	13.1
Twisted-Stalk	13.9	11.3	2.3	0.2	0.0	0.2
Cloudberry	3.5	2.9	0.6	0.0	0.0	0.0
Red Elderberry	2.7	2.7	0.0	0.0	0.0	0.0
Trailing Black Currant	0.4	0.2	0.2	0.0	0.0	0.0
Northern Black Currant	0.8	0.4	0.4	0.0	0.0	0.0
Red Currant	0.2	0.2	0.0	0.0	0.0	0.0
Highbush Cranberry	1.8	1.4	0.2	0.2	0.0	0.0
Rosehips	5.5	3.1	1.2	0.8	0.0	0.4
Raspberry	3.9	2.5	0.8	0.6	0.0	0.0
Cornus canadensis	1.6	1.0	0.4	0.2	0.0	0.0
Geocaulon lividum	0.4	0.2	0.0	0.2	0.0	0.0
Blueberry	0.8	0.2	0.4	0.2	0.0	0.0
Crowberry	0.8	0.6	0.0	0.2	0.0	0.0
Flowers						
Clover	7.8	5.5	1.6	0.6	0.0	0.0
Pedicularis spp.	1.4	0.6	0.4	0.4	0.0	0.0

Appendix IV(cont.)

Scat Item	Total percent frequency of occurrence	Percent Volume Category				
		Tr-5	6-25	26-50	51-75	76-100
Green Vegetation						
Lowbush Cranberry leaves	60.2	37.5	17.4	5.1	0.2	0.0
Equisetum spp.	46.1	11.5	6.1	8.0	7.2	13.3
Spruce needles	50.6	49.0	0.6	1.0	0.0	0.0
Grass, Sedge	26.6	15.4	3.7	2.3	2.0	3.3
Devil's Club leaves, stems	22.1	11.1	10.0	1.0	0.0	0.0
Clover leaves, stems	14.8	0.6	3.5	1.8	3.5	5.3
Spruce cambium	2.0	0.4	1.6	0.0	0.0	0.0
Menziesia leaves	3.9	3.3	0.4	0.2	0.0	0.0
Twisted-Stalk leaves	5.1	3.7	0.6	0.2	0.2	0.4
Ledum leaves	11.7	11.3	0.2	0.2	0.0	0.0
Birch leaves	7.2	7.2	0.0	0.0	0.0	0.0
Willow leaves	0.6	0.6	0.0	0.0	0.0	0.0
Moss	12.3	11.7	0.4	0.2	0.0	0.0
Cornus canadensis leaves	3.1	3.1	0.0	0.0	0.0	0.0
Lichen	1.8	1.8	0.0	0.0	0.0	0.0
Fern	2.3	2.3	0.0	0.0	0.0	0.0
Alder leaves	0.6	0.6	0.0	0.0	0.0	0.0
Pedicularis spp. leaves	1.2	0.6	0.4	0.2	.0	.0

Appendix IV(cont.)

Food Item	Total percent frequency of occurrence	Percent Volume Category				
		Tr-5	6-25	26-50	51-75	76-100
Cottonwood leaves	2.0	0.6	1.0	0.2	0.0	0.2
Twinflower leaves	1.8	1.8	0.0	0.0	0.0	0.0
Geocaulon leaves	0.2	0.0	0.2	0.0	0.0	0.0
Animal						
Moose	35.9	18.4	9.4	4.3	1.2	2.5
Hare	11.9	9.0	1.6	0.4	0.6	0.2
Birds	8.8	5.7	2.0	0.6	0.2	0.2
Fish	2.7	1.8	0.8	0.0	0.0	0.0
Black Bear	22.7	20.9	0.4	0.2	0.2	1.0
Red-backed Vole	0.6	0.6	0.0	0.0	0.0	0.0
Insects	52.7	33.8	13.9	3.7	1.0	0.2
Insect larvae	15.6	15.2	0.2	0.2	0.0	0.0
Snail	0.2	0.2	0.0	0.0	0.0	0.0
Toxascaris(*Balysascaris*)	0.2	0.0	0.0	0.2	0.0	0.0
Miscellaneous Vegetation						
Misc. Veg. fragments	34.6	34.2	0.4	0.0	0.0	0.0
Debris						
Wood chips	35.9	20.5	11.1	3.9	0.2	0.2
Sand, Dirt, Gravel	4.7	4.1	0.6	0.0	0.0	0.0

[a]Includes all items found in scats, both food and nonfood.

Appendix V. Bear scat analysis data form.

BEAR SCAT ANALYSIS

No.____ Cond._____ Date ______________ Study area and specific collection location ________________
Habitat type and age ____
Gross aspect ____
Bear ID., sex, age ____

Item	Food type code	Est. % Volume 1 tr-5	2 6-25	3 26-50	4 51-75	5 76-100	remarks

Date examined______________

Appendix VI. Bear Scat Analysis Data Codes

Scat numbers

001, 002, 003 . . . . .

Scat condition

1 = Fresh	2 = Not fresh	3 = Very old

Collection location

1 = 1947 burn	2 = 1969 burn	3 = Old growth forest
Summer Feeding areas:	4 = north	5 = west

Food types

1 = Fruits, berries and seeds - identified

2 = Flowers and flower parts - identified

3 = Leaves, stems and roots - identified

4 = Animal remains - identified

5 = Miscellaneous vegetation fragments

6 = Debris (wood, rocks, dirt etc.)

7 = Fruits, berries and seeds - unidentified

8 = Flowers and flower parts - unidentified

9 = Animal remains - Parasites or unidentified items

0 = Garbage (foil, plastic, paper etc.)

Percent volume categories

0 = 0%	1 = Trace - 5%	2 = 6 - 25%
3 = 26 - 50%	4 = 51 - 75%	5 = 76 - 100%

Seasons

Den emergence through 30 June (Spring/early summer)

1 July through 15 August(Midsummer)

16 August to denning (Late summer/fall)

LITERATURE CITED

Bailey, T.N. 1981. Factors influencing furbearer populations and harvest on the Kenai National Moose Range, Alaska. Proc. Worldwide Furbearer Conf. 1980 (1): 249-272.

Bangs, E.E. 1979. The effects of tree crushing on small mammal populations in southcentral Alaska. M.S. Thesis. Univ. of Nevada, Reno. 80 pp.

_____ and T.N. Bailey. 1980. Interrelationships of weather, fire and moose on the Kenai National Wildlife Refuge, Alaska. Proc. N. Am. Moose Conf. and Workshop. 16: 255-274.

_____ and _____. 1982. Moose movement and distribution in response to winter seismological exploration on the Kenai National Wildlife Refuge, Alaska. Unpubl. Final Rep. prepared for ARCO, Alaska, Inc., Anchorage, AK 46pp.

_____, T.H. Spraker, T.N. Bailey and V.D. Berns. 1982. Effects of increased human populations on wildlife resources of the Kenai Peninsula, Alaska. Trans. N. Am. Wildl. and Natur. Res. Conf. 47: 605-616.

Beeman, L.E. and M.R. Pelton. 1980. Seasonal foods and feeding ecology of black bears in the Smoky Mountains. pp. 141-147 in C.J. Martinka and K.L. McArthur (ed.). Bears - their biology and management. IUCN Ser. No. 3.

Bossert, A. 1976. Nutritional ecological studies on the alpine rock ptarmigan (*Lagopus mutus*) in the Aletsch Forest area, Switzerland. Rev. Suisse Zool. 83(4): 80-883. (Abstr.)

Botticher, W. 1977. Woodland and wild berries in Germany. Acta. Hortic. 61: 319-323.

Bradt, G.W. 1946. The black bear - buffoon of the north woods. Mich. Cons. 15(11): 5.

Bunnell, F.L., T. Hamilton and R.M. Beames. 1978. Nutrition of grizzly bears (*Ursus arctos*). Congr. Theriol. Int. 2: 102 (Abstr.)

_____. 1983. Food habits of grizzly bears: synthesis, hypothesis, and tests. Prog. Sixth Intl. Conf. on Bear Research and Manage. p. 15. (Abstr.)

Chatelain, E.F. 1950. Bear - moose relationships on the Kenai Peninsula. Trans. N. Am. Wildl. Conf. 15: 224-233.

Cherkasov, A.F. 1974. Determining the yielding capacity of wild berries. Rast. Resur. 10(2): 253-260.

Clark, W.K. 1957. Seasonal food habits of the Kodiak bear. Trans. N. Am. Wildl. Conf. 22: 145-149.

Cooney, R.M. 1943. Montana moose survey, Hellroaring - Buffalo -Slough Creek Unit. Wildl. Rest. Div. Rep. Montana Fish and Game Dep. cited by Hosley, N.W. 1949. The moose and its ecology. USFWS, Wildlife Leaflet 312. 51 pp.

Cowan, I. McT. 1972. Bear behavior. P. 251 in S. Herrero (ed.). Bears - their biology and management. IUCN New Ser. No. 23. (Discussion summary.)

Craighead, F., E. Folk, R. Hensel and C. Jonkel. 1972. Denning - control mechanisms, site selection and physiology. pp. 133-137 in S. Herrero (ed.). Bears - their biology and management. IUCN New Ser. No. 23. (Discussion summary.)

Culver, W.G. 1923. Report of moose on Kenai Peninsula. Unpubl. Rep. Kenai National Wildlife Refuge files. 18 pp. typewritten.

Curtis, H. 1975. Biology. Worth Publ. Inc. New York. 1065 pp.

Douglas, G.W. 1974. Montane zone vegetation in the Alsek River region, southwestern Yukon. Can. J. Bot. 52: 2505-2532.

Erickson, A.W. 1965. The black bear in Alaska: Its ecology and management. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Rep. Proj. W-6-R-5, Job F. Juneau. 19 pp.

Folk, G.E., M.A. Folk and J.G. Minor. 1972. Physiological condition of three species of bears in winter dens. pp. 107-125 in S. Herrero (ed.). Bears - their biology and management. IUCN New Ser. No. 23.

_____, A. Larson and M.A. Folk. 1976. Physiology of hibernating bears. pp. 373-380 in M.R. Pelton, J. Lentfer and G.E. Folk (eds.). Bears - their biology and management. IUCN New Ser. No. 40.

_____, J.M. Hunt and M.A. Folk. 1980. Further evidence for hibernation of bears. pp. 43-46 in C.J. Martinka and K.L. McArthur (Eds.). Bears - their biology and management. IUCN Ser. No. 3.

Franzmann, A.W. and C.C. Schwartz. 1978. Moose calf mortality study, Kenai Peninsula. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Rep. Proj. W-17-10. Juneau. 20 pp.

_____, C.C. Schwartz and R.O. Peterson. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. J. Wildl. Manage. 44(3): 1980.

_____, C.C. Schwartz and D.C. Johnson. 1984. Moose calf mortality in the 1969 Kenai Peninsula burn. Alaska Dep. Fish and Game Fed. Aid in Wildl. Rest. Rep. Proj. W-22-1, W-22-2. Job 1, 33R (in press).

Friedman, B.F. 1981. Fire ecology and population biology of two taiga shrubs, lingonberry, Vaccinium vitis-idaea, and alpine blueberry, Vaccinium uliginosum. M.S. Thesis. Univ. of Alaska, Fairbanks. 162 pp.

Gilbert, D.L. 1951. Economics and related biology of the black bear in Colorado. M.S. Thesis. Colorado Agricultural and Mechanical College, Fort Collins. 147 pp.

Grenfell, W.E. Jr. and A.J. Brody. 1983. Seasonal foods of black bears in Tahoe National Forest, California. Calif. Fish and Game. 69(3): 132-150.

Hall, I.V. and J.M. Shay. 1981. The biological flora of Canada. 3. Vaccinium vitis-idaea L. var. minus Lodd. Supplementary account. Can. Field Nat. 95(4): 434-464.

Hamer, D., S. Herrero and L. Rogers. 1981. Differentiating black and grizzly bear feces. Wildl. Soc. Bull. 9(3): 210-212.

Hatler, D.F. 1967. Some aspects in the ecology of the black bear (Ursus americanus) in interior Alaska. M.S. Thesis Univ. of Alaska, Fairbanks. 111 pp.

_____. 1972. Food habits of black bears in interior Alaska. Can. Field Nat. 86: 17-31.

Heller, C.A. 1962. Wild, edible and poisonous plants of Alaska. Alaska Coop. Ext. Serv. Bull. No. F-40.

Holloway, P.S. 1981. Studies on vegetative and reproductive growth of lingonberry, Vaccinium vitis-idaea L. Ph.D. Thesis. Univ. of Minnesota, St. Paul. 148 pp.

Hultén, E. 1974. Flora of Alaska and neighboring territories: a manual of the vascular plants. Stanford University Press, Stanford, CA 1008 pp.

Jonkel, C.J. 1961. Tips on hunting black bear. Montana Wildl. 1961 (July): 7-8.

Juniper, I. 1978. Morphology, diet and parasitism in Quebec black bears. Can. Field Nat. 92(2): 186-189.

Kolupaeva, K.G. 1980. Dynamics of the yield capacity of forest berry and fruit plants in Kirov Oblast, Russian SFSR, USSR. Rasit. Resur. 16(1): 139-145. (Abstr.)

Landers, J.L., R.J. Hamilton, A.S. Johnson and R.L. Marchinton. 1979. Foods and habitat of black bears in southeastern North Carolina. J. Wildl. Manage. 43(1): 143-153.

Lehmushovi, A. and H. Hiirsalmi. 1973. Cultivation experiment with the cowberry. Significance of substrate, liming, fertilization and shade. Ann. Agric. Fenn. 12(2): 95-101.

_____ and J. Sako. 1975. Domestication of the cowberry (Vaccinium vitis-idaea L.) in Finland. Ann. Agric. Fenn. 14(3): 227-230.

Leopold, A.S. and F.F. Darling. 1953. Wildlife in Alaska: An ecological reconnaissance. Roland Press Co. New York. 118 pp.

LeResche, R.E. 1966. Behavior and calf survival in Alaskan moose. M.S. Thesis. Univ. of Alaska, Fairbanks. 84 pp.

_____ and J.L. Davis. 1973. Importance of non-browse foods to moose on the Kenai Peninsula, Alaska. J. Wildl. Manage. 37(3): 279-287

Levin, O.R. 1954. The South Olympic tree farm. J. Forest. 52(4): 243-249.

Lloyd, K. and S. Fleck. 1978. Food habits of black (*Ursus americanus* Pallus) and grizzly bears (*Ursus arctos* Linne) in coastal and interior British Columbia, Canada. Congr. Theriol. Int. 2:139. (Abstr.)

Lutz, H.J. 1951. Damage to trees by black bears in Alaska. J. Forest. 49(7): 522-523.

_____. 1960. History of the early occurrence of moose on the Kenai Peninsula and in other sections of Alaska. Misc. Publ. No. 1. Alaska Forest Research Center, U.S. Forest Service. 25 pp.

Mace, R.D. and C.J. Jonkel. 1983. Regional food habits of the grizzly bear in Montana. Prog. Sixth Intl. Conf. on Bear Research and Manage. p. 36. (Abstr.)

McIlroy, C.W. 1970. Aspects of the ecology and hunter harvest of black bears in Prince William Sound, Alaska. M.S. Thesis. Univ. of Alaska, Fairbanks. 69 pp.

Mealey, S.P. 1975. The natural food habits of free-ranging grizzly bears in Yellowstone National Park, 1973-74. M.S. Thesis. Montana State University, Bozeman. 158 pp.

Miller, S. 1983. Big game studies. Vol. VI. Black bear and brown bear. Phase II first annual prog. rep. Alaska Dep. Fish and Game. Juneau. 99 pp.

Modafferi, R.D. 1982. Black bear movements and home range study, Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-17-10, W-21-1, W-21-2. Job 17.2 R. Juneau. 73 pp.

Moore, T.D., L.E. Spence, C.E. Dugnolle and W.G. Hepworth. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Dep. Bull. No. 14. Laramie. 177 pp.

Mulé, R.S. 1982. An assessment of a wildlife habitat evaluation methodology for Alaska. M.S. Thesis. Univ. of Alaska, Fairbanks. 215 pp.

Oldemeyer, J.L. and R.K. Seemel. 1976. Occurrence and nutritive quality of lowbush cranberry on the Kenai Peninsula, Alaska. Can. J. Bot. 54: 966-970.

_____, A.W. Franzmann, A.L. Brundage, P.D. Arnescn and A. Flynn. 1977. Browse quality and the Kenai moose population. J. Wild. Manage. 41(3): 533-542.

_____ and W.L. Regelin. 1980. Response of vegetation to tree crushing in Alaska. Proc. N. Am. Moose Conf. and Workshop. 16: 429-443.

Palmer, L.J. 1939. Kenai Peninsula moose. Research Proj. Rep., Bureau of Biological Survey. Sept.-Oct. 1938. Unpubl. rep. Kenai National Wildlife Refuge Files. 24 pp. typewritten.

Poelker, R.J. and H.D. Hartwell. 1973. Black bear of Washington: its biology, natural history and relationship to forest regeneration. Washington State Game Dep. Fed. Aid in Wildl. Rest. Rep. Proj. W-71-R. Biol. Bull. No. 14. 145 pp.

Pojar, J. 1974. Reproductive dynamics of four plant communities of southwestern British Columbia. Can. J. Bot. 52: 1819-1834.

Pulliainen, E. 1972. Nutrition of the arctic hare (Lepus timidus) in northwestern Lapland. Ann. Zool. Fenn. 9(1): 17-22.

Rausch, R.L. 1961. Notes on the black bear, Ursus americanus Pallus, in Alaska, with particular reference to dentition and growth. Zeit. fur Sauge., 26: 65-128.

Rearden, J. 1981. Alaska Mammals. Vol. 8, No. 2. Alaska Geographic Society. Anchorage. 184 pp.

Rogers, L.L. 1976. Effects of mast and berry crop failures on survival, growth and reproductive success of black bears. Trans. N. Am. Wildl. and Natur. Res. Conf. 41: 431-438.

_____ and S.M. Rogers. 1976. Parasites of bears: a review. Pp. 411-430 in M.R. Pelton, J.W. Lentfer, and G.E. Folk (eds.). Bears - their biology and management. IUCN New. Serv. No. 40.

Rowan, W. 1928. Bears and bird's eggs. Condor. 30(2): 246.

Sarber, H.R. 1944. Report of the moose studies, National Moose Range, Kenai Peninsula, Alaska. Unpubl. Rep. Kenai National Wildlife Refuge files. 10 pp. typewritten.

Sautin, V.I., A.S. Palamarchuk and P.N. Raiico. 1975. Production and resources of berries in forests of the Belorussian - SSR. Rasit. Resur. 11(3): 320-328.

Schaffer, S.C. 1971. Some ecological relationships of grizzly bears and black bears of the Apgar Mountains in Glacier National Park, Montana. M.S. Thesis. Univ. of Montana, Missoula. 127 pp.

Schwartz, C.C. and A.W. Franzmann. 1980. Black bear predation on moose. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Rep. Proj. W-17-11 and W-21-1. Job 17.3R. Juneau. 82 pp.

_____ and A.W. Franzmann. 1981. Black bear predation on moose. Alaska Dep. Fish and Game. Fed. aid in Wildl. Rest. Rep. Proj. W-17-2. Job 17.3R. Juneau. 43 pp.

_____, _____ and D.C. Johnson. 1983a. Black bear predation on moose (bear ecology studies). Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-17-10, W-17-11, W-21-1, W-21-2, W-22-1. Job 17.3R. Juneau. 135 pp.

_____, _____, and _____. 1983b. Population ecology of the Kenai Peninsula black bear. Alaska Dep. Fish and Game. Fed. Aid in Wild. Rest. Rep. Proj. W-2-1, W-22-2. Job 17.5R. Juneau. 17 pp.

_____, _____, and _____. 1984. Population ecology of the Kenai Peninsula black bear. Alaska Dep. Fish and Game. Aid in Wildl. Rest. Rep. Proj. W-22-1, W-22-2. Job 17.5R. (in press).

Seton, E.T. 1929. Lives of game animals. Vol II, Part I. Doubleday, Doran & Co. Garden City, NY. 367 pp.

Smith, D.W. 1962. Ecological study of *Vaccinium* species in Alberta. Can. J. Pl. Sci. 42: 82-90.

Spencer, D.L. and J.B. Hakala. 1964. Moose and fire on the Kenai. Proc. Tall Timbers Fire Ecol. Conf. 3: 11-33.

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

Sprent, J.F.A. 1968. Notes on *Ascaris* and *Toxascaris* with a definition of *Baylisascaris* gen. nov. Parasitology. 58: 185-199.

Stark, R., I.V. Hall and P.A. Hendrickson. 1978. The partridgeberry of Newfoundland. Canadex. Horticultural Crops. Agriculture Canada No. 230.

Stelmock, J.J. 1981. Seasonal activities and habitat use patterns of brown bears in Denali National Park-1980. M.S. Thesis. Univ. of Alaska, Fairbanks. 118 pp.

Tisch, E.L. 1961. Seasonal food habits of the black bear in the Whitefish range of northwestern Montana. M.S. Thesis. Montana State Univ. Bozeman. 108 pp.

Viereck, L.A. and E.L. Little, Jr. 1972. Alaska Trees and Shrubs. Agric. Handbook #410. Forest Service, USDA, Washington D.C. 265 pp.

Weeden, R.B. and L.N. Ellison. 1968. Upland game birds of forest and tundra. Alaska Dep. Fish and Game. Wildl. Booklet Ser. No. 3. 44 pp.

Wright, W.H. 1910. The black bear. Charles Scribner's Sons, New York. 127 pp.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, NJ. 620 pp.

Zytaruk, B. and D. Cartwright. 1978. Black bear movements and food habits in New Brunswick. Pp 227-239 in R.D. Hugie (ed.). Fourth Eastern Black Bear Workshop.

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