To the Graduate Council:

I am submitting herewith a thesis written by Thomas C. Eagle entitled "Foods of Black Bears in the Great Smoky Mountains National Park." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

Michael R. Pelton, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

FOODS OF BLACK BEARS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Thomas C. Eagle

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ABSTRACT

Seasonal patterns of food utilization by black bears (*Ursus americanus*) in the Great Smoky Mountains National Park were determined by sampling 86 composites of 646 scats during 1976 and 1977. Five seasonal patterns based on composition of the diet were identified. Major plant food items were grass (Graminae) and other herbaceous material; squawroot (*Conopholis americana*); fruits of serviceberry (*Amelanchier arborea laevis*), blackberry (*Rubus* sp.), huckleberry (*Gaylussacia* sp.), blueberry (*Vaccinium* sp.), black cherry (*Prunus serotina*), fire cherry (*P. pennsylvanica*), and sassafras (*Sassafras albidum*); and acorns (*Quercus* sp.). Plant foods composed 80% of the diet, and animal remains, mostly insects, were 12%. Crude protein, acid detergent fiber, and lignin content of major food items and corresponding scats were determined, and nutritional value of the seasonal diets was evaluated. The Early Spring diet is of low nutritional value, and bears lose weight while following this pattern of food consumption. The Late Spring, Summer, and Early Fall diets are conducive to healthy growth of bears because they are high in available protein and energy. The Late Fall diet may not contribute to structural growth, but high energy availability in the diet leads to rapid increase of body fat reserves.

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I. INTRODUCTION

Food habits are frequently among the first aspects of a species biology investigated during a research effort. Studies of the food habits of black bears are no exception; such studies were reported as early as the 1920's and continue in the literature to the present.

Many of the earlier studies were of a descriptive nature or limited discussion to 1 or very few food items. Bigelow (1922) discussed the bear's use of insects for food. Bailey (1923) and Shadle (1941) described evidence of bears eating 1 particular food item. Lutz (1951), Merrill (1953), and Zeedyk (1957) described damage to timber stands attributed to bears consuming the cambium layer of the trees.

Newsom (1937), Seton (1953), and Cahalane (1961) wrote general descriptions of the diets of black bears in their works on the life histories of wildlife.

Other studies were quantitative, but were of limited value because the data represented only 1 season of sampling. Murie (1937) analyzed scats collected in Wyoming in July. Cottam et al. (1939) determined the early winter food habits of bears in George Washington National Forest, Virginia. Gilbert (1951) analyzed scats and stomach contents collected in Colorado in summer. Harlow (1961) determined the summer food habits of bears in Florida.

Fortunately, many quantitative food habits studies, for which data were collected during all seasons during which bears are active, appear in the literature. Such studies were reported from Alaska

(Chatelain 1950, Hatler 1967), Montana (Tisch 1961, Jonkel and Cowan 1971), mountains of Tennessee and North Carolina (Beeman and Pelton 1977), Washington (Poelker and Hartwell 1973), North Carolina coast (Hardy 1974, Landers et al. 1979), and California (Piekielek and Burton 1975) (summer and fall only).

Beeman and Pelton (1977) reported seasonal food habits of bears in the Smoky Mountains. Although their work was quantitative and based on a large collection of scats and stomachs, the general nature of the spatial and temporal separation needed to be refined. Since many of the scats analyzed in the earlier study were collected from locations throughout the Smoky Mountains of Tennessee and North Carolina, it was believed that results did not accurately reflect the food habits of bears residing in the current study area.

Beeman and Pelton's (1977) results were presented with no spatial division within the Smoky Mountains. Beeman (1975), Eubanks (1976), and Garshelis (1978) found that individual bears in the Great Smoky Mountains National Park (GSMNP or Park) do not range throughout the study area. Instead, each bear's movements are generally restricted to a portion of the area, often within a single watershed. Since the movements of bears were so restricted, scats collected for the present study were grouped according to the section of the study area in which they were deposited (see page 13). This spatial division was designed to compare food utilization by bears inhabiting different sections of the study area.

Also, the earlier seasonal food habits study reported results for 4 seasons, which were as follows: Spring (emergence through

June 30), Summer (July 1 through August 31), Early Fall (September 1 through October 15), and Late Fall (October 16 to hibernation).

A more appropriate approach to determine seasonal food habits may be to evaluate food utilization over shorter periods of time and examine the results to determine patterns. This approach was used for the present study. It was felt that 2-week intervals were short enough to be sensitive to dietary changes, yet long enough to ensure the collection of an adequate sample of scats.

The technique for scat analysis in most studies followed the hand separated analysis described by Tisch (1961). Each scat was separated and examined, and frequency of occurrence and an index to volume were calculated for each food item. Hardy (1974) used a different approach to scat analysis, which was to sample the contents of each scat using a point frame analysis (Chamrad and Box 1964). Hansen (1975) used another sampling technique and sampled composites of 25 feces to determine the food habits of hoary marmots (Marmota caligata) in Alaska. Johnson and Hansen (1977) found no significant difference in results from analysis of coyote (Canis latrans) scats using point frame and hand separated techniques. In light of the above studies it was assumed that sampling composites was adequate to describe the basic patterns of food utilization by black bears in the GSMNP, and a technique based on that assumption was developed for use in the present study.

Descriptions of basic patterns of food utilization are of limited use unless the nutritional value of the food items and the seasonal diets are known. Several authors (Wainio and Forbes 1941,

King and McClure 1944, Beck and Beck 1955, Burns and Viers 1973, Landers et al. 1979) evaluated the nutritional value of food items used by wildlife in various parts of the United States.

Beeman and Pelton (1977) reviewed some available information on the nutritional content of food items utilized by black bears in the Park. Foods in the diets of bears in that study were high in carbohydrates and low in proteins. The nutritional value of seasonal diets or the annual diet was not evaluated.

Wackernagel (1961) reported that a diet which encourages healthy growth in omnivores, with which he included bears, must have a crude protein content of approximately 15%. From data reported in previous studies, the natural, annual diet of black bears probably contain less than 15% crude protein. It was, therefore, speculated that growth in black bears does not occur throughout the year, but is limited to certain seasons. The evaluation of the nutritional value of seasonal diets of bears, especially determination of the protein content, may show which season or seasons are most conducive to growth.

Specific objectives were as follows:

1. Determine the biweekly use of food items by black bears in the study area.
2. Compare the patterns of food utilization by bears inhabiting different sections within the study area.
3. Determine the nutritional value of major food items in the diet of bears in the study area.
4. Evaluate the nutritional value of the seasonal diets of black bears in the study area.

II. STUDY AREA

The boundaries of the GSMNP encompass 2072 km^2 of land in eastern Tennessee and western North Carolina. The Park comprises part of the Unaka Mountain Range of the Blue Ridge Province in the southern division of the Appalachian Highlands (Fennemen 1938). Divided by a prominent ridge running approximately northeast-southeast, along which lies the Tennessee-North Carolina state line, and a transmountain road, U.S. 441, which links Gatlinburg, Tennessee and Cherokee, North Carolina, the Park consists of 4 easily recognizable quarters. The study area is the northwest quarter, that portion of the Park in Tennessee west of the transmountain road. It encompasses parts of Blount and Sevier counties (Fig. 1).

The rugged, mountainous terrain of most of the study area is accessible only by foot trails. Over 90% of the surface consists of slopes greater than 10% (Message from the President 1902). The Ramsey association, which is characterized by low water storage capacity, moderate natural fertility, and medium to high acidity, comprises the predominant soil type (Soil Survey 1945, 1953). Most parent material is feldspathic sandstone, siltstone, and conglomerate from the Ocoee series of the late Precambrian (King et al. 1968).

Precipitation and temperatures in the Park vary greatly with elevation. The climate may be categorized generally as mesothermal perhumid (warm-temperate rain forest) using Thornthwaite's (1948) system. At low elevations, precipitation averages about 140 cm per year, while well over 220 cm may occur at the highest elevation.

Fig. 1. Study area within the GSMNP.

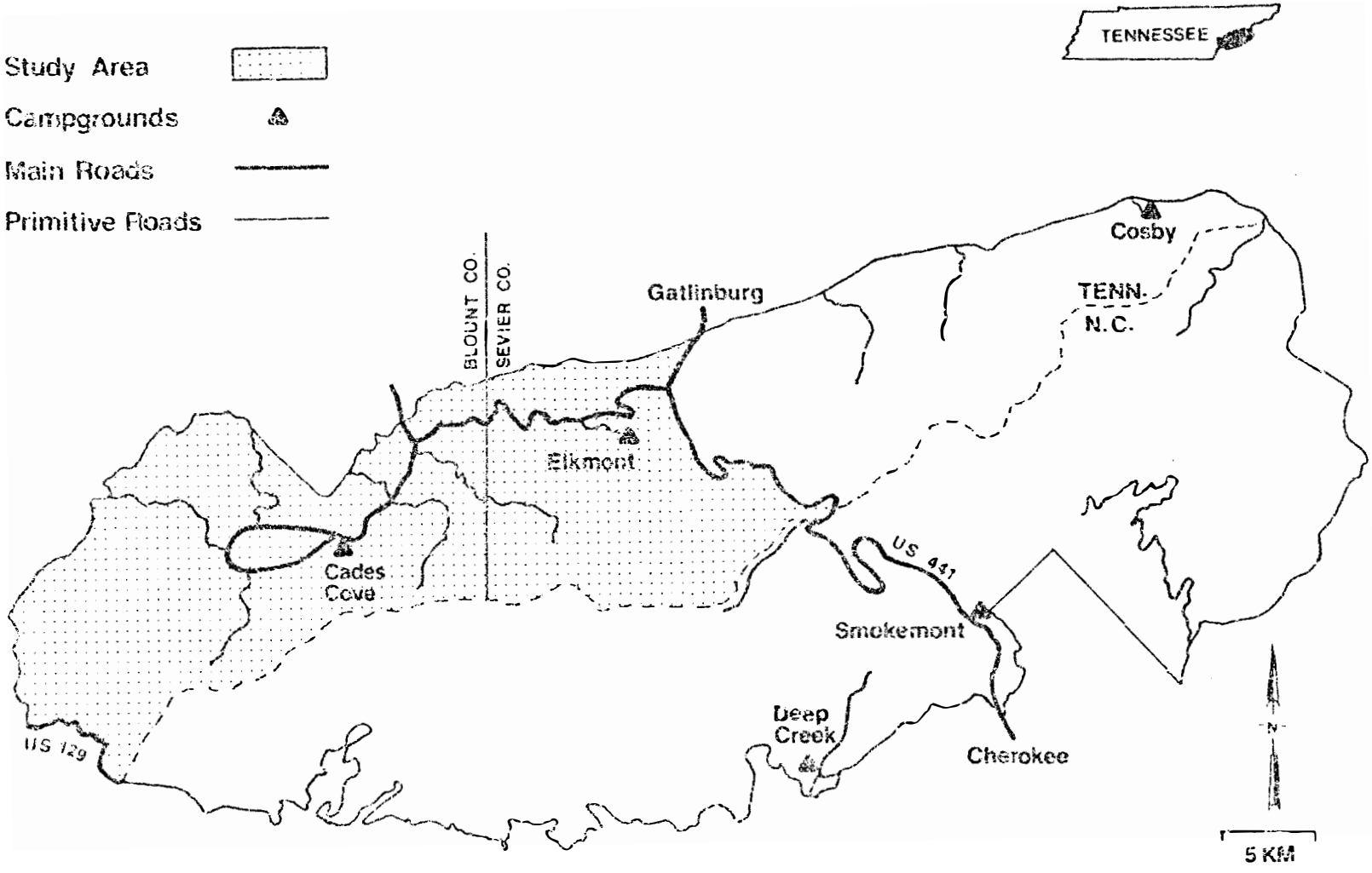
Study Area
Campgrounds
Main Roads
Primitive Roads
TENNESSEE
Cosby
TENN.
N.C.
Gatlinburg
BLOUNT CO.
SEVIER CO.
Elkmont
Cades Cove
US 441
Smokemont
Deep Creek
Cherokee
US 129
N
5 KM

Figure 1

Monthly precipitation ranges from a low of 8 cm in September and October to a high of 16 cm in July, according to National Park Service records at Gatlinburg, Tennessee (elevation 445 m). For most years precipitation exceeds evapotranspiration during all seasons. Average annual temperature is 14C at lower elevations (below 450 m) and 6C at higher elevations (above 1900 m), with a temperature gradient of 4.07C per 1000 m rise in elevation. Monthly temperature means are usually at a low in February and reach a peak in July (Shanks 1954a, Tanner 1963, Climatography of the U.S. 1972).

The numerous microhabitats in the Park support dense and highly diverse vegetation with much interspersion of forest types. Hoffman (1964) listed 1450 species of vascular plants, 131 of which are native trees. King and Stupka (1950) and Stupka (1960) identified 32 different ferns, approximately 350 mosses and liverworts, 230 lichens, and more than 2000 species of fungi. Cain (1935), Shanks (1954b), Whittaker (1956), and Golden (1974) categorized major forest types within the Park, and Shanks's (1954b) description is the most widely used classification (Table 1).

There are 69 species of mammals inhabiting the GSMNP, nearly half (approximately 25) of which are of the order Rodentia (Linzey and Linzey 1971). Other than black bears, large mammals in the Park include white-tailed deer (Odocoileus virginianus) and European wild hogs (Sus scrofa). The presence of the eastern mountain lion (Felis concolor) is speculated (Culbertson 1977), but recent substantiated evidence is yet to be found. More than 200 species of birds, 23 species of snakes (2 poisonous), over 72 species of fish, and 1 of the

Table 1. Forest associations and their important trees and shrubs in the GSMNP.

Forest Association	Important Species
Cove hardwood	Eastern hemlock (*Tsuga canadensis*) Silverbell (*Halesia monticola*) Yellow buckeye (*Aesculus octandra*) Sugar maple (*Acer saccharum*) Yellow birch (*Betula allegnaniensis*) Tulip poplar (*Liriodendron tulipifera*) Beech (*Fagus grandifolia*) Black cherry (*Prunus serotina*) Sasswood (*Tilia heterophylla*) Hydrangea (*Hydrangea arborenscens*) Dog hobble (*Leucothoe editorum*) Sweetshrub (*Calycanthus floridus*) Mountain laurel (*Kalmia latifolia*)
Hemlock	Eastern hemlock Yellow birch Silverbell Frazier magnolia (*Magnolia fraseri*) Rhododendron (*Rhododendron catawbiense* and *R. maximum*) Mountain laurel Dog hobble
Northern hardwood	Beech Yellow birch Yellow buckeye Sugar maple Mountain maple (*Acer spicatum*) Hydrangea Witch-hobble (*Viburnum alternifolium*) Dogwood (*Cornus alternifolia*)
Closed oak	White oak (*Quercus alba*) Chestnut oak (*Q. prinus*) Northern red oak (*Q. rubra*) Black oak (*Q. velutina*) Pignut hickory (*Carya glabra*) Mockernut hickory (*C. tomentosa*) Sourwood (*Oxydendrum arboreum*) Black locust (*Robinia pseudoacacia*) Mountain laurel Catbrier (*Smilax rotundifolia*)

Table 1 (Continued)

Forest Association	Important Species
Open oak and pine	Scarlet oak (*Quercus coccinea*) Sassafras (*Sassafras albidum*) Pitch pine (*Pinus rigida*) Table mountain pine (*P. pungens*) Virginia pine (*P. virginiana*) Mountain laurel High bush blueberry (*Vaccinium simulatum*) Hairy blueberry (*V. hirsutum*) Huckleberry (*Gaylussacia baccata*)
Spruce-fir	Red spruce (*Picea rubens*) Fraser fir (*Abies fraseri*)
Heath bald	Mountain laurel Rhododendron (*R. catawbiense*, *R. carolinianum*, and *R. maximum*) Pepperbush (*Clethra acuminata*) Blueberries (*Vaccinium* species) Huckleberry Lyonia (*Lyonia ligustrina*) Sand-myrtle (*Leiophyllum buxifolium*) Minnie-bush (*Menziesia pilosa*) Witherod (*Viburnum cassinoides*) Fetter-bush (*Pieris floribunda*)
Grassy bald	Serviceberry (*Amelanchier laevis*) Blueberries Blackberry (*Rubus* species) Pin cherry (*Prunus pennsylvanica*)

Source: Shanks (1954b).

world's richest arrays of salamanders are also found in the Park (National Park Service 1969).

III. METHODS AND MATERIALS

Scat Collection and Preservation

The study area was divided into 5 sections with an Index Route running through each section (Fig. 2). The 5 Index Routes were established in 1970 for earlier studies of black bears in the GSMNP involving scat collections (Marcum 1974, Eagar 1977, Matthews 1977). These routes, 21 to 37 km in length, traversed all forest associations and different altitudes.

Index Routes were hiked and cleared of scats biweekly from 8 May through 27 September, with the exception of 22 May in 1976, and from 9 May through 10 October 1977. Scats were also collected from trails other than Index Routes and off trails when encountered, if the scats were freshly deposited.

To avoid the collection of excess debris which adhered to the bottoms of feces, only the top portion of large scats was collected. This practice was impossible when scats were badly weathered or small.

To prevent rapid deterioration of fecal material, scats were frozen upon return to the field laboratory and remained in the freezer until the winter months when the scats were thawed for analysis.

Scat Analysis

Scats were grouped according to the section and date of collection. After the scats were thawed, approximately 50 ml samples were taken from selected feces and dried 48 to 72 hours in a drying oven (60-70C) and stored in jars to await chemical analysis.

Fig. 2. Index Routes and sections within the study area.

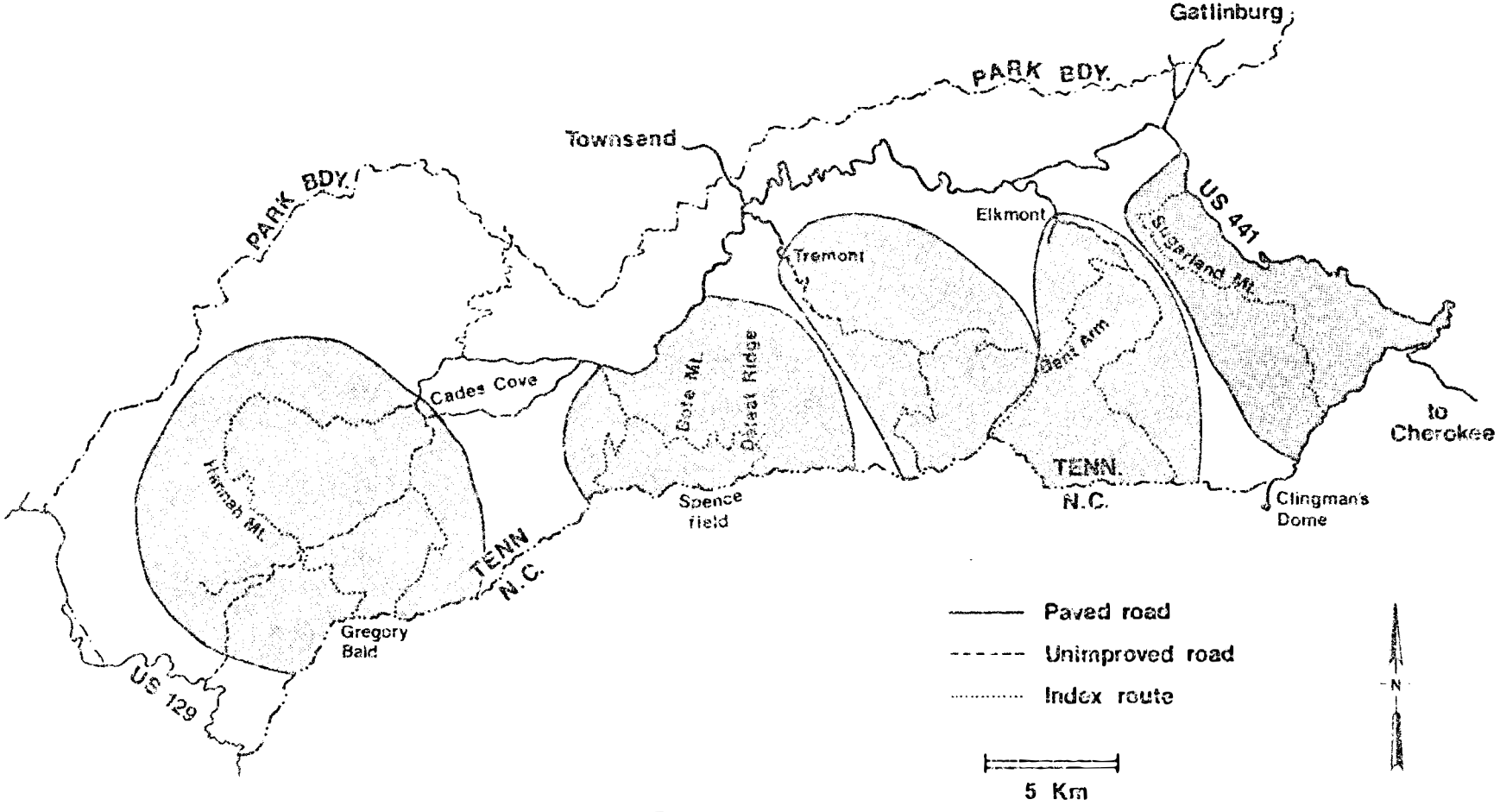
Gatlinburg
PARK BDY.
Townsend
PARK BDY.
US 441
Elkmont
Tremont
Sugarland Mt.
Cades Cove
Bote Mt.
Defeat Ridge
Dent Arm
to Cherokee
Hannah Mt.
TENN.
N.C.
Spence Field
TENN.
N.C.
Clingman's Dome
Gregory Bald
US 129
Paved road
Unimproved road
Index route
N
5 Km

Figure 2

Samples were taken from each feces and combined to form a composite scat representing each section for each 2-week interval. Numbers of scats in the composites ranged from 1 to 27 (Appendix, Tables 18-27). It was necessary to use all fecal material collected to form composites for which there were only 1 or 2 scats while a small sample, approximately 30 ml, was taken from each feces for composites containing 20 or more scats. Samples from scats were not precisely measured because entire feces were not always collected, and the volume of some scats was greatly reduced by weather and/or copraphagic animals.

Each composite was washed through 2 sieve screens (mesh size 2.00 mm and 0.42 mm) to eliminate material smaller than 0.42 mm in all dimensions. The composite was then placed in a drying oven at 70C or air dried for 48 to 72 hours.

A square sampling grid of 100 quadrats, each measuring 2x2 cm and numbered with a 2-digit number (00-99) was drawn on the bottom of a tray. Fecal material from a composite was sprinkled over the grid until each quadrat contained at least 1 particle. The fecal material in 10 randomly chosen quadrats was identified to the lowest taxon practical, and each different item occurring in each quadrat was recorded. After the items in all 10 quadrats were identified and recorded, the fecal material in the tray was returned to the composite, and the procedure was repeated until the material in 50 quadrats was identified. Initially, 100 quadrats were examined for each composite, but it was soon learned that the difference between results from 50 quadrats and from 100 quadrats was negligible (Wilcoxon signed rank test, $P > .5$).

The Relative Percentage Density (RD) of identified food items was calculated for each composite using methods described by Hansen (1975). The number of quadrats containing a given food item was converted to a percentage frequency. The percentage frequency (F) was used to determine density (D) of a food item in the composite by substitution in the following equation and solving for D:

$$F = 100\ (1-e^{-D})$$

where e is the base of natural logarithms. The above equation was derived from equations described by Fraker and Brischle (1944) used to measure the distribution of plants in a given area.

The D for each food item was used only to calculate RD for all identified food items in each composite by the following equation:

$$RD = \frac{D \text{ of each item}}{\Sigma D \text{ for all items}} \times 100$$

After the RD was calculated for food items in composites from all sections, the data were averaged to compute the composition of the diet throughout the study area for each 2-week interval and to determine major food items. Major foods were those which were consumed during both years of the study and comprised over 5% of the diet of bears throughout the study area for at least 1 biweekly diet. Biweekly consumption in the study area was examined for seasons (patterns based on the proportions of major food items in the diet).

The Wilcoxon signed rank test (Gibbons 1976) was used to test differences in the seasonal diets between the 2 years of the study. The Kruskal-Wallis test (Gibbons 1976) was used to test differences in biweekly diets from each section of the study area.

Seeds were identified with the aid of 2 seed manuals (Forest Service 1948, Martin and Barkley 1961) used in conjunction with 2 books describing the flora in the Smoky Mountains (Stupka 1964, Radford et al. 1968). A key for the study of insects (Borror et al. 1976) and assistance from Keith Watson, graduate student, Department of Agricultural Biology, The University of Tennessee, Knoxville, were helpful for identification of large insect fragments. A key to guard hair (Stains 1958) and a reference collection were aids used to identify hair in scats.

Most seeds, some herbaceous material, and some insect fragments could be identified macroscopically. Remaining items were identified using a dissecting microscope at 10X to 40X magnification.

Hoffman (1966) listed 1450 species in 126 families of vascular flora, including 118 species of grasses in the GSMNP. With this extreme diversity of plant material, fragments of grasses and most herbaceous material were identified no further than these broad categories. Tiny insect fragments were impossible to identify. Since only single hairs were encountered, and many of these were underhair, identification of hair was difficult, and much of the hair was not identified.

Chemical Analysis of Food Items and Scat Samples

Major plant food items identified in the 1976 diet were collected in 1977 for chemical analysis. A sample of squawroot was collected in the spring. In summer, samples of blackberry, huckleberry, and blueberry were collected. Chestnut oak (Q. prinus) acorns were

collected in the fall. All samples were dried in a drying oven at 70C for 48 to 72 hours upon returning to the field laboratory. Samples were stored in jars until the following winter. All samples were ground in a Wiley mill over a 20-mesh screen, and sent to the Animal Science Laboratory, The University of Tennessee, Knoxville, for chemical analysis to determine crude protein, acid detergent fiber (ADF), and lignin following procedures outlined in Crampton and Harris (1969).

Fecal samples from scats containing mostly herbaceous material, squawroot, blackberry, huckleberry and blueberry, or acorn remains were prepared in the same manner as the samples of food items and were sent to the laboratory for determination of the same fractions.

IV. RESULTS AND DISCUSSION

Patterns of Food Utilization

Biweekly food utilization by black bears throughout the study area was calculated (Tables 2 and 3) from composition of biweekly scat composites from each section of the study area (Appendix, Tables 18-27).

The major food items consumed by black bears in the Park during the 2-year study can be divided into 6 categories based on concurrent utilization and similar nutritional value. Herbaceous material, spring fruits, shrub-borne soft mast, tree-borne soft mast, hard mast, and animal material. Food items classed as herbaceous material included grasses, herbaceous stems, green leaves, and buds. Squawroot and serviceberry comprised the spring fruits. Serviceberry was not eaten both years, but the heavy and widespread use in 1977, however, justified classifying this fruit as a major food item. Shrub-borne soft mast consisted of blackberry, huckleberry, and blueberry. Black cherry, fire cherry, and sassafras were grouped as the category labeled tree-borne soft mast. The only items identified as hard mast were acorns, although mast producing trees in the study area include beech (*Fagus grandifolia*), 7 species of hickory (*Carya* sp.), and 3 species of walnut (*Juglans* sp.) (Stupka 1964 and others). Animal material included mostly insects, some mammal remains, and traces of crayfish (Crustacea).

Debris, generally items consumed incidentally while bears foraged for other foods, included fragments of dead leaves, pine (*Pinus* sp.) and hemlock (*Tsuga canadensis*) needles, woody twigs, rock

Table 2. Proportion of major food items in the biweekly diets of black bears in the GSMNP, 1976.

	2-week interval ending										
	Apr	May	Jun		Jul	Aug			Sep		
	26	10	7	21	19	2	16	30	13	27	Total
No. scats in sample	6	11	38	35	13	54	55	49	49	25	335
Food item	Percentage of diet										
Grass and herb. matl.	92	95	78	48	24	24	8	3	6	2	38
Squawroot			12	32	36	11	9	5	3		11
Blackberry					1	30	19	49	1	13	11
Huckleberry				6	7	11	28	10	19	1	8
Blueberry				3	3	5	3	6	4	2	3
Black cherry								Tr[a]	11	34	5
Fire cherry						3	3	1	1		1
Sassafras						1	Tr	4	12	7	2

Table 2 (Continued)

	2-week interval ending										
	Apr	May	Jun		Jul	Aug			Sep		
	26	10	7	21	19	2	16	30	13	27	Total
No. scats in sample	6	11	38	35	13	54	55	49	49	25	335
Food item	Percentage of diet										
Oak								Tr	6	13	2
Insect	1	1	2	7	19	8	19	15	23	19	11
Mammal			5		6	4	1	Tr		2	2
Debris	7	4	2	4	4	3	9	7	11	9	6
Garbage			1	Tr		Tr	1				Tr

[a]Trace.

Table 3. Proportion of major food items in the biweekly diets of black bears in the GSMNP, 1977.

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	26	6	20	4	18	1	15	29	12	26	10	Total
No. scats in sample	20	27	22	35	29	40	33	34	21	13	28	9	311
Food item	Percentage of diet												
Grass and herb. matl.	90	74	45	26	15	4	7	9	18	5	12	4	26
Squawroot		14	2	17	16	11	1						5
Serviceberry			19	27	9	9	3	1					6
Blackberry					11	35	48	23	1				10
Huckleberry				2	20	15	19	24	7				8
Blueberry				1	1	3	2	16	2	1			3
Black cherry									6	5			1
Fire cherry								Tr[a]	6				Tr
Sassafras								2					Tr

Table 3 (Continued)

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	26	6	20	4	18	1	15	29	12	26	10	Total
No. scats in sample	20	27	22	35	29	40	33	34	21	13	28	9	311
Food item	Percentage of diet												
Oak									8	65	63	78	18
Insect	1	5	17	8	12	6	4	7	11	9	11	6	8
Mammal	8		Tr	4	4	5	7		8				3
Debris	1	5	14	9	12	12	6	13	22	12	14	6	10
Garbage					Tr		Tr						Tr

[a]Trace.

chips, and wood fragments. Another source of debris was litter from the forest floor that adhered to the scat after it was deposited.

Garbage, although not an important food item for most of the bears in the Park, is included in this discussion because management implications may be related to the bears' use of garbage. Beeman and Pelton (1977) reported that garbage comprised 6% of the diet of bears in the Smoky Mountains while these artificial foods accounted for less than 1% of the diet in the present study. The intense search for scats deposited in areas of high concentrations of tourists, such as campgrounds and picnic areas, and a garbage dump (now closed) occurring in the previous study undoubtedly biased results toward the use of garbage. The study of Beeman and Pelton (1977) included a large sampling from a small cohort of the population of bears in the Park, the "panhandler" bears, while the present study was directed toward the cohort of "wild" bears. Wild bears are those which generally avoid contact with humans and comprise over 95% of the bear population in the GSMNP (Pelton and Burghardt 1976).

Data from Tables 2 and 3 were examined, and food items were combined into the 6 previously described categories; 5 patterns of food utilization were delineated. The patterns, named according to the season in which they were exhibited, were Early Spring, Late Spring, Summer, Early Fall, and Late Fall (Tables 4 and 5, Fig. 3). Each pattern was characterized by a single food category that was utilized more in that pattern than in any other diet. In all diets except Late Spring, the key food category was used more than any other group of foods of plant origin.

Table 4. Composition of the seasonal diets of black bears in the GSMNP, 1976.

Category	Season			
	Early spring	Late spring	Summer	Early fall
	Percentage of diet			
Herbaceous material	95	46	12	4
Spring fruits		31	7	1
Shrub-borne soft mast		8	60	22
Tree-borne soft mast			3	39
Hard mast				6
Animal material	1	11	13	19
Debris	4	3	5	7

Table 5. Composition of the seasonal diets of black bears in the GSMNP, 1977.

	Season				
	Early spring	Late spring	Summer	Early fall	Late fall
Category	Percentage of diet				
Herbaceous material	90	41	9	20	5
Spring fruits		30	11		
Shrub-borne soft mast		7	61	15	1
Tree-borne soft mast			Tr[a]	16	2
Hard mast				7	71
Animal material	9	12	9	17	9
Debris	1	8	9	16	9

[a]Trace.

Figure 3. Typical seasonal patterns of food utilization by black bears in the GSMNP.

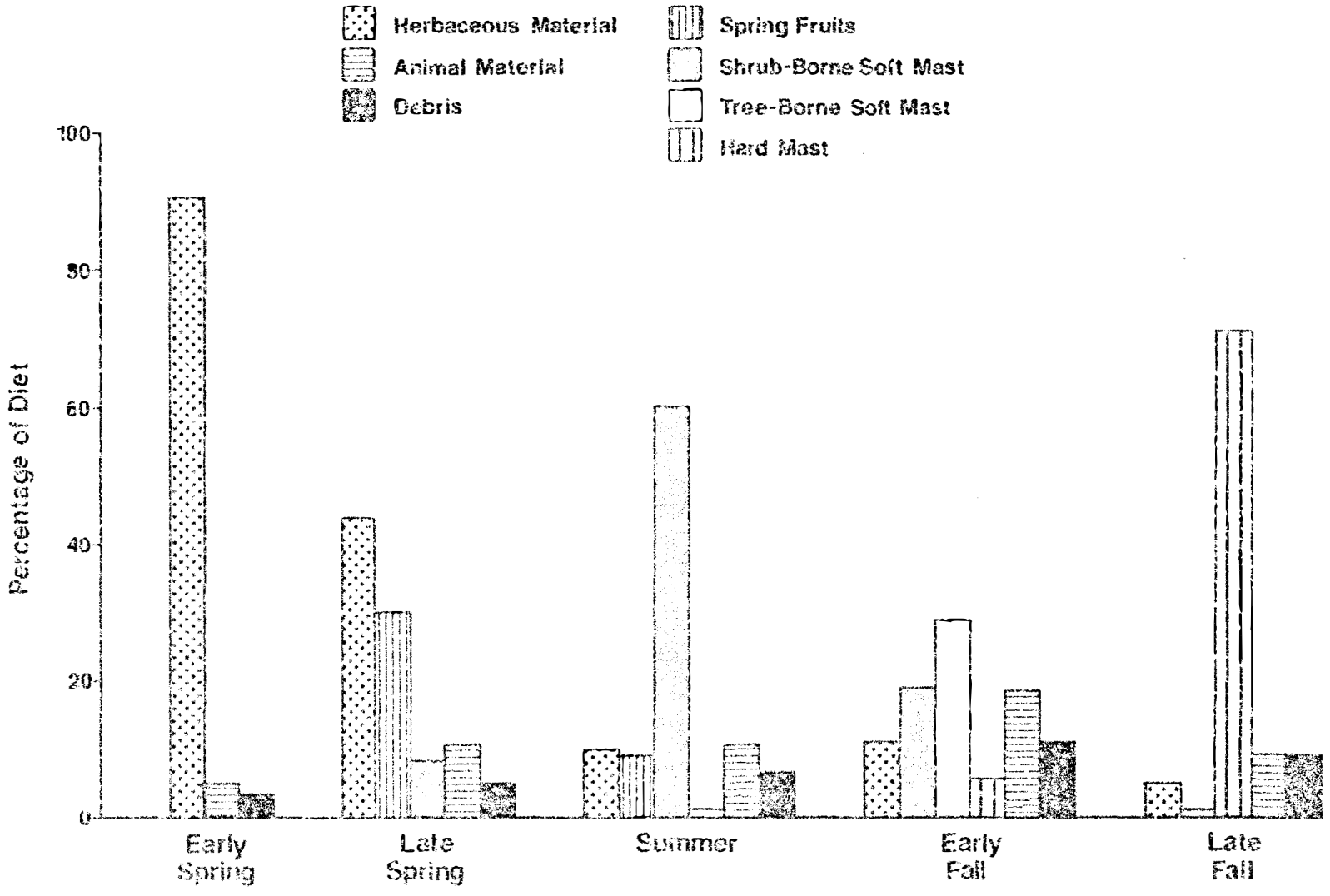
Herbaceous Material
Animal Material
Debris
Spring Fruits
Shrub-Borne Soft Mast
Tree-Borne Soft Mast
Hard Mast
Percentage of Diet
100
80
60
40
20
0
Early Spring
Late Spring
Summer
Early Fall
Late Fall

Figure 3

Data from Tables 2 and 3 were grouped into categories and averaged for the corresponding 2-week intervals; results illustrate the change in diet over time (Fig. 4). It is notable that results do not accurately reflect the seasonal pattern for either 1976 or 1977 because the changes in patterns of food utilization did not occur on the same date in both years. Instead, Fig. 4 may reflect the importance of each food category during a particular time interval over a number of years.

A general breakdown of food utilization showed that foods of plant origin comprised over 80% of the diet of bears in the Park, and insects were the most important animal food at 9% (Table 2). Mammals were a minor portion of the total diet, and it was believed that the method of scat analysis may have slightly overestimated the importance of mammals in the diet. The above findings concurred with the overall results of Beeman and Pelton (1977), which included a volume index percent of over 80 for plant foods, 7 for insects, and 1 for mammals. These results also agree with the general patterns of food utilization by black bears in most portions of their range.

Early Spring.--Results of scat analysis showed that bears depended almost exclusively on herbaceous material for food during the Early Spring (Tables 6 and 7), which included the time period from emergence until late May or early June. There was no major variation in the diet among the sections within the study area, nor between the 2 years of the study ($P > .1$).

Although mammal remains comprised 10% of the diet of bears inhabiting the Sugarland Mountain section and 14% of those in

Figure 4. Biweekly use of food categories by black bears in the GSMNP, 1976 and 1977.

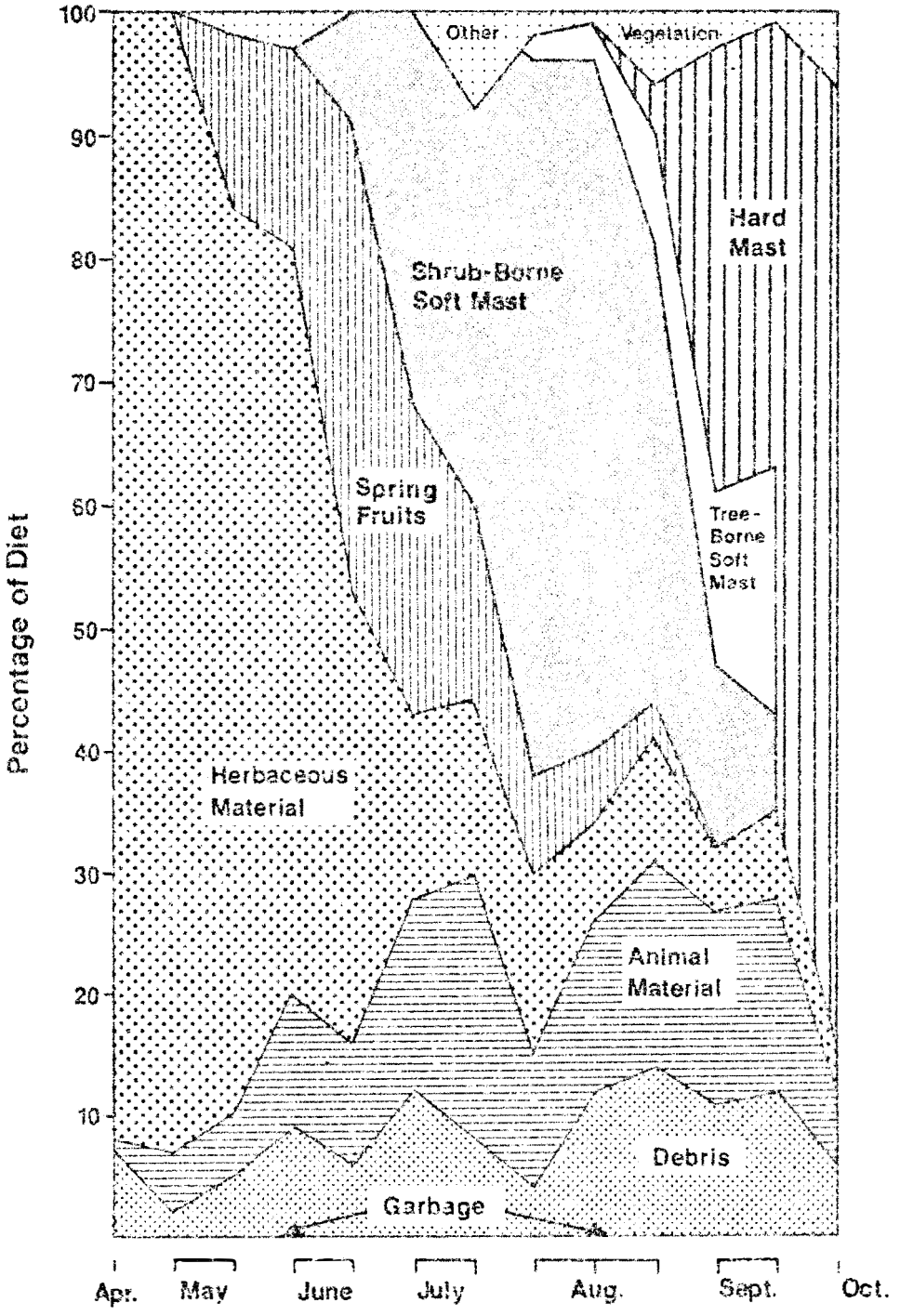
Percentage of Diet
100
90
80
70
60
50
40
30
20
10
Other
Vegetation
Hard Mast
Shrub-Borne Soft Mast
Spring Fruits
Tree-Borne Soft Mast
Herbaceous Material
Animal Material
Debris
Garbage
Apr.
May
June
July
Aug.
Sept.
Oct.
Two Week Interval

Figure 4

Table 6. Use of major food items in the Early Spring diet of black bears in 2 sections of the GSMNP, 1976.

	Elkmont-Bent Arm	Bote Mtn.-Defeat Ridge	Study area
No. scats in sample	8	9	17
Food item		Percentage of diet	
Grass and herb. matl.	97	93	95
Insect	1	1	1
Debris	2	6	4

Table 7. Use of major food items in the Early Spring diet of black bears in 3 sections of the GSMNP, 1977.

	Sugarland Mountain	Elkmont-Bent Arm	Bote Mtn.-Defeat Ridge	Study area
No. scats in sample	4	7	9	20
Food item		Percentage of diet		
Grass and herb. matl.	88	83	99	90
Insect		2		1
Mammal	10	14		8
Debris	2	1	1	1

Elkmont-Bent Arm in 1977 (Table 7), it was felt mammals were no more important to bears in the Smokies than insects, 1% of the diet. It was believed the incidence of mammals in 1977 was probably overestimated because the mammal remains in each of these sections consisted of hair in only 1 scat. The hair from the Sugarland Mountain section was woodchuck (Marmota monax) and that from Elkmont-Bent Arm was identified as eastern cottontail (Sylvilagus floridanus). Each occurrence probably represented only 1 meal. Results from Beeman and Pelton (1977) were not comparable to the findings of this study for Early Spring or Late Spring individually because their temporal separation included no division during spring.

Late Spring.--The Late Spring diet (Tables 8 and 9) was characterized by an increased use of spring fruits. In 1976 the switch to the Late Spring diet was in late May or early June accompanying the emergence of squawroot. Squawroot and serviceberry became available in late May, 1977 and were utilized heavily. Although herbaceous material still comprised almost half of the diet, its use was reduced from the 90% level of Early Spring.

There were more categories of foods used in the Late Spring diet than in the Early Spring pattern (Fig. 3, page 27), and there was variation, although insignificant ($P > .1$), among the sections of the Park. Bears inhabiting Sugarland Mountain and the Bote Mountain-Defeat Ridge section exhibited typical Late Spring patterns (Fig. 3) both years. Bears in the Elkmont-Bent Arm area displayed the typical pattern in 1977, but in 1976 the Late Spring pattern was not used.

Table 8. Use of major food items in the Late Spring diet of black bears in 5 sections of the GSMNP, 1976.

	Sugarland Mountain	Elkmont-Bent Arm	Tremont	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	8	15	7	53	8	86
Food item	Percentage of diet					
Grass and herb. matl.	42	81	32	25	51	46
Squawroot	48	1	32	60	12	31
Blackberry				1		Tr[a]
Huckleberry			17		14	6
Blueberry	1		4		3	2
Insect	5	9	7	4	18	9
Mammal	Tr	5		7		2
Debris	1	4	7	3	2	3
Garbage	3		1			1

[a]Trace.

Table 9. Use of major food items in the Late Spring diet of black bears in 5 sections of the GSMNP, 1977.

	Sugarland Mountain	Elkmont-Bent Arm	Tremont	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	6	36	3	36	3	84
Food item	Percentage of diet					
Grass and herb. matl.	30	57	84	34		41
Squawroot	2	5	5	15	50	15
Serviceberry	18	18		41		15
Huckleberry					33	7
Blueberry					1	Tr[a]
Insect	33	7	4	4	3	10
Mammal					12	2
Debris	15	10	7	6	1	8

[a]Trace.

Both the Tremont and Hannah Mountain sections were inhabited by bears showing dietary variation in both years. Huckleberry and blueberry comprised over 20% of the diet of bears in Tremont in 1976, almost a Summer diet, while in 1977 the bears displayed an Early Spring pattern. Bears in the Hannah Mountain section used huckleberry and blueberry extensively both years.

Squawroot was utilized throughout the study area in both years; however, its use was considerably reduced in most areas in 1977. Serviceberry was a large portion of the diet of bears in the Sugarland Mountain, Elkmont-Bent Arm, and Bote Mountain-Defeat Ridge sections in 1977. A similar occurrence was noted by Beeman (1971) who found serviceberry in scats in 1969, but not in 1970. Although no availability data were collected, members of the research team noticed few, if any serviceberries in 1976; however, in 1977 serviceberries were abundant. Any difference in availability of squawroot between the 2 years was unnoticeable. It appeared that the bears' use of squawroot was influenced strongly by the availability of serviceberry; the latter was apparently preferred when available.

When the Early Spring and Late Spring diets were combined and compared to findings of Beeman and Pelton (1977), there was general agreement. The use of animal material, however, was reported somewhat higher in the present study, 11% compared to 4% in the previous effort. Results in the present study were increased by findings in 2 composites, Hannah Mountain for 19 July 1976 and Sugarland Mountain for 6 June 1977 (Appendix, Tables 22 and 23), which were both nearly 50% insect remains. Elimination of these 2 composites decreased the disparity between the 2

studies, but a difference was still evident. The use of animal material was greater than 5% in most sections and was over 10% in 4 instances in the present study. The increased use of animal material in this study, especially insects, was possibly related to the decreased use of garbage. Garbage comprised 4% of the Spring foods in the Beeman and Pelton (1977) study, but was less than 1% in the current study during this period. It was believed that results in the previous study were biased in favor of panhandler bears, and those animals apparently substitute the use of garbage for the foraging for insects or carrion to fulfill the protein requirement in their diet.

Summer.--The Summer pattern was marked by the use of shrub-borne soft mast, blackberry, huckleberry, and blueberry, as the largest source of food (60%). Although bears used the latter 2 fruits as early as middle June during both years, it was not until early August in 1976 and middle July in 1977 that the Summer pattern was displayed (Tables 10 and 11).

Bears throughout the study area continued to consume the food items which characterized the 2 previous seasonal patterns, but the use of these items was reduced. Herbaceous material and spring fruits each comprised approximately 10% of the Summer diet. The use of animal material, particularly insects, increased in the Summer diet. This increase was attributed to greater availability and activity of the insects during the warm months. Tree-borne soft mast was eaten in the summer, but these items remained less than 5% of the diet.

Table 10. Use of major food items in the Summer diet of black bears in 5 sections of the GSMNP, 1976.

	Sugarland Mountain	Elkmont-Bent Arm	Tremont	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	7	38	18	48	47	158
Food item	Percentage of diet					
Grass and herb. matl.	26	8	13	8	3	12
Squawroot	8	5	7	16	1	7
Blackberry	23	71	28	48	1	34
Huckleberry	22		35	2	50	22
Blueberry			1	2	15	4
Fire cherry		8		2		2
Sassafras		1	1	3		1
Oak				2		Tr[a]
Insect	10	4	9	11	19	11
Mammal	3		1		4	2
Debris	8	2	3	5	7	5
Garbage			Tr	1		Tr

[a]Trace.

Table 11. Use of major food items in the Summer diet of black bears in 5 sections of the GSMNP, 1977.

	Sugarland Mountain	Elkmont-Bent Arm	Tremont	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	12	18	22	58	26	136
Food item			Percentage of diet			
Grass and herb. matl.	14	7	6	12	4	9
Squawroot	11	6	5	4	4	6
Serviceberry	3	5	1	12	3	5
Blackberry	47	39	38	37		32
Huckleberry	5	3	37	7	67	24
Blueberry	7	7		5	5	5
Sassafras				1	1	Tr[a]
Insect	9	9	2	5	5	6
Mammal	1	3	2	7	4	3
Debris	4	20	4	10	8	9
Garbage		Tr	Tr			Tr

[a]Trace.

Although there was insignificant variation ($P > .1$) in the general dietary patterns between the 2 years or among the sections of the study area, different food items within the key category were used in some sections. Bears in the Sugarland Mountain and the Tremont sections ate large proportions of blackberries as well as huckleberries. Blackberries were by far the most heavily used food item in the Elkmont-Bent Arm and Bote Mountain-Defeat Ridge sections. Bears inhabiting the Hannah Mountain section ate mostly huckleberry and blueberry during the summer, and virtually no blackberry.

Availability of the various fruits in the sections of the study area was not determined. It was, however, noted that most scats collected in the Hannah Mountain section were deposited in the Open Oak and Pine forest association, which dominated the higher elevations in this section and was the location of most of the research activity. Huckleberry and blueberry are both important shrubs in this forest asscciation (Shanks 1954b). Considering the above, it was not surprising that huckleberry and blueberry were the food items most heavily used by bears in this section.

Early Fall.--In middle to late August the incidence of shrub-borne soft mast in the diet of bears was reduced in most sections (Tables 2 and 3, pages 20 and 22, respectively), presumably accompanying a decline in fruit production. Ripening of the tree-borne soft mast was, undoubtedly, another factor. In 1976 cherries and sassafras accounted for over half of the diet in 3 sections (Table 12) and in 1 region in 1977 (Table 13). Black cherry was the most important food

Table 12. Use of major food items in the Early Fall diet of black bears in 5 sections of the GSMNP, 1976.

	Sugarland Mountain	Elkmont-Bent Arm	Tremont	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	4	6	14	32	6	74
Food item	Percentage of diet					
Grass and herb. matl.	1	6	5	4	6	4
Squawroot				6		1
Blackberry				19		4
Huckleberry	1	15	5	5	52	16
Blueberry			1	1	10	2
Fire cherry			4			1
Black cherry	69	44	25	3		28
Sassafras	10	10	28	3		10
Oak		1		29		6
Insect	13	18	16	17	25	18
Mammal			4			1
Debris	6	6	12	8	7	7

Table 13. Use of major food items in the Early Fall diet of black bears in 5 sections of the GSMNP, 1977.

	Sugarland Mountain	Elkmont-Bent Arm	Tremont	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	2	4	2	8	5	21
Food item	Percentage of diet					
Grass and herb. matl.	35	47	8	6	2	20
Blackberry	1	5				1
Huckleberry					35	7
Blueberry	33				3	7
Fire cherry		10		15		5
Black cherry			53			11
Oak		6		26	4	7
Insect	4	10	2	26	4	9
Mammal					38	8
Debris	27	8	11	27	14	16

item among the 3 classified as tree-borne soft mast. Sassafras ranked second in 1976, but was not encountered in 1977. Fire cherry was a major food item in only 2 sections, Elkmont-Bent Arm and Bote Mountain-Defeat Ridge.

The use of herbaceous material declined during Early Fall in most sections; however, it accounted for about 40% of the diet on Sugarland and in the Elkmont-Bent Arm section. Small sample size, 2 and 4 scats, respectively, was believed to be a factor affecting these results.

Shrub-borne soft mast declined in use during Early Fall in most sections, but bears in the Hannah Mountain section continued using huckleberry as the primary food item. In fact, bears in this section failed to change from the Summer to the Early Fall pattern during either year. Although sassafras is an important tree in the forest association comprising much of the Hannah Mountain section, only during Summer, 1976, was any evidence of the bears' use of sassafras encountered, and then it constituted only 1% of the diet.

Acorn remains were found in scats during Early Fall, but comprised less than 5% of the diet in most sections. Acorns accounted for over 25% of food consumed by bears inhabiting the Bote Mountain-Defeat Ridge section during this season.

The use of insects increased slightly with the change to the Early Fall pattern. The availability of insects was not believed greater during this period, but total daily movements by bears in the study area are higher in the Fall (Garshelis 1978), and this increased movement may have resulted in more encounters with insect nests.

Late Fall.--The use of hard mast characterized the Late Fall pattern (Fig. 3, page 27) of food utilization by black bears in the Park, and acorns were the only items within this food class encountered in this study (Table 14). The Late Fall pattern was delineated only in 1977. If scat collection had continued through October or November, the switch to the Late Fall diet would probably have been detected in 1976 because the acorn crop was good (Tennessee Wildlife Resources Agency 1977), and peak acorn availability is usually not realized in East Tennessee until middle October (Strickland 1972).

Consumption of acorns accounted for over 70% of the diet throughout the study area during the Late Fall. Table 14 shows that acorns were 83% of the diet in 2 sections, Elkmont-Bent Arm and Hannah Mountain. Bears inhabiting Sugarland appeared to utilize acorns less than those animals in other sections, but Appendix, Table 23, shows that the use of acorns in that section rose steadily during the period in which bears ate the Late Fall diet, 12 September through 10 October. Similarly, acorns comprised 80% and 75% of the diet of bears in the Bote Mountain-Defeat Ridge section during 2 of the 2-week intervals of this period and only 37% in the third (Appendix, Table 26). Only 2 scats were in the composite of scats for the 2-week period ending 10 October in the Bote Mountain-Defeat Ridge section; 1 of which contained mostly acorns and the other mostly grape (Vitis sp.) remains. The lack of grape in the diet in other sections or during other time periods suggested that the use of grape was probably overestimated in this instance as a result of the small sample, and that

Table 14. Use of major food items in the Late Fall diet of black bears in 4 sections of the GSMNP, 1977.

	Sugarland Mountain	Elkmont-Bent Arm	Bote Mtn.-Defeat Ridge	Hannah Mountain	Study area
No. scats in sample	7	6	30	5	50
Food item	Percentage of diet				
Grass and herb. matl.	15		7	2	5
Blueberry	3				1
Black cherry		4		2	2
Oak	52	83	64	83	71
Insect	18	2	8	6	9
Debris	10	11	9	6	9

acorns were more important in the Bote Mountain-Defeat Ridge area than was indicated by this composite.

Herbaceous material remained in the diet, but comprised only 5% of the total. Blueberry was found in only 1 composite, which represented the earliest collection of this seasonal diet. Black cherry was found in 2 sections, but was only 2% of the diet of bears in the study area. No mammal remains were found during this period, and insect remains decreased to 9% of the diet.

Results from the current study disagreed with findings in Beeman's (1971) study. Although acorns were major food items during Late Fall in the previous study, that effort indicated a much lower use of oak mast (15% in 1969 and 41% in 1970). Acorn production rated only fair in East Tennessee during the years of Beeman's (1971) study (Conley 1970, Tennessee Wildlife Resources Agency 1977), but was good both years of the current study. This difference in availability of acorns undoubtedly accounted for part of the difference between the use of oak mast found in the 2 studies.

Another factor may be considered in the low utilization of acorns during the first year of Beeman's (1971) study. He found that 1 species of tree-borne soft mast, black cherry, was the most important item of the late fall diet in 1969. That study possibly suffered the same problem noted in 1976 of the present study; scat collection ended before the bears changed from the Early Fall to the Late Fall pattern of food utilization.

The use of hard mast increased to 60% of the diet during 1970, the second year of Beeman's (1971) study. This level of hard mast

consumption placed the 1970 diet within the Late Fall pattern defined in the present study. Hard mast found in the previous study, however, included beechnuts as 19% of the diet.

The exclusion of much of the beech forest occurred when the study area was reduced after the Beeman (1971) study. That exclusion may explain part of the reason beech was a major food item in the previous study while only traces of beech were encountered in the present study.

Major Food Items

Samples of major food items and corresponding scats were analyzed to determine crude protein, ADF, and lignin content (Table 15). Results of other researchers applicable to the diet of black bears in the GSMNP are presented in Table 16. Most authors did not determine ADF content of foods; instead, they determined crude fiber content. Both ADF and crude fiber analyses reveal the fraction of foods that is usually not digestible by monogastric species such as bears, and nutritionists have mathematically compared the 2 determinations (Chandler 1978). ADF content may be approximated from crude fiber determination using the following equation:

$$ADF = \text{crude fiber}/0.75$$

All plant food items except acorns were low in proteins and high in fiber. Acorns were low in both protein and fiber. Animal material, both insects and mammals, was high in protein and low in fiber.

Herbaceous Material.--Herbaceous material, grasses and other succulent plants, comprised nearly all of the Early Spring diet of

Table 15. Crude protein, acid detergent fiber, and lignin content of food items of black bears and of corresponding scats from the GSMNP.

	Composition (percentage of dry matter)		
Sample	Crude protein	ADF	Lignin
Herbaceous scat	11.3	40.2	13.1
Squawroot	5.0	22.2	10.0
Scat	6.5	57.0	30.3
Serviceberry	9.8	22.9	6.8
Blackberry	9.8	29.8	15.2
Scat	13.3	54.2	29.1
Huckleberry and blueberry	3.1	22.2	11.4
Scat	9.2	55.0	27.7
Acorns (kernel only)	6.0	4.2	0.2
Scat	11.1	9.2	1.2

Table 16. Crude protein and acid detergent fiber content of foods typically used by black bears in the GSMNP.

Food item	Composition (percentage of dry matter)	
	Crude protein	ADF[a]
Herbaceous matl.[b]	19.1	32.5
Blackberry[c]	8.2	45.2
Blackberry[d]	13.1	32.9
Blackberry[e]	5.8	28.7
Huckleberry[d]	2.2	20.7
Blueberry[c]	4.1	12.9
Blueberry[d]	5.8	19.7
Cherry (pulp and skin)[c]	5.1	17.7
Cherry[e]	13.9	43.5
Oak, red (with integument)[c]	6.6	4.1
Oak, chestnut (with integument)[c]	6.9	3.5
Oak, white (with integument)[c]	6.2	3.3
Oak, chestnut (with integument)[e]	6.4	20.3
Oak, white (with integument)[e]	6.7	23.2
Grape[c]	5.4	17.9
Grape[d]	6.0	26.5
Grape[e]	9.8	29.6
Insect[f]	43.4	20.1
Mammal[g]	79.0	1.7

Table 16 (Continued)

[a]ADF calculated by cellulose plus lignin for items taken from Wainio and Forbes (1941). ADF calculated by crude protein/0.75 for items from all other authors.

[b]Source: Mealey (1975), average of all herbaceous material.

[c]Source: Wainio and Forbes (1941).

[d]Source: Landers et al. (1979).

[e]Source: King and McClure (1944).

[f]Source: Beck and Beck (1955) and Southwood (1973), average of all insects.

[g]Source: Mealey (1975), average of Cervus canadensis (lean tissue) and Microtus sp.

bears in the Park. It was 44% of the Late Spring diet, and its use decreased to less than 10% of the diet in most other seasons during the study.

Similar patterns of use were described by other authors in previous studies. Chatelain (1950) found herbaceous material in almost all scats in May and June, but it was found in less than 10% of scats collected in the summer in Alaska. The spring diet of black bears in Maine was 60% herbaceous material while its use decreased to 10% and 3% in summer and fall, respectively (Spencer 1961). Herbage comprised the bulk of spring foods and was found in nearly all scats in Montana, and in summer it was found in many scats, but the volume was greatly decreased (Tisch 1961). In interior Alaska Hatler (1967) found that herbaceous items accounted for 70% of the spring diet, but only 15% of the fall diet. Hardy (1974) and Landers et al. (1979) reported that green vegetation was a major food item for bears on the coast of North Carolina only during the spring or early summer. In Washington approximately half of the annual diet of black bears consisted of herbaceous material (Poelker and Hartwell 1973).

While grass and other herbaceous items are the major portions of the diet, bears either gain weight slowly or lose weight (Jonkel and Cowan 1971). Poelker and Hartwell (1973) concurred with the above and termed this interval the "negative foraging period." Beeman (1975) and Rogers (1976) found the above to be true for bears in the GSMNP and in Minnesota, respectively.

Hatler (1967) found that green plant material appears to be little changed in either form or volume as it passes through a bear's

digestive system. This lack of digestion is not surprising because bears lack a cecum and have simple stomachs that are too acid to support the microbes needed for digestion of cellulose (Rogers 1976).

The protein and fiber content of herbaceous material was not determined in this study. Mealey (1975), however, determined nutritional content of many herbaceous items, and his results were averaged and included in Table 16. Use of the findings from that study were believed to be acceptable for use in the present study because analysis of scats from the Park comprised mainly of herbaceous items yielded results similar to those reported by Mealey (1975) for grizzly bears (U. arctos).

Herbaceous material was relatively high in protein and fiber content. The high fiber content greatly reduced the digestibility of these foods, and the nutrients extracted were probably used as energy sources.

Spring Fruits.--Beeman (1971) found that no other author reported the use of squawroot by black bears in other regions of the United States. Martin et al. (1951) did not list this plant as a food item of any wildlife in America.

Radford et al. (1968) reported that squawroot was distributed throughout most of the Carolinas and in West Virginia, Virginia, Georgia, and Florida, as well as Tennessee. Bears in the GSMNP and surrounding areas appear to be the only bears that consume squawroot even though it is widely distributed. In the Park squawroot was a key food item in the Late Spring pattern, up to 36% of the diet, and

accounted for over 10% of the annual diet (1976) of bears in the Park (Table 2, page 20).

Nutritionally, squawroot may be an important item in the diet of bears. The protein content (8.0%) is slightly higher than that found in most berries, while the fiber content (22.2%) is lower (Table 15, page 49). Protein content (6.5%) of scats containing mostly squawroot remains was slightly less than that in the food item. Fiber content (57.0%), however, was much higher in scats. Apparently bears are able to extract protein and other energy-supplying nutrients from squawroot. Although herbaceous material is higher in protein (19.1%) than squawroot, the fiber content is also much greater (32.5%). As a monogastric species, bears are probably able to digest a greater portion of squawroot than of herbaceous material. The greater digestibility of squawroot may be very important to an animal that is in a negative foraging period.

Serviceberry was the other spring fruit consumed by black bears in the Park. Tisch (1961) found that serviceberry occurred in only 5% of the summer scats of black bears in Montana in 1969, but this increased to over 20% of scats found during the summer of 1970, and an increase in volume accompanied the increased frequency of this item. Beeman (1971) found serviceberry seeds in scats in only 1 year of his 2-year study. Similar results were encountered in the present study. In 1976 when no serviceberry was available, bears consumed large amounts of squawroot (Fig. 5). In 1977 the use of serviceberry was greater than that of squawroot during June, but its use decreased greatly in July. It appears that while serviceberry may be preferred,

Figure 5. Biweekly use of spring fruits by black bears in the GSMNP, 1976 and 1977.


Squawroot (1978)
Serviceberry (1977)
Squawroot (1977)
40
30
20
10
0
Percentage of Diet
Apr.
May
June
July
Aug.
Sept.
Oct.
Two Week Interval

Figure 5

its peak availability is much shorter than that of squawroot. Martin et al. (1951) reported that serviceberry was not a major wildlife food item in America, but was of some importance in early summer.

The protein and fiber content (10% and 23%) of serviceberry is close to that found in squawroot (8% and 22%). Although no scat samples composed mainly of serviceberry remains were analyzed, it was believed that much of the protein in serviceberry may be available to bears. The protein content of this item was higher than that for most berries (Tables 15 and 16), and fiber, especially the lignin content, was much lower. With a high protein content and only a few seeds in each berry, serviceberry may contain protein that is available to black bears.

Shrub-borne Soft Mast.--The 3 fruits included in the shrub-borne soft mast category were blackberry, huckleberry, and blueberry. It should be noted that all species in the genus, Rubus, were considered blackberry; only species of Gaylussacia were included as huckleberry; and all species of Vaccinium were referred to as blueberry.

Beeman (1971) found that blackberries were the most heavily used fruit in the summer in the Smoky Mountains. Similar results were found in the current effort (Fig. 6). Blackberry became important later than the other kinds of shrub-borne soft mast, but was utilized much more heavily in late July and early August. Blackberry disappeared from the diet in most regions before huckleberry and blueberry. The September peak of blackberry use (Fig. 6) was due to an unusual utilization of this fruit in the Bote Mountain-Defeat Ridge section in 1976 (Appendix, Table 21).

Figure 6. Biweekly use of shrub-borne soft mast by black bears in the GSMNP, 1976 and 1977.

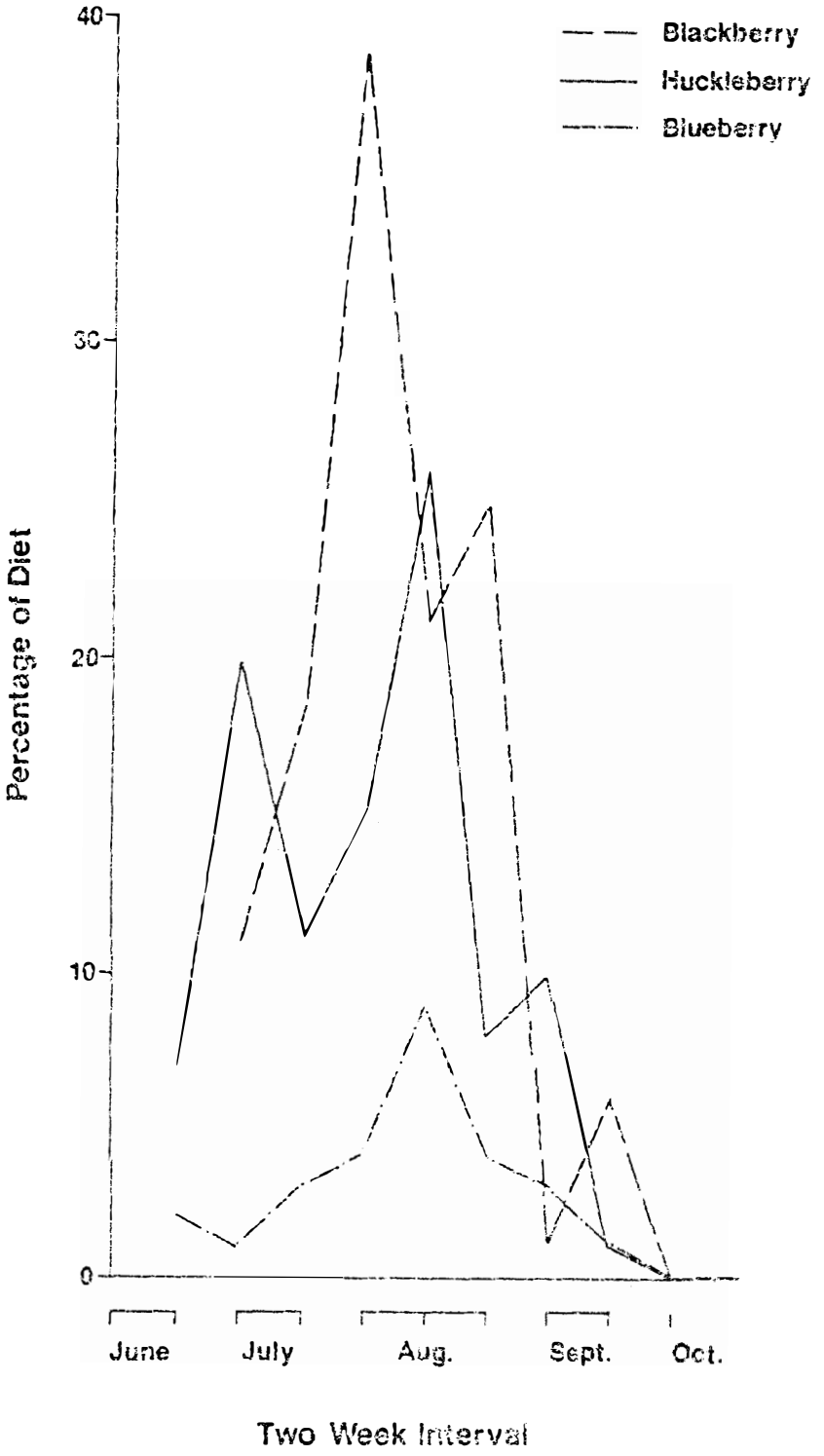
Blackberry
Huckleberry
Blueberry
40
30
20
10
0
Percentage of Diet
June
July
Aug.
Sept.
Oct.
Two Week Interval

Figure 6

This heavy utilization of blackberry concurred well with general wildlife usage, but was contrary to results from studies of food habits of black bears in other parts of their range. Martin et al. (1951) reported that blackberry ranked at the top of summer foods for wildlife and attributed this extensive use at least partly to its widespread distribution in most parts of the country.

Many studies, however, indicated that blackberry was relatively unimportant to black bears in other areas. Blackberry accounted for only 5% of the summer foods of black bears in Pennsylvania (Bennett et al. 1943). Harlow (1961) and Tisch (1961) found trace amounts of blackberry only in the fall in Florida and Montana, respectively. In Maine only 10% of the summer diet consisted of this fruit (Spencer 1961). Poelker and Hartwell (1973) reported that blackberry was of minor importance to bears in Washington and was found only in summer. Even along the North Carolina coast blackberry was not important to black bears, amounting to only 4% of the diet in June and July (Landers et al. 1979).

Huckleberry ranked second among the shrub-borne soft mast and was far more important than blueberry. Huckleberry was the most heavily used food item in the Hannah Mountain region in the Summer diet (Tables 10 and 11, pages 39 and 40, respectively) and was the most important plant food in that region in the Early Fall pattern (Tables 12 and 13, pages 42 and 43, respectively).

In other parts of the country, huckleberry was not a particularly important food item. Martin et al. (1951) reported only limited use of huckleberry by only a few species of wildlife,

and its distribution was limited to the eastern United States. In only 1 other region was huckleberry an important food item for black bears. Landers et al. (1979) reported that huckleberry was the most important food in July and comprised 18% of the August diet of bears in southeastern North Carolina.

Species of blueberry, the least important of the shrub-borne soft mast in the current study and in the previous effort in the Park (Beeman 1971), are widely used food items by many species of wildlife and can be very important to bears (Martin et al. 1951). Murie (1937) found blueberry remains in 3 of 64 scats during a summer when the abundance of crickets and grasshoppers was unusually high and precluded the occurrence of virtually all other food items. Cottam et al. (1939) reported that blueberries were second only to acorns in the fall diet of black bears in Virginia. On the Kenai Peninsula, Alaska, blueberry was found in scats during all seasons because bears consumed the previous year's crop until the current crop ripened (Chatelain 1950). Blueberry comprised 10% of the summer diet of bears in Maine (Spencer 1961). Tisch (1961) reported that blueberry was the most important food item in the fall for bears in Montana, and Jonkel and Cowan (1971) underscored the importance of blueberry to black bears in Montana by reporting that reproduction in bears approached zero when blueberries were scarce for 3 consecutive years. Blueberry formed the bulk of fall foods in interior Alaska (Hatler 1967) and Washington (Poelker and Hartwell 1973). In northeastern North Carolina blueberries were found in bear scats in spring and summer and were most important in August (Hardy 1974), but they were important only in June to bears

in the southeastern part of that state (Landers et al. 1979).

All 3 members of the shrub-borne soft mast were energy foods. Although blackberries had more protein than the others, results in Table 15, page 49, showed the protein content of any of the shrub-borne mast was probably not available to bears. The protein and fiber portions of the scats were much higher than the content of those nutrients in the food items. It was believed that little, if any, was digested by bears because protein is found mostly in the seeds of these fruits (Wainio and Forbes 1941). The concentration of seeds in scats collected in summer showed bears digest only the pulp and skin of fruits eaten, and carbohydrate is the principal nutrient in fruit pulp.

Tree-borne Soft Mast.--Black cherries, fire cherries, and sassafras berries comprised the tree-borne soft mast, the most important food category throughout most of the study area in the Early Fall diet; the Hannah Mountain and Bote Mountain-Defeat Ridge sections were exceptions (Table 12, page 42).

Black cherry was the most heavily used of these 3 fruits (Fig. 7). Up to 85% of a local diet was composed of black cherry during late September (Appendix, Table 19). Beeman and Pelton (1971) also found that black cherry was an important food item to bears in the Smoky Mountains during the early part of fall.

Bennett et al. (1943) reported that cherries comprised over half of the summer diet of bears in Pennsylvania. Spencer (1951) found that cherries were important to bears during the summer in

Figure 7. Biweekly use of tree-borne soft mast by black bears in the GSMNP, 1976 and 1977.

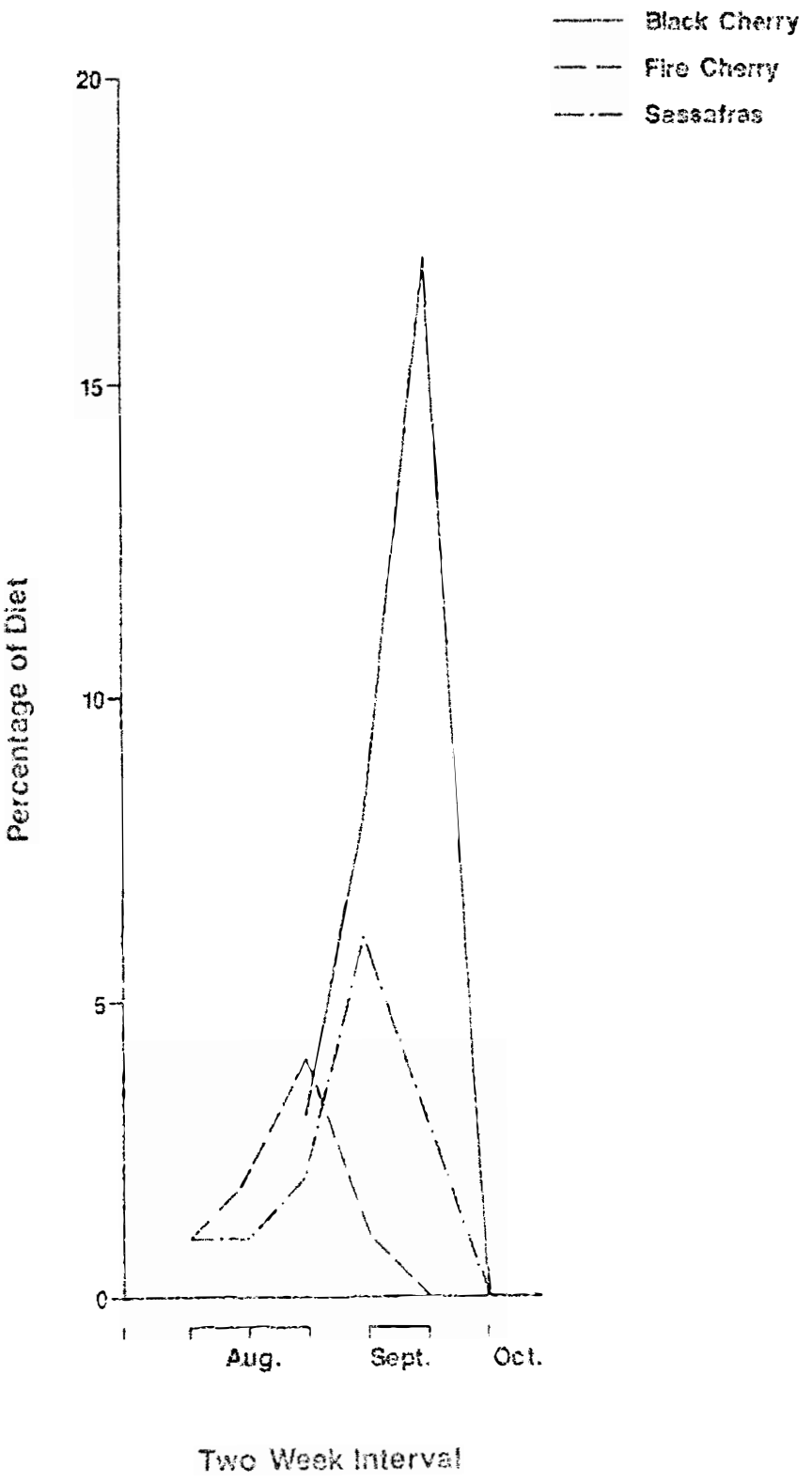
Black Cherry
Fire Cherry
Sassafras
20
15
10
5
0
Percentage of Diet
Aug.
Sept.
Oct.
Two Week Interval

Figure 7

Maine, but use of cherries decreased greatly during fall. Tisch (1961) found only trace amounts of cherries in fall scats in Montana, and Poelker and Hartwell (1973) reported similar findings in Washington. Cherries were, however, important to bears in Minnesota (Rogers 1976).

Sassafras comprised over 5% of the bears' diet during early September, but was not an important food source for black bears in the Smokies or in other parts of the country. Bennett et al. (1943) reported some use of sassafras by bears in Pennsylvania, but it comprised less than 2% of the diet. Martin et al. (1951) reported that sassafras was a small part of the diet of only a few species of wildlife.

Fire cherry was the least important food item among the tree-borne soft mast and hardly qualified as a major food item of bears in the Park. This fruit may be eaten by bears in other regions, but was not identified in any report. Some authors discussed wild cherries but did not identify the species.

Like the shrub-borne soft mast, cherries appeared to be energy foods. King and McClure (1944) reported a protein content of nearly 14%, but their samples included whole cherries. Wainio and Forbes (1941) analyzed just the pulp and skin of cherries and reported a protein content of approximately 5%. Since black bears utilize only the pulp and skin, rather than crack the seed coat, the values reported by Wainio and Forbes (1941) (Table 16, page 50) were used in this study.

Nutritional information was not obtained for sassafras and was

not available in the literature; a value equal to that of cherries was used. Although the above may have produced some error in calculating nutritional value of the Early Fall diet, sassafras was not an important food item, and any error produced was likely negligible.

Hard Mast.--The only food items identified as hard mast in the current study were acorns. Acorns were the most heavily used food item in the Late Fall diet, accounting for over 70% of that diet. The species of oak utilized were not identified in most instances because there were very few occurrences of the shell or cap on which to base identification. The 2 instances where identification was possible consisted of chestnut oak. It was believed, however, that all species of oaks were utilized, and that red oaks and white oaks may have been preferred because the tannin content was lower than that of chestnut oaks (Wainio and Forbes 1941).

Acorns may be the most important wildlife food item (Van Dersal 1940, Martin et al. 1951), and this importance may be due in part to their availability in winter. This winter availability was of little importance to black bears in the GSMNP, which were dormant during winter.

The importance of acorns in the diet of bears in the Park came in the pre-denning period. Beeman (1975) and Garshelis (1978) found that bears in the Park shifted their range in the fall and speculated that the availability of oak mast may have influenced this shift. Garshelis (1978) found that fall ranges had significantly more oaks of all sampled species than did spring/summer ranges. In addition,

Garshelis (1978) found that dominant (heavier) males shifted to the fall range earlier than other sex-age groups, and the fall ranges of the dominant males had a greater availability of white oaks and red oaks than did the ranges of females and subordinate males. Beeman (1975) reported that there were extensive movements by bears from the Park during years of oak mast failures and showed there was a decrease in reproduction following these mast failures. Beeman and Pelton (1977) hypothesized the periodic oak crop failures and resulting movements of bears likely played a role in population regulation.

Use of acorns by bears in other regions falls into 3 classifications. First, like that found in the GSMNP, are the regions where acorns are the main food during late fall or early winter. Second are regions in which acorns are important, but are secondary to some other food item, and finally are regions in which acorns are unimportant to bears. Cottam et al. (1939) reported that the use of acorns by bears in Virginia varied from year to year and attributed this variation to mast failures, but acorns accounted for over 80% of the diet when they were abundant and constituted over 50% of the diet over several years. Harlow (1961) found that acorns comprised over 50% of the diet of black bears in Florida. In California acorns were important to bears in October, but were secondary to manzanita berries (Arctostaphylos sp.), which were found in nearly all scats during summer and fall (Piekielek and Burton 1975). Acorns accounted for 12% of the diet of bears in Pennsylvania, and this amount increased to 36% in fall (Bennett et al. 1943). Spencer (1961) reported only 3% of the fall diet of bears in Maine consisted of acorns.

In southeastern North Carolina only 17% of the late fall and winter diet of black bears was acorns (Landers et al. 1979), and no acorns were noted in northeastern North Carolina (Hardy 1974).

Acorns are the main food item during the period when bears in the GSMNP gain weight most rapidly. The low protein and fiber content of acorns (Table 15, page 49) suggests that this food is high in available energy. Fat content is variable in acorns, but available carbohydrate is rated high (Wainio and Forbes 1941, King and McClure 1944).

Strickland (1972) reported that acorns persist through the winter in East Tennessee and are usually available in limited quantities in spring. Acorns were 15% of the spring diet of European wild hogs in the GSMNP (Scott and Pelton 1975); however, black bears did not consume acorns as a part of the Early Spring diet. This finding is surprising since bears lose weight during spring due to a diet low in energy.

Animal Material.--Animal material was encountered in all seasonal diets. The proportion of animal material, especially insects, increased from a low in Early Spring through Early Fall, then decreased in Late Fall (Fig. 8). The increased use of insects through the summer was attributed to greater availability, and high use was sustained in the Early Fall diet by greater hourly movements by bears and continued availability of insects.

Animal material amounted to 11% of the diet of bears during the entire study, and its use varied from 1% to 28% of the diet (Tables 2 and 3, pages 20 and 22, respectively). Insects were used more

Figure 8. Biweekly use of animal material by black bears in the GSMNP, 1976 and 1977.

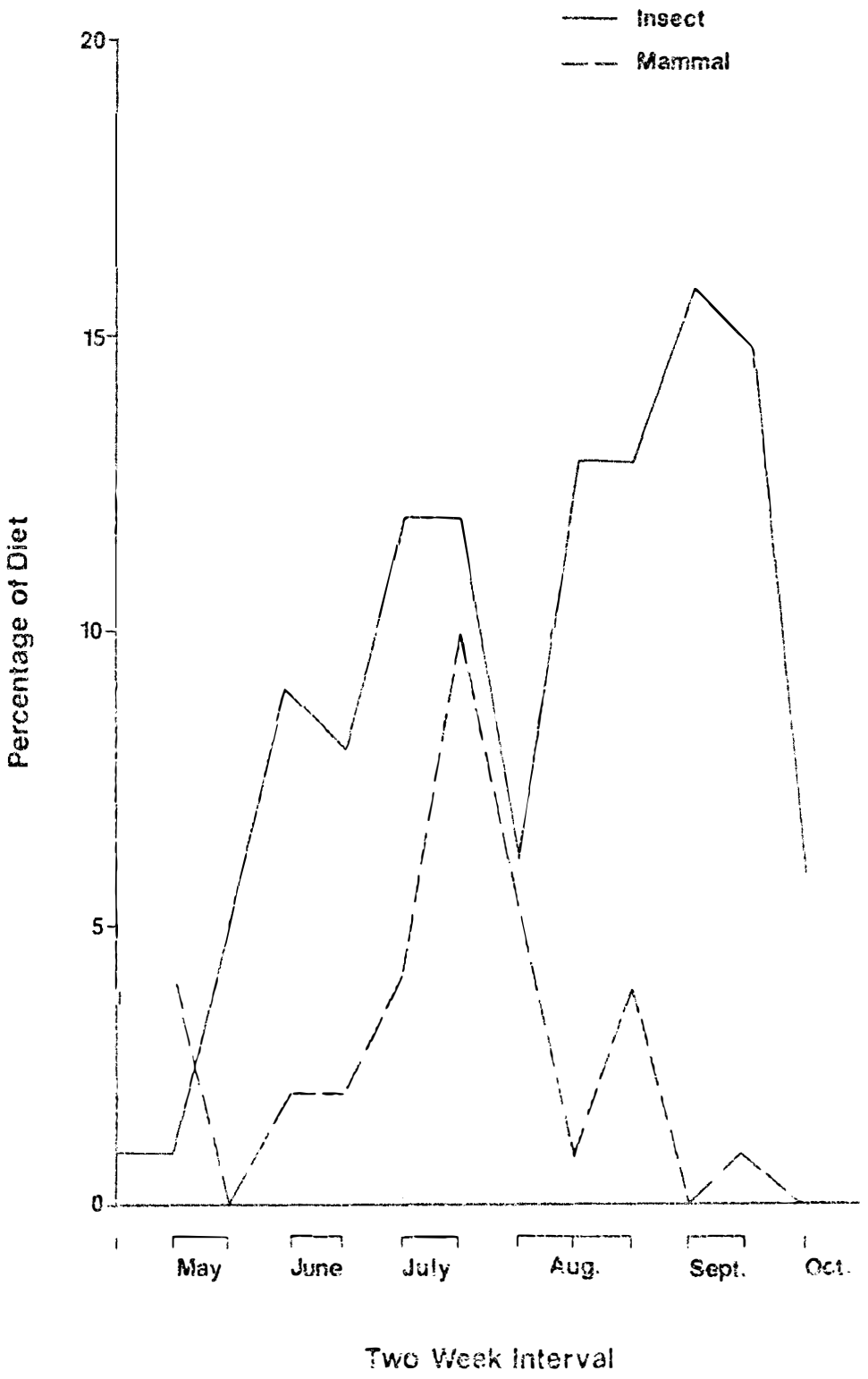
Insect
Mammal
20
15
10
5
0
Percentage of Diet
May
June
July
Aug.
Sept.
Oct.
Two Week Interval

Figure 8

extensively than mammals for food. These findings concurred generally with other studies. There were, however, seasonal or unusual exceptions. Murie (1937) found that 58 of 64 scats were comprised entirely of insect remains during a summer when crickets and grasshoppers were unusually abundant. Chatelain (1950) reported that mammals were usually unimportant to black bears in Alaska, but became important when insect utilization was low. Spencer (1961) wrote that carrion was the most important animal component of the fall diet of bears in Maine, and it was noted there were few other mammal remains.

Of all insects consumed by black bears in the Park, which amounted to 9% of the total diet, most (58%) were unidentified. Ants (Formicidae) were found in 19 composites and comprised 15%. Wood roaches (Orthoptera), in 3 composites, were 13%. Yellow jackets (Hymenoptera), 11% of all insect remains, were found in 5 composites, and beetles (Coleoptera) were 3% of the insects and were found in 4 composites. Maggots (Diptera) were infrequently encountered, and only few were observed. These maggots were assumed to have been deposited in scats already on the ground. No other insect larvae were seen. Apparently bears consumed ants most frequently, but only in small amounts. Yellow jackets and wood roaches were eaten less frequently, but made larger meals. Only infrequent, small meals were made of beetles.

Mammals were 2% of the total diet. Of the mammal remains found, most (38%) were not identified. Mammals that were identified included eastern cottontail 28%; white tailed deer, 11%; raccoon

(Procyon lotor), 9%; European wild hog, 8%; woodchuck, 5%; and black bear, 1%.

While most encounters of bear hair in scats were attributed to grooming, it was recognized that black bears may practice cannibalism. During 1976, 2 bears held in snares were killed by other bears. One was partially consumed while still in the snare. The other was carried away, presumably by the bear that killed it, after a researcher removed the dead animal from the trap, and the researcher departed for approximately 2 hours. It was believed that both animals were killed in acts of aggression rather than predation, and consumption was an act of opportunity.

The major role of animal material in the diet of black bears is a protein supplement to the plant foods that formed the bulk of the diet. Protein content of insects ranges from 27% in larva (Beck and Beck 1955) to 55% in ants (Southwood 1973); both figures were computed on a dry weight basis. Mammals contain an even greater proportion of protein, averaging 79% of dry matter (Mealey 1975). Although proteins in the diet may be used for energy as well as for incorporation in other body proteins, it is believed that the proteins of animal origin are used for the latter purpose because there is a lack of high quality proteins in the diet from other sources.

Other Foods.--There were 3 other plant food items encountered in small quantities during the present study that merit discussion, grapes, black gum (Nyssa sylvatica), and beech. Grapes do not appear to be a very important constituent in the diet of black bears in any part of their range in most years. Harlow (1961) reported only a

trace level of utilization in Florida. In Virginia grapes were 5% of the fall diet (Cottam et al. 1939), and Bennett et al. (1943) reported that grapes were 9% of the fall diet of bears in Pennsylvania. Black gum is unimportant in the Park, but is the most extensively used fall food in northeastern (Hardy 1974) and southeastern (Landers et al. 1979) North Carolina.

Both grapes and black gum represent sources of energy to black bears, being high in carbohydrates and low in protein and fiber (Wainio and Forbes 1941, Landers et al. 1979). Like acorns, both of these foods are components of the Early or Late Fall diet and are subject to variable yield. In years of grape or black gum abundance, these fruits may act as a substitute for acorns when the acorn crop is poor. Landers et al. (1979) found that acorns and black gum were scarce in alternate years and utilization of one of these foods compensated for a scarcity of the other. In eastern Tennessee the 1978 acorn yield was rated poor (Tennessee Wildlife Resources Agency 1979), and many local residents and several biologists agreed that the grape crop was more abundant than could be remembered in past years. Bear scats collected during the fall of 1978 showed a heavy utilization of grapes by bears in East Tennessee.

Of 7 radio-tagged bears that were viewed in their winter den in the winter of 1978-79, all appeared fat and in good condition. This good condition after an acorn crop shortage illustrates that bears may effectively utilize alternate foods that are available in sufficient quantities.

Beechnuts are important foods of black bears in the northeastern

United States. Beech was over 30% of the fall diet of bears in Pennsylvania (Bennett et al. 1943) and Maine (Spencer 1961). Beechnuts were important in the GSMNP (Beeman 1971) during the fall, but this was probably only at high altitudes. Most of the beech forest in the Park was, however, excluded from the present study.

Nutritional Value of Seasonal Diets

The nutritional value of seasonal diets was calculated from protein and fiber content of individual food items and the proportion of those food items in each seasonal diet. The crude protein content of the Early Spring diet was highest (21.3%); Late Spring (16.9%), Early Fall (14.3%), and Summer (12.6%) diets were intermediate; and the Late Fall diet (9.7%) was low in protein (Table 17). If the diet that encourages healthy growth in bears must contain about 15% crude protein (Wackernagel 1961), it appears that growth of bears in the GSMNP occurs from Early Spring through Early Fall. Such a long period of growth, however, is not believed to occur.

It is recognized that healthy growth requires not only an adequate quantity of protein in the diet, but also there must be a balance of essential amino acids in the protein. Proteins from green plants tend to lack certain essential amino acids and are, therefore, termed "low biological value" proteins. Once the amino acid in shortest supply is depleted, remaining amino acids are deaminized and used as food energy rather than structural components (Crampton and Harris 1969).

Table 17. Crude protein and acid detergent fiber content of the seasonal diets of black bears in the GSMNP, 1976 and 1977.

	Composition (percentage of dry matter)	
Diet	Crude protein	ADF
Early spring	21.3	30.3
Late spring	16.9	24.6
Summer	12.6	23.4
Early fall	14.3	17.7
Late fall	9.7	7.5

Early Spring.--The protein of the Early Spring diet is derived from grasses and other herbaceous material and is, therefore, of low biological value. In addition, the high fiber content of this diet undoubtedly prevents the extraction of much of the energy contained in food items. The nutritional value, therefore, of the Early Spring diet is low. As a result there is a tendency for bears to lose weight (Beeman 1975) because fat reserves are being depleted, and little, if any, structural growth occurs.

Late Spring.--While herbaceous material comprised approximately half of the Late Spring diet, the proportion of animal material rose from 1% in Early Spring to over 10%. The result was a decrease in fiber, and an increased availability of protein. In addition, the proteins from animal material are of high biological value, and therefore, conducive to growth.

A decrease in the protein content as well as the fiber content from the Early Spring diet suggests that a high level of available energy in the form of carbohydrates is in the Late Spring diet. This carbohydrate content is attributed to the use of spring fruits. As a result, bears probably make a transition from a negative to a positive energy balance late in the spring and may start to gain weight.

The increase of high biological value proteins in the diet suggests this increasing weight represents structural growth as well as, and possibly instead of, increasing fat reserves.

Summer.--The change from the Late Spring to the Summer pattern of food use results in a decrease in consumption of herbaceous

material and an increase in consumption of fruits. The utilization of animal material remained about 10% of the diet and provides adequate protein with a good balance of essential amino acids required to sustain growth.

The fiber content of the Summer diet was only slightly lower than that of Late Spring and reflects the many seeds found in the fruits that comprise the bulk of summer foods. The high utilization of fruits in the Summer diet provides much energy in the form of readily available carbohydrates.

The Summer diet is high in available energy and contains an adequate level of high quality protein. Therefore, bears in the Park exhibit structural growth accompanying the increase in weight during the summer reported by Beeman (1975).

Early Fall.--Although different fruits were consumed in the Early Fall diet compared to that of Summer, nutritional value of the diets is similar. Fiber content is lower in Early Fall, 17.7% compared to 23.4% in Summer, but this decrease is attributed to the use of pulp and skin only of cherry in calculation rather than actual dietary differences.

Proteins for growth and carbohydrates for energy use are provided by the Early Fall diet, and bears probably continue increasing weight and growing structurally while these foods are eaten.

Late Fall.--Growth of bears may cease, but increases in weight occur during fall (Beeman 1975). The weight gains during this period are made possible by the high utilization of acorns in the Late Fall

diet and probably reflect only increases in fat reserves.

The protein and fiber content of the Late Fall diet (9.7% and 7.5%, respectively) are the lowest recorded for any diet. Therefore, the level of energy-supplying nutrients, fats or carbohydrates, is high. Fat content in white oaks and chestnut oaks is low while that of red oaks is moderately high (Wainio and Forbes 1941). As a result, much energy is available to bears consuming Late Fall foods, and rapid weight gains are possible.

It may be advantageous for structural growth of bears to cease during this pre-denning period. Energy utilized for growth of bones, muscle, and internal organs is no longer available to increase the fat reserves that provide energy during the winter denning period and the negative foraging period of the spring.

Growth sustained by only 3 seasonal diets does not apply to newborn cubs. These animals increase in weight as well as exhibit structural growth during the latter portion of the denning period and in early spring when most bears experience the negative foraging period. Fats and proteins in their mother's milk account for the availability of nutrients for growth during the periods when other bears are losing weight. It is not known whether cubs continue structural growth during their first Late Fall diet, but it is believed that they, like older bears, increase weight only by increasing fat reserves during the time when bears consume mostly acorns in the GSMNP.

To sustain milk flow, lactating females probably require a high protein content in the Early Spring diet in addition to the seasonal

diets in which protein content is usually high. Even with a higher protein intake in all seasons during which lactation occurs, body proteins are probably utilized during milk production, which may result in deterioration of muscle tissue. As a result, the protein requirement during Late Fall is probably higher for females with cubs than for other bears because this muscle tissue must be replaced. The additional protein requirement for females with cubs necessitates a much higher foraging effort by these animals and probably explains the high level of activity exhibited by female bears with cubs during all seasons except winter (Garshelis 1978).

Evaluation of the Scat Analysis Technique

Only sampling of composites was used for scat analysis during this study; therefore, no basis exists for direct comparison to the results obtained by hand separation of each scat. Sampling individual scats, however, was used to determine food habits of black bears (Hardy 1974) and coyotes (Johnson and Hansen 1977). Sampling composites of scats was used successfully to determine foods consumed by hoary marmots (Hansen 1975). There is a general agreement of food utilization found in this study and that reported by Beeman and Pelton (1977) which was determined using a hand separation method.

Sampling composites was rapid; composites containing as many as 25 scats were analyzed in 20-30 min once identification of food items was learned. Preparation of scats for analysis required use of only a small portion of most scats and was, therefore, much easier and faster than preparing entire scats for hand separation.

There were possible disadvantages to the technique, but it was felt these were negligible. Mammal remains were mostly hair, and hair separates easily and was found in many quadrats even when only 1 of many scats in a composite contained hair; therefore, mammal remains may have been over-estimated. Incidence of mammal remains in the present study were comparable, however, to most other studies.

Identification of insect fragments and mammal hair was difficult in this study because most insect remains were tiny body fragments, and many single hairs were found. Both of these items were virtually impossible to identify with confidence. It is felt, however, that this lack of identification in the present study is a small problem because it has been well documented that social insects, ants, beetles, yellow jackets, etc., form the bulk of animal material in the diets of bears in most regions of the country (Spencer 1961, Tisch 1961, Poelker and Hartwell 1973, Beeman and Pelton 1977, Landers et al. 1979, and others). In addition, black bears are generally scavengers rather than predators; therefore, the species of mammal found in the diet matters little.

Undoubtedly, many trace components of the diet were missed during analysis. This, however, is considered a benefit because trace items take much longer to identify and contribute very little to the diet of bears in the Park.

In light of the above, it is felt that sampling scat composites is a fast and reliable method to determine the basic patterns of food utilization by black bears. The determination of habitat requirements and nutritional requirements will require continued evaluation of food habits of black bears.

V. CONCLUSIONS

Major food items consumed by black bears in the GSMNP were divided into 6 categories: herbaceous material; spring fruits, including squawroot and serviceberry; shrub-borne soft mast, including blackberry, huckleberry, and blueberry; tree-borne soft mast, including black cherry, fire cherry, and sassafras; hard mast, including only acorns; and animal material, including insects and mammals.

Over 80% of the annual diet of black bears in the Park was comprised of plant foods. Insects were the major animal food while mammals were only of minor importance.

Based on composition of the diet, there were 5 seasonal patterns of food utilization displayed by bears in the Park. Each pattern was keyed to a single category of food items. The Early Spring diet was keyed by herbaceous material which accounted for over 90% of this diet. Utilization of animal material was low, accounting for only 5% of the diet.

In the Late Spring pattern spring fruits (30%) were the key component. Herbaceous material dropped to less than 50% of the diet. In the latter portion of the time interval during which bears displayed the Late Spring pattern, shrub-borne soft mast was utilized slightly. The use of animal material, mostly insects, increased to over 10% of the diet.

In 1976 squawroot was the only spring fruit consumed while both squawroot and serviceberry were eaten in 1977. It appears that

serviceberry is preferred when it is available.

Shrub-borne soft mast keyed the Summer pattern, accounting for over 60% of the diet. Use of herbaceous material was unimportant. Tree-borne soft mast appeared in the Summer diet, but was not utilized heavily (less than 5%). Animal material remained just over 10% of the diet.

Blackberry was the most important fruit of the Summer diet throughout most of the study; however, in the Hannah Mountain region almost no blackberry was eaten, and huckleberry was the most important item. Blueberry generally appeared in composites containing huckleberry, but was at a much lower level of utilization.

While it was the key category of the Early Fall pattern, tree-borne soft mast accounted for only 28% of the diet. Herbaceous material remained an unimportant component, and shrub-borne soft mast decreased to less than 20%. Acorns appeared in the diet, but were only slightly utilized. Consumption of animal material rose to its highest level (almost 20%) in the Early Fall diet, and this high utilization was attributed to increased hourly movements by bears when insects were active and available.

Black cherry was the most important fruit in the key category of the Early Fall diet. Sassafras ranked a distant second, and fire cherry was third.

The key component of the Late Fall diet was hard mast, which accounted for over 70% of the diet. Consumption of animal material decreased, and other categories of food items were unimportant.

The Late Fall diet was delineated only during 1977. The lack

of a Late Fall pattern in 1976 scats is attributed to the early cessation of scat collection, not to a lack of consumption of acorns that year.

Consumption of artificial foods, garbage, was unimportant during all seasons. It was, however, present in trace amounts in all seasonal diets.

Herbaceous material is high in protein and fiber. The high fiber content prevents complete digestion of these foods, and the protein is probably of poor quality due to a poor balance of essential amino acids. Bears are able to extract some protein and other nutrients from herbaceous material, but the protein is probably used as an energy source, and little energy is available.

The spring fruits are higher in protein content than other fruits consumed by bears in the Park, but this protein, too, is probably of low quality and likely used for energy. Fiber content is moderate, and these fruits are considered good sources of carbohydrates.

The shrub-borne soft mast is similar to the tree-borne soft mast in nutritional value. Both are energy foods being high in carbohydrates. Protein content of blackberry and cherry is high, but is located within the seed and is unavailable to black bears.

Hard mast, acorns, is a concentrated energy food that is probably highly digestible by black bears. The protein and fiber contents are very low.

Animal material is the protein supplement of all seasonal diets. While insects are utilized to a greater extent, mammals have more protein and less fiber.

The Early Spring diet is of low nutritional value. The protein available is generally of low biological value, and little food energy is available to bears from this diet. As a result, bears exhibit a negative foraging period until more nutritious foods are available.

During the period of the Late Spring diet, bears probably make the transition to a positive energy balance. Crude protein in the diet decreases from the Early Spring, but much of it is of animal origin and probably of high biological value. With fiber decreased from Early Spring, the Late Spring diet is more digestible, and more energy is derived from foods. It is believed that bears begin to grow structurally while consuming the Late Spring diet.

The nutritive value of the Summer and Early Fall diets are similar. Both diets are moderately low in fiber and moderately high in high quality protein. Structural growth probably accompanies increasing weights when the foods of these diets are eaten.

The Late Fall diet is mainly an energy source. Both protein and fiber content are low, while carbohydrates are high. Fats are moderately high in red oak acorns. Structural growth may stop in late fall, and rapidly increasing weight represents energy stored in fat reserves. Cessation of structural growth to maximize energy storage in the pre-denning period is believed to be of survival value.

Bear cubs grow during all seasons and must have adequate protein and energy in the diet. Their mother's milk supplies these nutrients. Lactation, however, adds to the protein and energy requirement of a female bear's diet. Increased foraging by females with cubs is needed throughout the year and is reflected in a high

level of activity by these animals in all seasons.

Sampling scat composites is a satisfactory method to determine the patterns of food utilization of black bears. Although certain problems were encountered, these were minor.

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APPENDIX

Table 18. Composition of the biweekly diets of black bears in the Sugarland Mountain section of the GSMNP, 1976.

	2-week interval ending										
	Apr 26	May 10	Jun 7	Jun 21	Jul 19	Aug 2	Aug 16	Aug 30	Sep 13	Sep 27	Total
Food item	Percentage of diet										
No. scats collected	0	0	2	0	6	5	2	0	4	0	19
Grass			71		Tr[a]	14	14				20
Herb. matl.			8		5	19	5		1		
Squawroot			8		88	10	5				22
Blackberry						43	3				9
Huckleberry							44		1		9
Blueberry					1						Tr
Black cherry									69		14
Sassafras									10		2
Other veg.			Tr[b]								Tr
Insect[c]			4		5	6	13[d]		13		8
Mammal[c]			Tr			7[e]					1
Debris			2			1	16		6		5
Garbage			6								1

[a]Trace.

[b]Maple seed (Acer sp.).

[c]Unidentified unless otherwise specified.

[d]Ant fragments.

[e]Deer hair.

Table 19. Composition of the biweekly diets of black bears in the Elkmont-Bent Arm section of the GSMNP, 1976.

	2-week interval ending										
	Apr	May	Jun		Jul	Aug			Sep		
	26	10	7	21	19	2	16	30	13	27	Total
Food item	Percentage of diet										
No. scats collected	0	8	13	1	1	13	4	21	4	2	67
Grass		96	78	95	19	12	9	3	8	2	36
Herb. matl.		1	6	1	45		1		2		6
Squawroot				2		8	5	1			2
Blackberry						67	64	82			24
Huckleberry								1	29		3
Black cherry								1	3	85	10
Fire cherry						8	16	1			3
Sassafras								4	19		3
Oak										2	Tr[a]
Other veg.							1[b]				Tr
Insect[c]		1	Tr	Tr	26	2	3[d]	6[e]	31[f]	69	8
Mammal			15[h]								1
Debris		2	Tr	2	10	3	3	1	7	5	4

[a]Trace.

[b]Beechnut.

[c]Unidentified unless otherwise specified.

[d]Includes 2% crayfish (Crustacea).

[e]Ant fragments.

[f]2% ant, 29% yellow jackets.

[g]1% beetle, 5% unidentified.

[h]European wild hog hair, found in 1 scat only.

Table 20. Composition of the biweekly diets of black bears in the Tremont section of the GSMNP, 1976.

	2-week interval ending										
	Apr 26	May 10	Jun 7	Jun 21	Jul 19	Aug 2	Aug 16	Aug 30	Sep 13	Sep 27	Total
Food item	Percentage of diet										
No. scats collected	0	0	0	7	0	5	9	4	14	12	51
Grass				12		18	3	Tr[a]	8		7
Herb. matl.				10		19			1		6
Squawroot				32		11	11				9
Blackberry						18		67			14
Huckleberry				17		25	61	19	8	3	22
Blueberry				4		2	1		1		1
Black cherry									4	45	8
Fire cherry									8		1
Sassafras								3	38	19	10
Other veg.						1[b]					Tr
Insect[c]				7		2	18	8[d]	16	16[e]	11
Mammal						2[f]				9[g]	2
Debris				7		2	5	3	16	8	7
Garbage				1			1				Tr

[a]Trace.

[b]Apple (*Malus* sp.).

[c]Unidentified unless otherwise specified.

[d]Ant fragments.

[e]13% yellow jackets, 3% unidentified.

[f]Deer hair.

[g]96% deer hair, 3% bear hair.

Table 21. Composition of the biweekly diets of black bears in the Bote Mountain-Defeat Ridge section of the GSMNP, 1976.

	2-week interval ending										
	Apr 26	May 10	Jun 7	Jun 21	Jul 19	Aug 2	Aug 16	Aug 30	Sep 13	Sep 27	Total
Food item	Percentage of diet										
No. scats collected	6	3	22	27	4	10	23	15	21	11	142
Grass	24	94	33	20	4	10	3	3	3	1	18
Herb. matl.	68	Tr[a]	3	2	12	6	1	1	2	1	9
Squawroot			58	69	54	15	17	16	12		30
Blackberry					4	32	67	46	2	36	17
Huckleberry						4	1		9		1
Blueberry						7			2		1
Black cherry									5	1	1
Fire cherry						5		2			1
Sassafras						5	1	3	3	2	1
Oak								6	26	31	6
Other veg.									14[b]	1[c]	1
Insect[d]	1	Tr	2	7	3	10[e]	7	15[f]	13[g]	21[h]	7
Mammal[d]				2[i]	21			1			2
Debris	7	5	4	1	2	4	3	7	10	6	5
Garbage						2					Tr

[a]Trace.

[b]Black chokeberry (Pyrus melanocarpa).

[c]Black gum.

[d]Unidentified unless otherwise specified.

[e]8% ant, 2% unidentified.

[f]5% ant, 10% unidentified.

[g]12% yellow jacket, 1% ant.

[h]7% beetle, 14% unidentified.

[i]1% deer hair, 1% bear hair.

Table 22. Composition of the biweekly diets of black bears in the Hannah Mountain section of the GSMNP, 1976.

	2-week interval ending										
	Apr 26	May 10	Jun 7	Jun 21	Jul 19	Aug 2	Aug 16	Aug 30	Sep 13	Sep 27	Total
Food item	Percentage of diet										
No. scats collected	0	0	1	0	2	21	17	9	6	0	56
Grass			94			2	2		6		17
Herb. matl.			1		7	5					2
Squawroot			4		20	2					4
Blackberry						1	1				Tr[a]
Huckleberry					27	43	47	61	52		38
Blueberry					6	16	8	20	10		10
Sassafras									1		Tr
Oak									Tr		Tr
Insect[b]					37	20	30	10[c]	25[d]		20
Mammal[b]						7[e]	4				2
Debris			1		3	4	8	8	7		5

[a]Trace.

[b]Unidentified unless otherwise specified.

[c]Yellow jacket.

[d]5% beetle, 13% ant, 7% yellow jacket.

[e]Deer hair.

Table 23. Composition of the biweekly diets of black bears in the Sugarland Mountain section of the GSMNP, 1977.

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	23	6	20	4	18	1	15	29	12	26	10	Total
Food item	Percentage of diet												
No. scats collected	4	0	1	5	7	0	3	2	2	2	2	3	27
Grass	21		1	22	1		1		35	4	10		10
Herb. matl.	67		15	22	38		1	2		17	12	1	18
Squawroot				3	30		2						4
Serviceberry				33	8								4
Blackberry							73	67	1				14
Huckleberry					1		13						1
Blueberry					4			17	33	8			6
Fire cherry								1					Tr[a]
Oak										32	41	83	16
Other veg.			6[b]							7[c]			1
Insect[d]			50[e]	17[f]	16[g]		5	6[h]	4	19	29[e]	5	15
Mammal[d]	10[i]						3						1
Debris	2		28	2	2		2	7	27	13	8	10	10
Garbage												1	Tr

[a]Trace.

[b]Hemlock needles.

[c]6% mountain ash (Sorbus americana), 1% viburnum (Viburnum sp.).

[d]Unidentified unless otherwise specified.

[e]Wood roaches.

[f]1% ant, 16% unidentified.

[g]5% ant, 11% unidentified.

[h]1% ant, 5% unidentified.

[i]Woodchuck.

Table 24. Composition of the biweekly diets of black bears in the Elkmont-Bent Arm section of the GSMNP, 1977.

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	23	6	20	4	18	1	15	29	12	26	10	Total
Food item	Percentage of diet												
No. scats collected	7	13	11	12	4	4	5	5	4	2	1	3	71
Grass	61	41	18	30	1	4	2	4	14			1	15
Herb. matl.	22	45	30	11	1	1	10	6	33				13
Squawroot		6	4	5	7	17							3
Serviceberry			26	29	10	4	4	1					6
Blackberry					11	51	59	35	5				13
Huckleberry							3	8					1
Blueberry						5	1	22					2
Black cherry										13			1
Fire cherry									10				1
Oak									6	80	71	97	21
Other veg.			1[a]	1[b]				4[c]	14[c]				2
Insect[d]	2	4	13	5	19[e]	8	5[f]	5	10[g]	1	3[e]	1	6
Mammal[d]	14[h]		1		5		5						2
Debris	1	4	7	19	46[i]	10	10	15	8	6	26	1	13
Garbage							1						Tr[j]

[a]Beechnut.

[b]Black chokeberry.

[c]Mountain ash.

[d]Unidentified unless otherwise specified.

[e]Ants.

[f]2% ant, 3% unidentified.

[g]1% ant, 9% unidentified.

[h]Eastern cottontail.

[i]Wood fragments, probably associated with consuming ants.

[j]Trace.

Table 25. Composition of the biweekly diets of black bears in the Tremont section of the GSMNP, 1977.

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	23	6	20	4	18	1	15	29	12	26	10	Total
Food item	Percentage of diet												
No. scats collected	0	2	1	0	4	8	7	3	2	0	0	0	27
Grass		37	2		18	2	1		5				9
Herb. matl.		41	90		1		1						19
Squawroot		9				20							4
Serviceberry					3								Tr[a]
Blackberry						56	95						22
Huckleberry					67	6	1	72					21
Blueberry					1								Tr
Black cherry									53				8
Other veg.		1[b]						23[c]	26[d]				7
Insect[e]		7	1			4	Tr	24[f]	2				3
Mammal[e]						99	Tr						1
Debris		5	7	9	3	2	1	11					6
Garbage					1								Tr

[a]Trace.

[b]Beechnuts.

[c]Mountain ash.

[d]Apple.

[e]Unidentified unless otherwise specified.

[f]1% ant, 23% unidentified.

[g]Raccoon.

Table 26. Composition of the biweekly diets of black bears in the Bote Mountain-Defeat Ridge section of the GSMNP, 1977.

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	23	6	20	4	18	1	15	29	12	26	10	Total
Food item	Percentage of diet												
No. scats collected	9	12	9	15	5	25	14	14	8	5	25	2	143
Grass	23	36	8	16	4		8	20	5		12	4	11
Herb. matl.	76	28	14	3	7	1	7	1	1		1	5	12
Squawroot		29	3	12	11	4							5
Serviceberry			68	54	16	17	11	3					14
Blackberry					50	36	32	28					12
Huckleberry						3	11	14					3
Blueberry						5	3	13					2
Fire cherry									15				1
Sassafras								4					Tr[a]
Oak									26	80	75	37	18
Other veg.												37[b]	3
Insect[c]		4	4	3	8	7	3[d]	3[e]	26	7[f]	6	11	7
Mammal						8[g]	19[h]						2
Debris	1	3	3	12	4	19	5	14	27	13	7	6	10

[a]Trace.

[b]Grapes.

[c]Unidentified unless otherwise specified.

[d]Ants.

[e]1% crayfish included.

[f]Wood roaches.

[g]Raccoon.

[h]6% eastern cottontail, 13% unidentified.

Table 27. Composition of the biweekly diets of black bears in the Hannah Mountain section of the GSMNP, 1977.

	2-week interval ending												
	May		Jun		Jul		Aug			Sep		Oct	
	9	23	6	20	4	18	1	15	29	12	26	10	Total
Food item	Percentage of diet												
No. scats collected	0	0	0	3	9	3	4	10	5	4	0	1	39
Grass					1	4	1	1	2			Tr[a]	1
Herb. matl.					1	1	1	3		1		2	1
Squawroot				50	16								8
Serviceberry						10							1
Huckleberry				33	67	75	82	44	35				42
Blueberry				1			3	16	3				3
Black cherry										4			1
Sassafras								5					1
Oak									4	73		93	21
Other veg.							10[b]			3[c]			2
Insect[d]				3	3[e]	2		13[f]	4	9[g]		3	5
Mammal[d]				12[h]	11		1		38[i]				8
Debris				1	2	8	2	18	14	10		2	7

[a]Trace.

[b]Pine (Pinus sp.) needles.

[c]2% black gum, 1% grapes.

[d]Unidentified unless otherwise specified.

[e]Ants.

[f]1% ants, 12% unidentified.

[g]Beetles.

[h]Eastern cottontail.

[i]Eastern cottontail, all hair in 1 scat.

VITA

Thomas C. Eagle, son of Mr. and Mrs. William E. Eagle, was born on 1 September 1947 in Wilmington, North Carolina. He moved to Knoxville, Tennessee in 1961 and graduated from Young High School in June 1965. The following September he enrolled at The University of Tennessee, Knoxville. After 1 year, he joined the U.S. Navy. Upon discharge in 1970, he re-enrolled at The University of Tennessee, Knoxville, where he received a Bachelor of Science degree in Animal Science in June 1975. He was accepted by The Graduate Program in Ecology, The University of Tennessee, Knoxville, in September 1975. In 1978 he was employed by the Tennessee Wildlife Resources Agency. He was awarded the Master of Science degree in Ecology from The University of Tennessee, Knoxville, in June 1979.

He is married to the former Paula Beryl Phillips of Candler, North Carolina.