12-1973

Seasonal Food Habits of European Wild Hogs (*Sus scrofa*) in the Great Smoky Mountains National Park

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To the Graduate Council:

I am submitting herewith a thesis written by Charles D. Scott entitled "Seasonal Food Habits of European Wild Hogs (*Sus scrofa*) in the Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

James Byford, George Merriman

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 17, 1973

To the Graduate Council:

I am submitting herewith a thesis written by Charles D. Scott entitled "Seasonal Food Habits of European Wild Hogs (Sus scrofa) in the Great Smoky Mountains National Park." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife Management.

Michael R. Pelton
Major Professor

We have read this thesis and recommend its acceptance:

James L. Byford

George M. Merriman

Accepted for the Council:

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SEASONAL FOOD HABITS OF EUROPEAN WILD HOGS (*SUS SCROFA*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Charles D. Scott

December 1973

ACKNOWLEDGMENTS

I am grateful to Dr. Michael R. Pelton, Associate Professor of Forestry, The University of Tennessee, who served as director of research.

I would like to thank Dr. James Byford, Assistant Professor of Forestry, and Dr. George Merriman, Professor of Animal Science, who served on my committee. I am grateful to Dr. Ralph W. Dimmick, Associate Professor of Forestry, for assistance in reviewing the manuscript. I would also like to thank the graduate students of The University of Tennessee, especially Robert W. Duncan, for assistance in field work.

Financial support for this study was provided cooperatively by The University of Tennessee Department of Forestry, the Great Smoky Mountains Natural History Association, and McIntire-Stennis funds.

ABSTRACT

This study was conducted on the Tennessee side of the Great Smoky Mountains National Park from the fall of 1971 to the spring of 1973. Seasonal food habits information of the European wild hog (Sus scrofa) was obtained by the analyses of stomach contents.

Hogs ate primarily plant material in all seasons. Grasses (Gramineae) were the most important food item in the spring. Grasses were important to hogs in the summer, as were the fruits of Gaylussacia sp., Vaccinium sp., and Malus sp. Roots were the major food item in the fall and winter months, although the mast of Quercus sp. and Carya sp. was important when available.

Animal matter consumed consisted primarily of invertebrates, salamanders, and small mammals. Invertebrates were the most frequently found animal food. Total volume of animal matter was small.

Evaluation of rooting sites supplemented the stomach analyses in determining some foods eaten by wild hogs. Such evaluations were highly subjective, however, and the delineation of specific food items was difficult. Increased rooting and concomitant damage may be associated with years of low mast production.

Due to similarities in fall and winter utilization of mast foods by European wild hogs and some native wildlife, hogs are considered to be competitors with these species during years of mast shortage.

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CHAPTER I

INTRODUCTION

The European wild hog (*Sus scrofa*) was first introduced into the Southern Appalachians on Hooper's Bald, North Carolina, in 1912 (Jones, 1959). Since the initial introduction, this animal has extended its range and now occurs in the Great Smoky Mountains National Park (GSMNP or Park). The first hog to be taken by control measures in the GSMNP was taken near the Gregory Bald area in 1959. Since that time, the European wild hog has established itself in the western portion of the GSMNP and appears to be further extending its range in the Park.

The European wild hog is considered an exotic animal, and its presence in the GSMNP is not in keeping with National Park Service policy of maintaining the flora and fauna of the Park in their natural state. The National Park Service is concerned that the European wild hog may compete for food with native species, especially the black bear (*Ursus americanus*). In addition, siltation of streams, contamination of springs and streams, and ecological, as well as aesthetic damage to the grassy balds have been mentioned as possible undesirable effects of these animals. Control measures have been conducted since 1959 in an attempt to eventually greatly

reduce or eliminate these animals from the Park. When it became apparent that more information was needed on movements, range, food habits, adaptation to various environments, reproduction, and other factors in order to successfully control European wild hogs in the GSMNP, the University of Tennessee, Department of Forestry, in cooperation with the National Park Service and the Great Smoky Mountains Natural History Association began investigations to obtain this information.

The European wild hog has been the subject of an intensive research effort by the Tennessee Game and Fish Commission since 1959. Studies have been concerned primarily with reproduction (Henry, 1966, 1968a, 1968b; Matschke, 1964; Rary et al., 1968), aging techniques (Matschke, 1963, 1967), parasites (Henry and Conley, 1970), weights and measurements (Henry, 1969b, 1970), and trapping and handling techniques (Henry, 1969c; Henry and Matschke, 1958; Matschke, 1962; Matschke and Henry, 1969; Williamson and Pelton, 1971). Other studies have dealt with movements (Matschke and Hardister, 1966), control techniques (Fox, 1972), rooting and wallowing activities (Belden, 1972), and hematological and serum biochemical parameters (Williamson, 1972).

Food habits research on the European wild hog in the Southern Appalachians has been limited to: (1) general observations on feeding habits (Jones, 1959; Stegeman, 1938;

Belden, 1972); (2) studies of hog predation on ground-nesting birds (Matschke, 1965; Henry, 1969a); and (3) a fall (October-November) food habits study conducted on the Tellico Wildlife Management Area in Monroe County, Tennessee (Henry and Conley, 1972).

The objective of the present study was to determine the seasonal food habits of European wild hogs in the GSMNP. Complete food habits information for this species should provide a basis for further investigations of seasonal variability and availability of important foods, and the relationship of food supply to, nutrition, reproduction, and incidence of disease. Food habits information for the wild hogs of the GSMNP should aid in determining the impact of this exotic on natural habitats and delineating problems between wild hogs and native species.

CHAPTER II

DESCRIPTION OF STUDY AREA

I. LOCATION AND PHYSIOGRAPHY

The GSMNP is located along the Tennessee-North Carolina border, extending in a general northeasterly direction. This area contains 800 square miles (516,626 acres) of mountainous terrain located in Blount, Sevier, and Cocke counties in Tennessee and Swain and Haywood counties in North Carolina. One transmountain road (U.S. Highway 441) bisects the Park from Gatlinburg, Tennessee to Cherokee, North Carolina. One other major road (Tennessee State Route 73) parallels the northern boundary just inside the Park. There are over 650 miles of horse and foot trails in the Park (Figure 1).

The GSMNP is part of the Unaka Mountain Range section of the Blue Range Province, located in the southern division of the Appalachian Highlands. The topography of the area is characterized by high mountains and narrow ridges separated by steep-sloped, V-shaped valleys. Numerous swift-flowing streams are present over the entire area. Cove sites, characterized by relatively flat topography, are also present in the area. Elevations in the GSMNP range from 888 feet

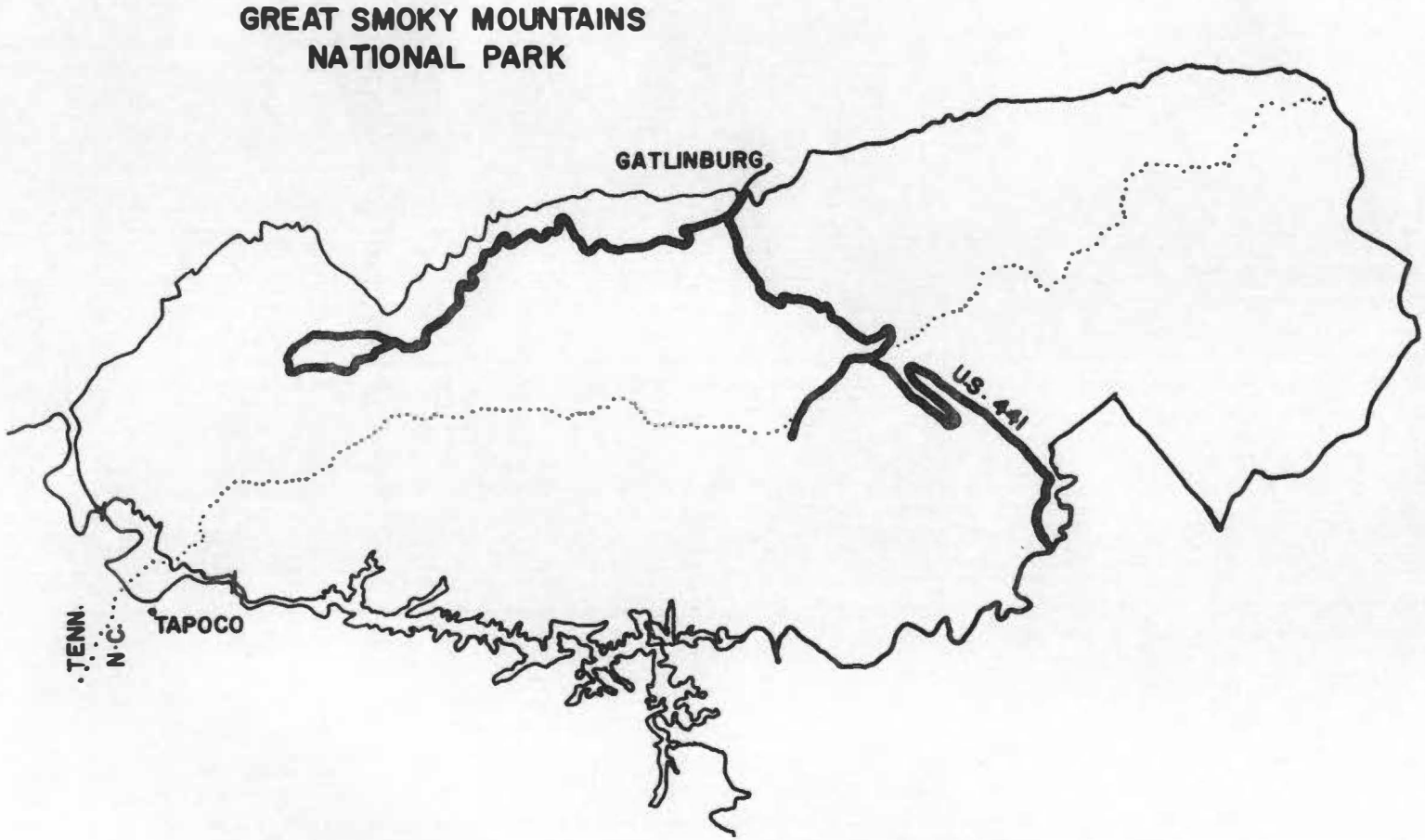

Figure 1. Map showing the geographical location of the Great Smoky Mountains National Park.

above sea level where Abrams Creek enters Chilhowee Lake, to 6,643 feet at Clingmans Dome.

This study was conducted on the Tennessee side of the Park in the area south and west of U.S. Highway 441 (Figure 2). This area, including several drainages in North Carolina, is the primary area of European wild hog range in the GSMNP at the present time. The major drainages in the study area include Abrams Creek and the East, Middle and West Prongs of Little River. Approximately 40 miles of paved roads are present in the study area, with much of the area accessible only by unpaved roads and trails.

II. GEOLOGY AND SOILS

The rocks underlying the GSMNP belong to the Great Smoky formation of the late Precambrian age Ocoee series. These greatly metamorphosed rocks are of sedimentary origin and are principally composed of quartz, feldspar, and slate, with lesser amounts of schist and limestone (King et al., 1969).

Soils of the area are typically upland soils, derived from the underlying bedrock and classified as the Ramsey soil types. Soil depths and development of horizons are highly variable. The deeper soils result from local alluvial deposits and occur on the ridgetops and steep slopes. Ramsey soils are characterized by their moderate natural

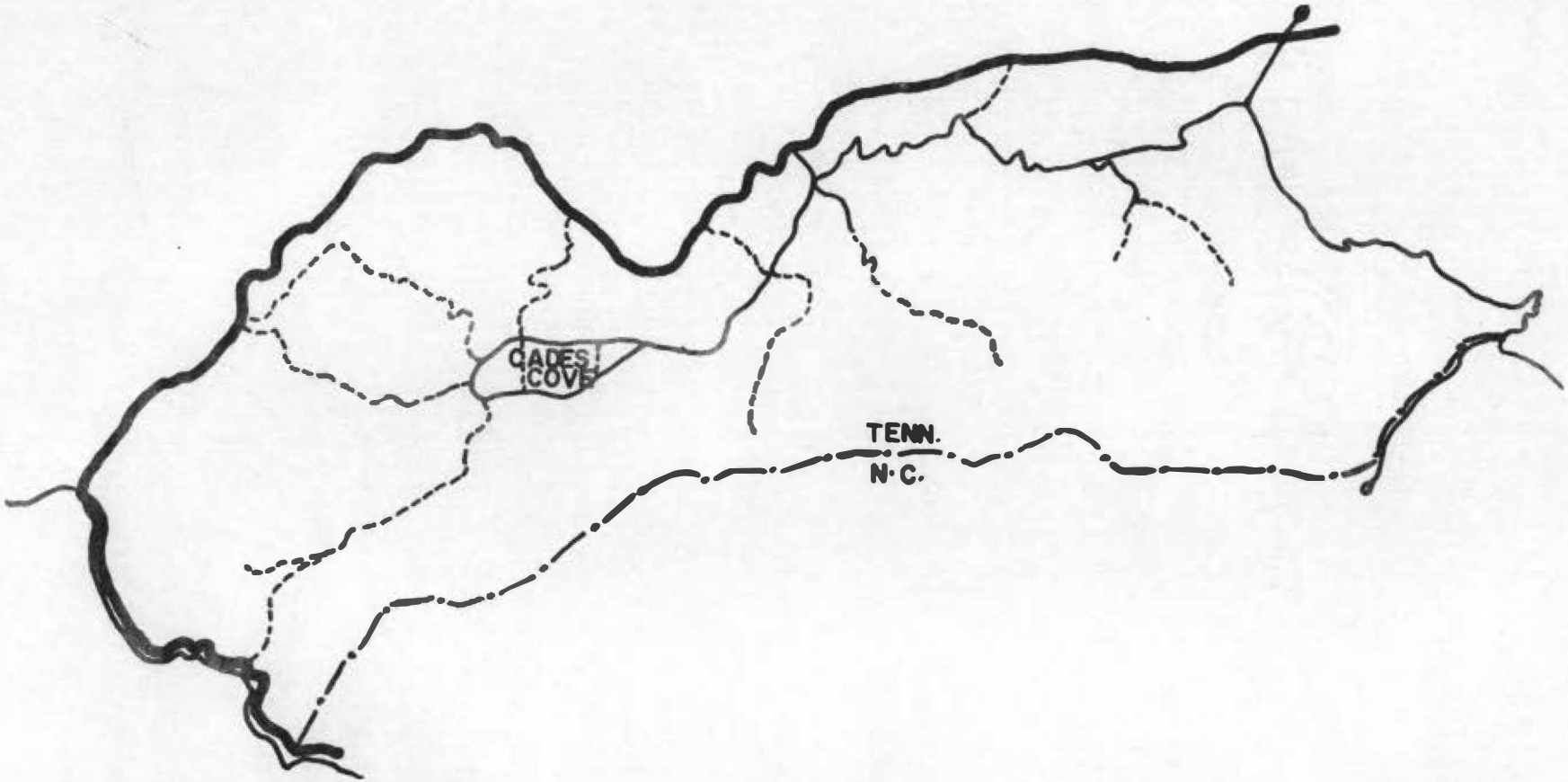

Figure 2. Map of the study area, located in the Great Smoky Mountains National Park.

fertility, medium to high acidity, rapid water percolation, and low water storage capacity (U.S. Forest Service, 1970). Differences in these soils are marked, with a pH range of 2.9-3.6 for ridge top soils, 4.1-4.3 for middle slope soils, and 4.8-5.1 for the cove soils (Cain, 1931).

III. CLIMATE

The climate of the GSMNP is quite variable due to the differences in elevation, but is generally characterized by cool temperatures and high rainfall. Temperatures on the higher peaks of the Park average 10° to 15° F cooler than those of the lowest elevations, due to an average rate of 2.23° F decrease in temperature for every one thousand foot rise in elevation. The general annual temperature trends in the GSMNP are characterized by a rapid warming period between April and May and a rapid cooling between October and November, with a distinct difference between six cold months and six warm months.

Precipitation in the surrounding lowlands is comparable to that of the lower elevations in the Park, averaging 45 to 55 inches per year (Gatlinburg and Elkmont, Tennessee). The precipitation at 4,500 to 5,000 feet is about 50 percent greater, and the highest elevations may average more than 85 to 95 inches per year (Clingmans Dome). The summer season is the period of greatest precipitation, while the fall is

the driest time of the year (Shanks, 1954). Weather data collected at Gatlinburg, Tennessee (elevation 1,460 feet) and Tapoco, North Carolina (elevation 1,117 feet) and presented in Tables I and II.

IV. VEGETATION

The GSMNP is a densely forested area of complex vegetation patterns and varied community types. The area supports over 1,300 varieties of flowering plants, almost 350 mosses and liverworts, 230 lichens, and more than 2,000 fungi (Stupka, 1960). Most of the vegetation is either topographic climax or secondary succession, as primary succession is nearly completed over much of the area. Whittaker (1956) has divided the vegetation into 15 types based on the environmental gradients of moisture and elevation. Shanks (1954) has categorized these types into six relatively distinct physiognomic types on the basis of the sites occupied and differences in minor vegetation. These six vegetation types include the cove hardwood forests, hemlock forests, northern hardwood forests, spruce-fir forests, closed oak forests, open oak and pine standsheath balds. The general altitudinal and topographic position of these types is shown in Figure 3, and the important tree species making up each type is shown in Table III.

TABLE I

TEMPERATURE DATA FROM GATLINBURG, TENNESSEE AND TAPOCO, NORTH CAROLINA

	Average Monthly Temperature in °F[a]				
	Gatlinburg (1460 ft.)			Tapoco (1117 ft.)	
Month	1923 to 1967 Mo. Av.[b]	1972	1973	1972	1973
January	39.3	41.2	36.5	44.0	41.1
February	41.9	36.2	36.8	40.1	41.6
March	47.8	45.7	52.8	48.9	57.3
April	56.8	55.6	54.0	58.1	57.3
May	64.8	61.5		63.9	
June	72.0	65.6		68.3	
July	73.6	71.1		72.8	
August	73.7	71.8		73.3	
September	68.9	68.4		70.0	
October	57.9	53.9		58.9	
November	46.7	46.1		49.8	
December	40.2	44.0		47.9	

[a]Source: U.S. Weather Bureau, Climatological Data, U.S. Dept. Comm. Annual Summary, 1972, 1973. Vols. 77, 78.

[b]Source: From records of the Great Smoky Mountains National Park.

TABLE II

PRECIPITATION DATA FROM GATLINBURG, TENNESSEE AND TAPOCO, NORTH CAROLINA

	Total Monthly Precipitation in Inches[a]				
	Gatlinburg (1460 ft.)			Tapoco (1117 ft.)	
Month	1923 to 1967 Mo. Av.[b]	1972	1973	1972	1973
January	4.84	6.53	4.25	8.49	4.84
February	4.76	4.88	2.43	4.80	3.65
March	5.32	5.40	9.98	6.33	10.82
April	4.50	3.28	5.45	5.58	5.88
May	4.50	6.75		6.05	
June	5.20	6.29		4.48	
July	5.66	6.41		7.30	
August	5.29	4.29		6.15	
September	2.98	7.57		6.57	
October	3.12	6.20		8.45	
November	3.42	3.20		3.59	
December	4.46	6.63		7.25	
Annual	54.05	67.43		75.04	

[a]Source: U.S. Weather Bureau, Climatological Data, U.S. Dept. Comm. Annual Summary, 1972, 1973. Vols. 77, 78.

[b]Source: From records of the Great Smoky Mountains National Park

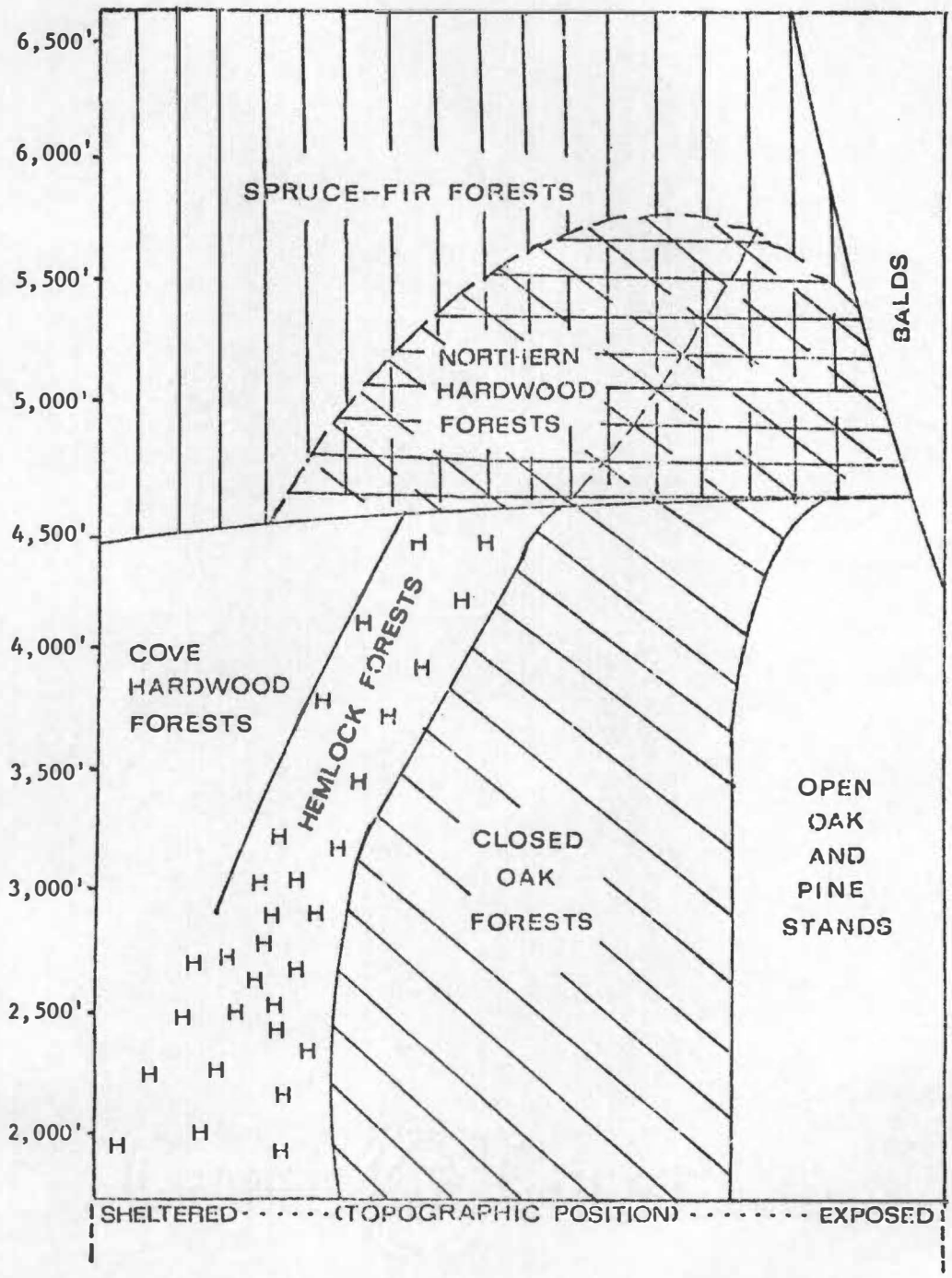

Figure 3. Vegetation pattern of the Great Smoky Mountains.

NOTE: Used by permission of the Botany Department, The University of Tennessee, Knoxville.

TABLE III

VEGETATION TYPES AND THEIR IMPORTANT TREE SPECIES IN THE GREAT SMOKY MOUNTAINS

Vegetation Type	Important Species
Cove hardwood	Eastern hemlock (Tsuga canadensis) Silverbell (Halesia monticola) Yellow buckeye (Aesculus octandra) Tulip poplar (Liriodendron tulipifera) Beech (Fagus grandifolia)
Hemlock	Eastern hemlock (Tsuga canadensis) Yellow birch (Betula alleghaniensis) Silverbell (Halesia monticola) Fraser magnolia (Magnolia fraseri) Rhododendron (Rhododendron spp.) Mountain laurel (Kalmia latifolia)
Northern hardwood	Beech (Fagus grandifolia) Yellow birch (Betula alleghaniensis) Yellow buckeye (Aesculus octandra) Sugar maple (Acer saccharum) Mountain maple (Acer spicatum)
Closed oak	White oak (Quercus alba) Chestnut oak (Quercus prinus) Northern red oak (Quercus rubra) Black oak (Quercus velutina) Pignut hickory (Carya glabra) Mockernut hickory (Carya tomentosa) Sourwood (Oxydendrum arboreum) Black locust (Robinia pseudoacacia)
Open oak and pine	Scarlet oak (Quercus coccinea) Virginia pine (Pinus virginiana) Pitch pine (Pinus rigida) Table mountain pine (Pinus pungens)
Spruce-fir	Red spruce (Picea rubens) Fraser fir (Abies fraseri)

Source: R. E. Shanks, "Reference list of native plants in the Great Smoky Mountains." Botany Department, The University of Tennessee, 1954. (Mimeographed).

The cove hardwood forest type occurs in sheltered, deep-soiled coves below 4,500 feet. These forests are generally broader and extend to higher elevations on the Tennessee side of the Park, due to the general northerly exposure. Seven tree species constitute 80 to 90 percent of the forest canopy in this type. The rich herb stratum is characteristic of cove forests, with summer herb coverage reaching 80 percent in some sites (National Park Service, 1969; Shanks, 1954; Whittaker, 1956).

The hemlock forest type occurs on sheltered topography along streams to 3,000 feet and to a lesser extent on exposed slopes and lead ridges up to 4,500 feet. Rhododendron (Rhododendron spp.) may dominate the undergrowth, or a low-tree layer of small-tree species may be well developed in some stands. Herb coverage varies from zero to 60 percent, with the lowest coverage being characteristic of the more distinctive hemlock type occurring on the steeper slopes at higher elevations. Greater density of herb coverage, more hardwoods, and less heath are characteristic of hemlock stands at lower elevations. The hemlock type gradually merges with the cove forests below 2,500 feet (Shanks, 1954; Whittaker, 1956).

The northern hardwood forest type typically occurs above 4,500 feet, usually at the heads of coves, in gaps, and other mesic sites. These forests are distinguished as a

separate type by the larger numbers of beech stems, limitation of tree size, and the more subalpine cast of the flora. Sedges, ferns, and other herbs dominate the sparse undergrowth with seedlings and shrubs occurring infrequently or not at all. Herb coverage is 40 to 60 percent with species composition similar to that of the upper cove forests. Sedges (Carex sp.) are characteristic of the herb stratum in this type, being nearly always present in small coverage (Whittaker, 1956).

The spruce-fir forest type occurs above 4,500 feet, and is dominated by red spruce (Picea rubens) at the lower elevations, a combination of red spruce and Fraser fir (Abies fraseri) at the middle elevations, and Fraser fir at the highest elevations--above 6,000 feet. Structure and floristic composition of the undergrowth vary considerably along the moisture gradient (National Park Service, 1969; Whittaker, 1956).

Intermediate to dry slopes at low and middle elevations are generally occupied by the closed oak forest type. These sites have sufficient moisture to maintain a high and continuous canopy. Understories are usually dense, but not continuous. Coverage varies from 50 to 80 percent at the middle elevations to 20 to 50 percent below 2,500 feet, and is characterized by mountain laurel (Kalmia latifolia) and rhododendron thickets or stands of young oaks, locusts,

catbrier (Smilax rotundifolia), and oilnut (Pyrularia pubera). Herb coverage is 10 to 40 percent at the lower elevations and 20 to 60 percent at the middle elevations (National Park Service, 1969; Shanks, 1954; Whittaker, 1956).

The open oak and pine forest type occurs on most of the steep, south- and southwest-facing slopes with shallow, rocky soils. The overstory is not continuous, but a continuous tall shrub stratum dominated by mountain laurel is usually present. Scarlet oak (Quercus coccinea) is the dominant hardwood in this type, replacing northern red oak (Q. rubra) of the closed oak type. The driest sites below 2,200 feet support Virginia pine (Pinus virginiana), while pitch pine (P. rigida) is found between 2,200 and 3,200 feet, and table mountain pine (P. pungens) occurs over 3,200 feet. Understory and herb layer composition is similar to that of the closed oak type, except for its greater density (National Park Service, 1969; Shanks, 1954).

Heath balds occur over 4,000 feet on the more exposed sites. Mountain laurel and great rhododendron (Rhododendron maximum) are characteristic of the balds at lower elevations, while the high-elevation balds are dominated by rhododendron (R. catawbienese and R. carolinianum) and vaccinium (Vaccinium constablaei). Herb coverage is generally below 5 percent (Whittaker, 1956).

The grassy balds are considered a separate vegetation type. This type is generally restricted to exposed sites at high elevations. Dominant plant cover consists of mountain oat grass (Danthonia compressa), old-field cinquefoil (Potentilla canadensis), and creeping aster (Aster surculosus). The most common tree invader is the serviceberry (Amelanchier laevis), and the most common shrub invaders are the blueberries (Vaccinium spp.) National Park Service, 1969).

Some openings other than the grassy balds are present in the GSMNP. Old home sites and their associated fields and orchards are scattered throughout the Park. Forest succession has been reclaiming these areas since they were abandoned in the 1930's. The Cades Cove area is maintained in a pre-park condition with approximately 2,400 acres in pastures and hay. Only limited agricultural practices, including grazing, fertilizing, mowing, and seeding of pastures, are carried out in this area. Plant cover in the fields consists primarily of fesque (Festuca sp.), orchard grass (Dactylis glomerata), red top grasses (Agrostis sp.), timothy (Phleum pratense), ladino clover (Trifolium sp.), and red clover (Trifolium pratense).

CHAPTER III

METHODS

I. COLLECTION METHODS

Animals were collected from the fall of 1971 through the spring of 1973, by a combination of live-trapping and shooting. Semi-portable box traps of the type described by Williamson and Pelton (1972) were used, as were permanent trap structures located on the study area (Fox, 1972; Matschke, 1962). Whenever possible, animals were shot. Hunting methods consisted of hunting while walking, during the day or night, and night hunting from a vehicle when hogs were utilizing open, pastured areas. An effort was made to collect animals from different elevations in the study area wherever hog activity was noted. Collection of hogs at high elevations necessitated hiking into the back country and night hunting. Inaccessibility of much of these areas limited collection efforts, particularly in the winter months.

Weight, sex, age (Matschke, 1967), location of capture, and other data were recorded for each animal collected. Complete dissections were made, where possible, of animals collected. Whole stomachs were collected, along with other materials to be used in physiological studies. Most stomachs

were preserved by freezing at approximately minus 20° F. A few stomachs were preserved in a 10 percent formalin solution.

Throughout the study period, direct observations of hog feeding and evidence of hog feeding activity in different areas were recorded. Evaluation of rooting sites as to the types of foods eaten was also attempted. Results of these methods were used to supplement information from stomach contents analyses.

II. STOMACH ANALYSIS

The total volume of the contents of each stomach was measured in graduated beakers and a homogeneous 900 cc sample was taken for analysis. The total volume of stomachs containing 900 cc or less was analyzed. The volume of corn (*Zea mays*) in those stomachs taken from trapped animals was measured and used in the percentage volume calculations for each stomach but was not included in the listing of food items. Stomach contents were washed through three consecutive sieves of decreasing mesh size to segregate identifiable items and remove very fine particles of little value in identification. Material passing through the fine screen was discarded according to the method used by Bergerud and Russel (1964). Items remaining in the three sieves were left segregated to aid in separation and identification. Identified

items were removed and their volumes measured by water displacement in graduated cylinders. Volumes below 0.1 cc were recorded as trace quantities. The remaining finely masticated material was apportioned by ocular estimate and on the basis of the measured volumes of identified items (Korschgen, 1962). Because of the loss of diagnostic characters due to thorough mastication of some items, specific identification was impossible, and only general headings were used. For each stomach, the percentage volume for each food item was determined (Robel and Watt, 1970). The total volume of each food item as a percentage of the total volume of all food items was calculated for each season (Martin et al., 1946). The frequency (in percent) of occurrence of all food items was calculated seasonally.

Plant nomenclature is from Fernald (1950). Invertebrate nomenclature is from Chu (1949) and Peterson (1960). Vertebrate nomenclature is from Blair et al. (1957).

CHAPTER IV

RESULTS AND DISCUSSION

A total of 128 stomachs was collected for analysis from September 1971 to May 1973. Sixty-six of these were males and 62 were females. The age ratio was 73 adults to 55 juveniles, separated on the basis of tooth eruption (Matschke, 1967) and weight (Duncan, 1973). Foods eaten by hogs did not appear to differ between sexes or between adults and juveniles. A summary of the generalized categories of foods eaten by European wild hogs during the study period is presented in Tables IV and V and Figure 4. Plant materials were divided into three categories: roots, leaves and stems, and fruits and seeds. The major volume of foods consumed by hogs consisted of plant materials (99.1%). Roots comprised the major plant food by volume (44.3%) and frequency of occurrence (64.1%) during the study period. The volume of roots consumed increased from spring to the fall and winter months. Consumption of leaves and stems was greatest in the spring and decreased to the smallest amounts in the winter. The consumption of fruits and seeds was highest during the summer months. Acorns, hickory nuts, and other mast were included in the fruits and seeds category,

TABLE IV

PERCENT OF TOTAL VOLUME OF FOOD ITEMS IDENTIFIED IN 128 EUROPEAN WILD HOG STOMACHS COLLECTED IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1971-1973

	Percent of Total Volume				
Items Identified	Spring (30)[a]	Summer (14)	Fall (48)	Winter (36)	Total (128)
Plant Matter					
Roots	0.2	11.4	62.2	61.6	44.3
Leaves and stems	63.2	30.8	11.1	7.3	21.7
Fruits and seeds	19.4	39.0	16.5	25.7	24.2
Total plants	82.8	81.2	89.8	94.6	90.2
Animal Matter					
Invertebrates	tr	tr	0.3	0.2	0.2
Other	tr	tr	0.2	0.2	tr
Miscellaneous					
Garbage	--	tr	--	tr	tr
Other (gravel, debris)	tr	--	tr	tr	tr

[a]Number in parentheses represents number of stomachs examined.

TABLE V

FREQUENCY OF OCCURRENCE OF FOOD ITEMS IDENTIFIED IN 128 EUROPEAN WILD HOG STOMACHS COLLECTED IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1971-1973

Items Identified	Percent of Frequency				
	Spring (30)[a]	Summer (14)	Fall (48)	Winter (36)	Total (128)
Plant Matter					
Roots	26.7	64.3	79.2	75.0	64.1
Leaves and stems	86.7	71.4	54.2	55.6	64.1
Fruits and seeds	63.3	50.0	39.6	44.4	47.6
Total plants	100.0	100.0	100.0	100.0	100.0
Animal Matter					
Invertebrates	30.0	64.3	52.1	72.2	52.3
Other	16.7	14.3	20.8	25.0	20.3
Miscellaneous					
Garbage	--	7.1	--	2.8	1.6
Other (gravel, debris)	10.0	--	4.2	2.8	4.7

[a]Number in parentheses represents number of stomachs examined.

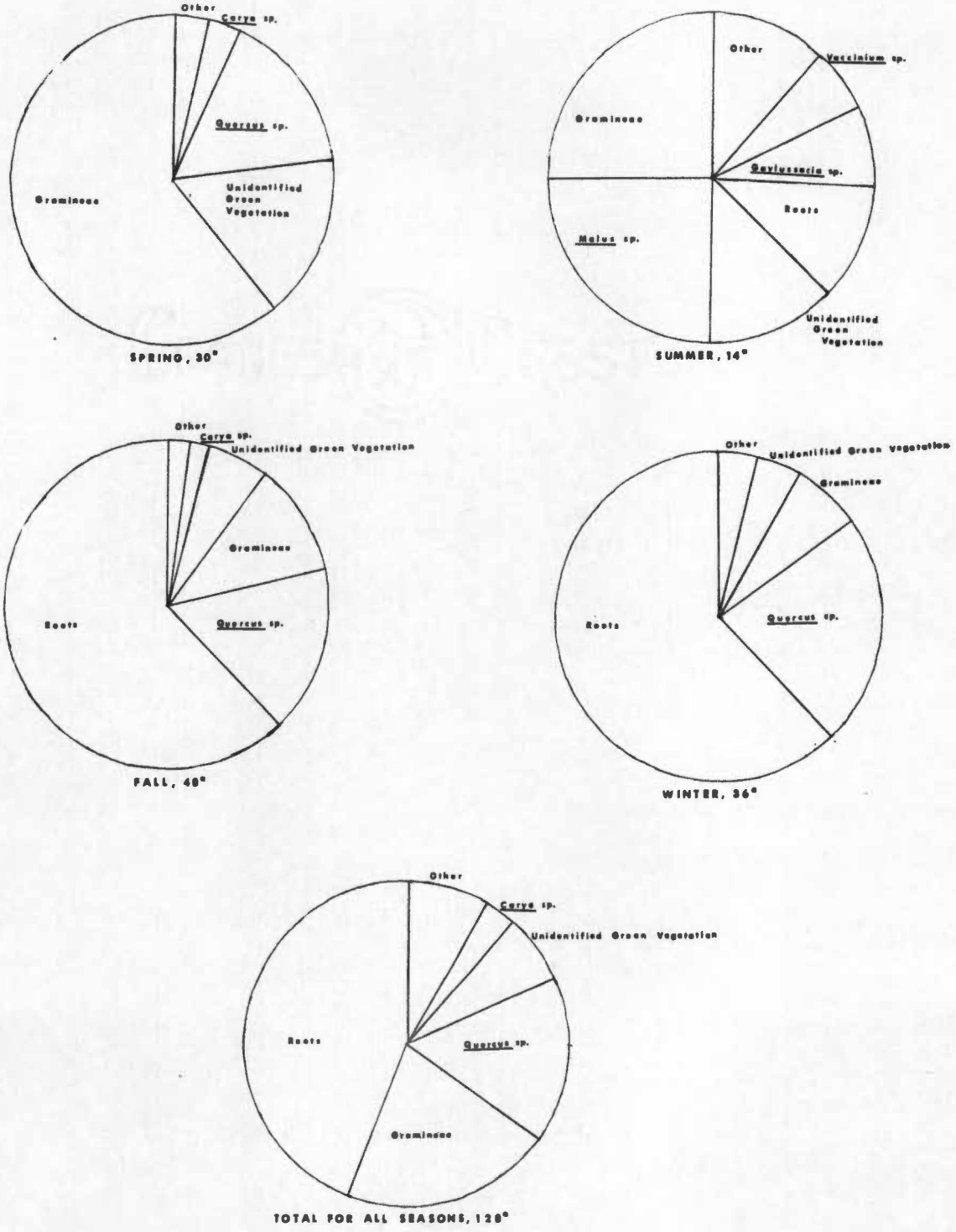

Figure 4. Volume and distribution of European wild hog food classes by season, and a total.

however, accounting for the moderately high percentage volume recorded for the winter season.

Animal foods occurred in all seasons, but made up only a minor portion (0.3%) of the total volume of foods consumed. Invertebrates occurred in 52.3 percent of the stomachs examined, although the percentage of total volume was small (0.2%). There was no apparent seasonal trend in consumption of invertebrates. Detection of earthworms was often difficult due to mastication and digestion. Field observations indicate that hogs do consume earthworms, however, and their importance as food may not have been sufficiently determined by stomach analyses. A list of the most common invertebrates found and the stage of the life cycle in which they were consumed is given in Table VI.

The low volume of animal foods found in this study suggests that the importance of these foods may have been overestimated by previous researchers (Belden, 1972; Tennessee Game and Fish Commission, 1972). Hogs may occasionally search for animal foods, especially some kinds of invertebrates, but the overall importance of these foods in the diet appears to be minor.

I. SPRING FOOD HABITS

Results of the analyses of 30 stomachs collected during the spring (March-May) are presented in Table VII. Grasses

TABLE VI

MOST COMMON INVERTEBRATES AND STAGE IN LIFE CYCLE CONSUMED BY EUROPEAN WILD HOGS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1971-1973

Invertebrate	Stage
Earthworms (*Lumbricus* sp.)	adult
Centipedes (*Chilopoda*)	adult
Millipedes (*Diplopoda*)	adult
Beetles (*Coleoptera*)	
Elateridae	larvae
Cerambycidae	larvae
Scarabaeidae	larvae
Tenebrionidae	larvae
Moths and butterflies (Lepidoptera)	
Geometridae	larvae
Flies (Diptera)	
Bibionidae	larvae
Rhagionidae	larvae
Tabanidae	larvae
Tipulidae	larvae

TABLE VII

VOLUME AND OCCURRENCE OF FOOD IN 30 EUROPEAN WILD HOG STOMACHS COLLECTED IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, SPRING (MARCH-MAY), 1971-1973

Food Item	Volume (%)	Frequency (%)
Plant Matter		
Gramineae (leaves and stems)	61.1	86.7
Unidentified green vegetation	15.7	40.0
Quercus sp. (fruit)	15.6	36.7
Carya sp. (fruit)	3.0	13.3
Vaccinium sp. (leaves and stems)	0.8	6.7
Trifolium sp. (leaves and stems)	0.8	10.0
Unidentified dried vegetation	0.8	46.7
Liriodendron tulipifera (flowers)	0.8	10.0
Amaranthus blitoides (seeds)	0.8	3.3
Roots	0.2	26.7
Juglans nigra (fruit)	tr	6.7
Viola sp. (leaves)	tr	3.3
Tsuga canadensis (leaves)	tr	3.3
Animal Matter		
Invertebrates	tr	30.0
Pseudotriton ruber	tr	3.3
Plethodon cinereus cinereus	tr	3.3
Sus scrofa (hair)	tr	10.0
Unidentified animal	0.1	20.0
Miscellaneous		
Gravel	tr	10.0

(Gramineae) were the major food item for this season by volume (61.1%) and frequency of occurrence (86.7%). Three hogs collected in April of 1973 in the Cades Cove area were found to have 100 percent grass remains in their stomachs. Although signs of rooting activity were scarce in the Cades Cove area, there was an apparent increase in feeding in the pastures in April of 1973 as indicated by field observations. Pastures in which feeding was observed contained mostly fesque, orchard grass, and/or clover. Grasses are common, but not always abundant in the GSMNP. Pastured areas are rare, although old home sites, trail sides, and grassy balds contain grasses. Grasses also made up a sizable proportion of the total volume of foods found in two stomachs collected in May above 4,500 feet. No evidence of feeding on mountain oat grass, which predominates on several of the grassy balds, was found. A recent study in California shows grasses to be important food items for wild pigs in the spring and summer months (Pine and Gerdes, 1973).

Animal matter eaten by hogs during the spring months amounted to 0.1 percent of the total volume. Invertebrates occurred in 30.0 percent of the stomachs examined for this period.

II. SUMMER FOOD HABITS

Food items from 14 stomachs collected during the summer (June-August) are listed in Table VIII. Consumption of grasses declined during the summer months. An increase in both percentage volume and frequency of occurrence of roots consumed was noted in this season. The small volume of tuberous roots may be misleading, since these foods appear to be finely masticated in most cases, and could not be consistently identified in the stomach.

Belden (1972) noted a general upward elevational shift in hog activity during the early summer months. One reason given for such a movement is the increased availability of food at higher elevations during this season. The availability of blueberries (Vaccinium sp.) and huckleberries (Gaylussacia sp.) may be an important factor since 60.0 percent of the stomachs collected at these higher elevations during the summer contained fruits of one or both of these species.

In late summer there was increased hog activity at the lower elevations, mainly concentrated around the scattered apple trees persisting in the Cades Cove area. Hogs were observed and collected at night while feeding in these areas. Apples appeared to be a highly preferred food, since hogs continued to return to the trees to feed despite frequent harassment. It is likely that hogs will also concentrate in

TABLE VIII

VOLUME AND OCCURRENCE OF FOOD IN 14 STOMACHS COLLECTED IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, SUMMER (JUNE-AUGUST), 1971-1973

Food Item	Volume (%)	Frequency (%)
Plant Matter		
Gramineae (leaves and stems)	25.3	71.4
Malus sp. (fruit)	25.3	14.3
Unidentified green vegetation	12.9	57.1
Roots	11.4	64.3
Gaylussacia sp. (fruit)	7.6	14.3
Vaccinium sp. (fruit)	6.1	14.3
Vaccinium sp. (leaves and stems)	5.5	14.3
Unidentified tubers	3.1	21.4
Unidentified dried vegetation	2.6	64.3
Prunus pensylvanica (fruit)	tr	7.1
Ilex opaca (fruit)	tr	7.1
Animal Matter		
Invertebrates	tr	64.3
Plethodontidae	tr	14.3
Sus scrofa (hair)	tr	7.1
Unidentified animal	tr	14.3
Miscellaneous		
Garbage	tr	7.1

old orchards or home sites where apple trees persist. Again, as in the spring, visible signs of hog rooting activity were not readily apparent, since hogs did not have to root to obtain apples.

Total volume of animal matter was lowest during summer, possibly reflecting the increased availability of other foods. Invertebrates occurred more frequently, however, in this season than in the spring, also a reflection of increased availability.

III. FALL FOOD HABITS

Results of the analysis of 48 stomachs collected during the fall months (September-November) are given in Table IX. Roots were the major food item consumed by hogs during the fall by volume (62.2%) and frequency of occurrence (79.2%). Consumption of grasses was lower than in the spring and summer, although this item occurred in 50.0 percent of the stomachs examined. Oak (Quercus sp.) and hickory (Carya sp.) mast began to appear in the stomach contents in October and November. These two foods made up 18.5 percent of the total volume of fall foods. Field observations indicated that hogs continued to feed on apples through the early fall until the supply was exhausted.

Henry and Conley (1972) found that oak and hickory mast accounted for 47.6 percent and 26.0 percent respectively, of

TABLE IX

VOLUME AND OCCURRENCE OF FOOD IN 48 EUROPEAN WILD HOG STOMACHS COLLECTED IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, FALL (SEPTEMBER-NOVEMBER), 1971-1973

Food Item	Volume (%)	Frequency (%)
Plant Matter		
Roots	62.2	79.2
Quercus sp. (fruit)	16.1	20.8
Gramineae (leaves and stems)	11.1	50.0
Unidentified green vegetation	5.8	27.1
Carya sp. (fruit)	2.4	18.8
Liriodendron tulipifera (samaras)	0.5	4.2
Juglans nigra (fruit)	0.4	2.1
Unidentified dried vegetation	0.3	50.0
Pyrularia pubera (fruit)	tr	2.1
Festuceae (spikelets)	tr	2.1
Unidentified seed	tr	2.1
Pinus virginiana (leaves)	tr	2.1
Tsuga canadensis (leaves)	tr	2.1
Animal Matter		
Invertebrates	0.3	52.1
Serpentes	0.2	2.1
Plethodontidae	tr	4.2
Aves	tr	2.1
Sus scrofa (hair)	tr	10.4
Sciuridae (hair)	tr	2.1
Unidentified animal	0.1	14.6
Miscellaneous		
Gravel	tr	4.2
Unidentified material	0.6	2.1

foods consumed by hogs during October and November on the Tellico Wildlife Management Area (Monroe County, Tennessee). The present study involved two fall and winter periods--1971-72 and 1972-73. Consumption of oak mast during the fall and winter of 1971-72 was significantly greater than during a comparable period in 1972-73. There was a corresponding increase in the proportion of the total volume of roots consumed in the 1972-73 period of fair to low mast production over the proportion of roots consumed during the 1972-73 year of higher mast production. Oak mast production indexes for the Tellico Wildlife Management Area show the 1971 season as a year of "medium" production of oak mast, whereas the 1972 season is rated as only a "fair" year for oak mast production (Tennessee Game and Fish Commission, 1972). The differences in availability of oak mast for the two seasons are reflected in the stomach analyses. Differences in the consumption of oak mast and roots for the two fall and winter periods encompassed in this study are presented in Figure 5.

The complete cessation of reproduction during an oak mast failure has been shown to occur in the European wild hog (Matschke, 1964). Reproductive studies of the animals collected in the present study indicate very low ovarian activity in sows examined during fall, winter, and spring of 1972-73 (Duncan, personal communication).

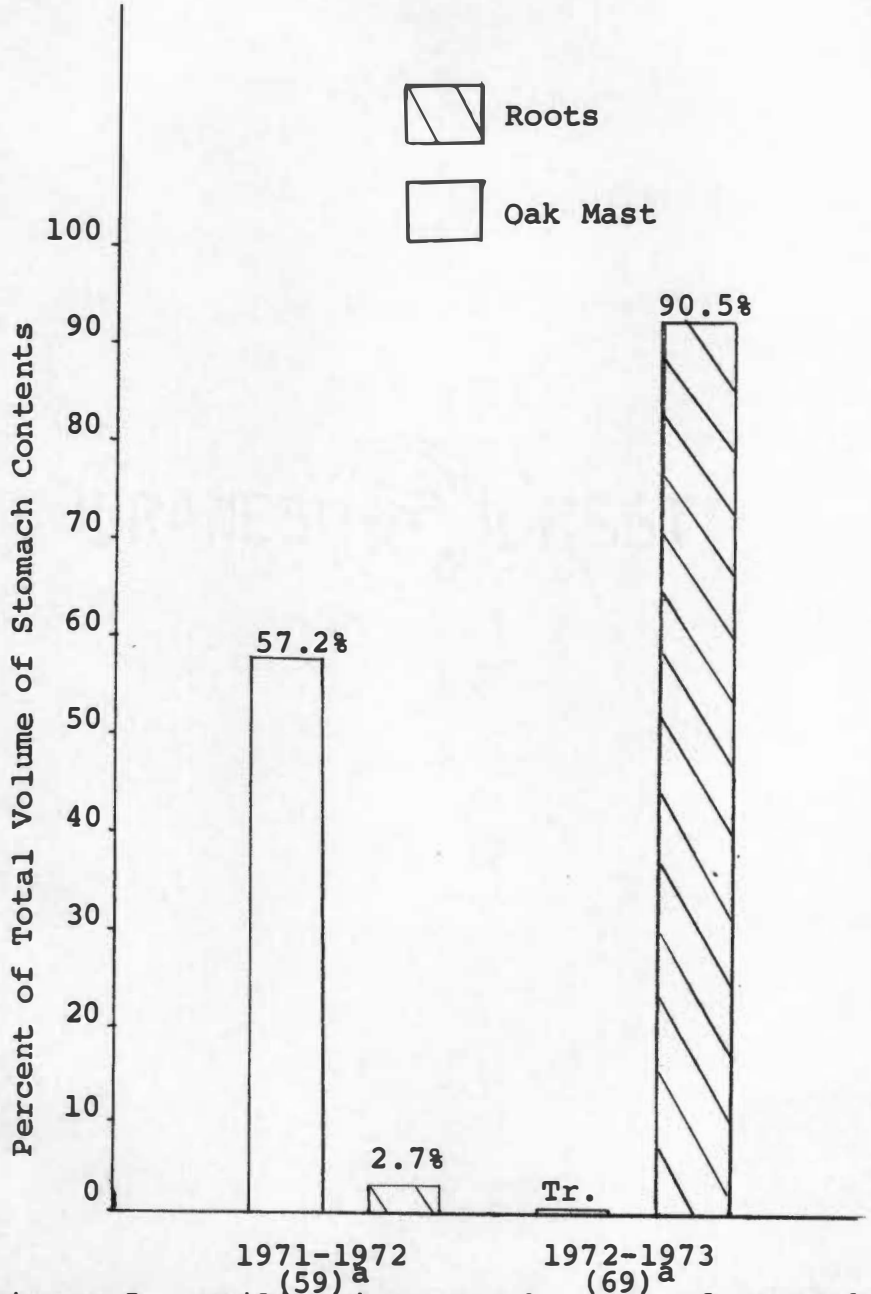

Figure 5. Utilization of oak mast and roots by European wild hogs in the Great Smoky Mountains National Park during the fall and winter, 1971-1973.

[a]Number of stomachs collected.

IV. WINTER FOOD HABITS

Results of the analysis of 36 stomachs collected in the winter months are given in Table X. Roots were the major food item by volume (61.6%) for this season. Field observations indicate that hogs often fed on the epidermis of pitch pine roots during the winter months, although the epidermis of the roots of Virginia pine, white pine (Pinus strobus), and yellow poplar (Liriodendron tulipifera) were occasionally utilized. As indicated by the increase in consumption of roots during the "fair" mast production year of 1972, roots of the above and other species may become significant in the diet of hogs in years of low mast production.

Consumption of oak mast was higher than in the fall months, comprising 22.8 percent of the total volume of winter foods. One observation of a group of hogs feeding under a large northern red oak was made in February of 1972. One of these animals was collected, and an examination of the stomach contents showed that 99.7 percent of the total volume of the contents consisted of acorns.

V. COMPARISON OF STOMACH ANALYSES OF TRAPPED AND SHOT HOGS

Results of the stomach analyses of hogs taken by trapping and by direct reduction were compared for differences in food habits information obtained. A total of 15

TABLE X

VOLUME AND OCCURRENCE OF FOOD IN 36 EUROPEAN WILD HOG STOMACHS COLLECTED IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, WINTER (DECEMBER-JANUARY), 1971-1973

Food Item	Volume (%)	Frequency (%)
Plant Matter		
Roots	61.6	75.0
Quercus sp. (fruit)	22.8	33.3
Gramineae (leaves and stems)	7.3	55.6
Unidentified green vegetation	2.8	38.9
Carya sp. (fruit)	1.9	16.7
Juglans nigra (fruit)	0.6	8.3
Unidentified dried vegetation	0.5	52.8
Vitis sp. (fruit)	0.4	5.6
Trifolium sp. (leaves and stems)	tr	2.8
Festuceae (spikelets)	tr	5.6
Unidentified seed	tr	2.8
Tsuga canadensis (leaves)	tr	5.6
Pinus sp. (leaves)	tr	2.8
Animal Matter		
Invertebrates	0.2	72.2
Rana sylvatica	0.1	2.8
Cricetidae (hair)	0.1	11.1
Sus scrofa (hair)	tr	16.7
Odocoileus virginianus (hoof)	tr	2.8
Richmondena cardinalis (feathers)	tr	2.8
Unidentified animal	0.1	2.8
Miscellaneous		
Gravel	tr	2.8
Garbage	tr	2.8
Unidentified material	0.2	13.9

stomachs from 69 trapped hogs were empty and were not included in the analyses. Only two stomachs from the total of 59 hogs taken by direct reduction could not be included in the analyses. One of these stomachs was empty, and the other was destroyed by shooting the animal. Thirteen of the stomachs collected from trapped hogs contained over 90 percent corn and were of little value for food habits information. A total of 23 categories of food items was identified from the stomachs of trapped animals, and 37 categories were identified from stomachs collected by direct reduction.

Differences in stomach contents between the two collection methods are most obvious during summer. These differences are probably due to the increased number of hogs at higher elevations at this time where trapping is difficult to accomplish and direct reduction is the more practical method of collecting the animals. All hogs trapped during the summer were taken at the lower elevations. Examination of the stomach contents of these animals did not show evidence of utilization of huckleberries and blueberries. Field observations indicated that these fruits were available on several of the grassy balds during this period, and stomach analyses of two hogs taken at these elevations confirmed that hogs were utilizing these foods.

Stomachs from European wild hogs which were shot while roaming free are preferred over those from trapped animals

for complete food habits information. However, differences among the percentage volumes of major foods for hogs taken by both methods in all seasons are minor. Misleading results may occur when different elevations are not sampled adequately in all seasons. Collection by shooting may be the only feasible means of sampling populations in inaccessible areas.

VI. EUROPEAN WILD HOG FOOD HABITS AND NATIVE WILDLIFE

Several species of wildlife native to the GSMNP utilize some of the same foods as the European wild hog. The mast of several species of oaks is probably the most important of these foods. The eastern wild turkey (Meleagris gallopavo), white-tailed deer (Odocoileus virginianus), and black bear may become dependent upon oak mast as a staple food during certain seasons. In addition, oak mast is considered to be an important food in the diet of many other species of wildlife (Martin et al., 1951).

The importance of oak mast in the diet of wild turkeys is well known (Bennett and English, 1941; Culbertson, 1948; Kozicky, 1942). Korschgen (1967) considered free-ranging or feral hogs to be more competitive with turkey for choice mast foods under most circumstances than cattle, sheep, and goats. He estimated that a medium-sized hog will consume

about ten times as much food as a medium-sized turkey. Competition between hogs and turkeys in the GSMNP may occur in years of low mast production in areas where these two species coexist on the same range.

Hosley (1956) regarded hogs as competitors with white-tailed deer in various regions of the United States. Competition between hogs and deer for mast may exist in parts of the GSMNP. The Cades Cove area supports the highest density of deer in the Park. Trapping and direct reduction data indicate moderate to high populations of hogs in this area as well. If serious competition does occur between hogs and deer, it would seem that such high population densities would not exist for both species in the same area. One explanation for such a condition may be the abundance and availability of pastures in the area, serving as an alternate food source for both species. However, more information on seasonal hog movements and concentrations in relation to food is needed to delineate any problems between hogs and deer.

Specific food habits information for the black bear in the GSMNP is available. Beeman and Pelton (1973) considered acorns to be possibly the single most critical food item for black bears in the GSMNP. Acorns were frequently eaten by black bears in the late fall (mid-October to dormancy), and the abundance and availability of oak mast appeared to have a substantial effect on black bear populations.

In summary, European wild hogs may be competitive for food with some species of native wildlife in the GSMNP. Oak mast ranked third in percentage volume (16.6%) of the total foods consumed by hogs during the study. Observations in the South show that feral hogs can rapidly exhaust the acorn crops on game ranges--as much as twice as quickly as on ranges where hogs are absent (Goodrum, 1949). In years of poor mast production, such utilization of available mast by hogs could be detrimental to native species, although the extent of such competition in the GSMNP is not known.

The importance of European wild hogs as nest predators of ground-nesting birds has been investigated (Matschke, 1965; Henry, 1969a). No evidence was found during this study of such predation.

VII. OBSERVATIONS OF ROOTING SITES

Field observations of hog feeding activity throughout the study period provided some additional information on hog food habits. Attempts by previous investigators to determine foods eaten by hogs on the basis of field observations have resulted in listings of a variety of plant species consumed (Tennessee Game and Fish Commission, 1972; Belden, 1972). Field observations are not adequate in themselves for hog food habits information, since rooting may result in large disturbed areas with a variety of plant species

uprooted. Determining what plant species have been eaten in such situations is difficult and highly subjective. Belden (1973) concluded that the greatest utilization of roots appeared to be in the warmer months. This conclusion is not supported by the stomach analyses, which showed a 0.2 percent and 11.4 percent of the total volume utilization of roots for spring and summer respectively.

Observations during this study indicate that hogs do eat certain tuberous roots. Evidence of feeding on wild yam (Dioscorea villosa), catbrier (Smilax sp.), and blackberry (Rubus sp.) roots was seen in all seasons. Extensive rooting in blackberry thickets was observed in late summer and early fall, but depth of the rooting was shallow, and it was not readily apparent that hogs were consuming the roots.

Considerable rooting activity around certain species of plants indicate a more than random selection of these species. Rooting often appeared to be concentrated around white snakeroot (Eupatorium rugosum) and nettle (Urtica sp.) at the higher elevations in late summer. Christmas fern (Polystichum acrostichoides) was frequently uprooted by hogs in the winter and spring months. One hog was observed rooting under Christmas fern; an examination of the site indicated that the roots had been eaten.

Although the total volume is low, evidence indicating that hogs do sometimes root for invertebrates was observed.

Hogs frequently overturned piles of cattle manure in the pastured areas during the winter months, apparently searching for earthworms or other invertebrates. Occasional rooting by hogs in shallow streambeds may be attempts to obtain aquatic invertebrates. Aquatic diptera larvae of the family Tipulidae were found in several stomachs.

The low volume of vertebrate matter found in the stomach analyses indicates that such food is probably obtained while rooting for other foods. Snakes, salamanders, and small mammals are probably taken only incidentally to other foods. Small mammals, in particular, may be obtained most frequently as carrion.

Feeding activity of European wild hogs may result in physical damage to certain areas in the GSMNP. Extensive rooting activity did not occur on the grassy balds in the study area during the course of the present study. Such activity did occur prior to the study, however, with large areas of sod being rooted up in some areas. Rooting of this type may result in alteration of normal plant succession. In addition, visible signs of rooting may persist on the grassy balds for months, reducing the aesthetic quality of these areas for Park visitors. Availability of mast foods may affect the amount of visible rooting activity, since hogs apparently have to root more for roots and other foods in the fall and winter months of years of low mast production.

Damage to wildflowers in the GSMNP appears to be incidental to hog feeding activity. No evidence of actual feeding on important wildflower species was noted during this study, although large beds of wildflowers were sometimes disturbed by rooting activity. Furthermore, the majority of root remains observed in the stomach contents were coarse and woody and therefore not herbaceous wildflowers.

It should be re-emphasized that food habits information based on field observations cannot be relied upon in determining significant foods eaten by European wild hogs. Evaluation of rooting sites to determine the specific foods eaten is often difficult and highly subjective. Collection of hogs should be intensified where rooting sign does not indicate specific food items.

CHAPTER V

SUMMARY

A food habits study of the European wild hog (Sus scrofa) was conducted in the Great Smoky Mountains National Park from September 1971 to May 1973. The objective of the study was to determine the seasonal food habits of European wild hogs in the Park.

One hundred twenty-eight stomachs were collected by a combination of live-trapping (69 animals) and direct reduction (59 animals). Results were presented by percentage volume and frequency of occurrence. Results were grouped into four seasons: spring (March-May), summer (June-August), fall (September-November), and winter (December-February).

Grasses (Gramineae) were the major food items in the spring. Unidentified green vegetation and oak (Quercus sp.) mast ranked second and third, respectively, in total volume of spring foods eaten. Roots were eaten in the least volume during this season. Invertebrates appeared frequently, but in only trace amounts by volume.

Consumption of grasses declined during the summer months, although these foods still made up one-fourth of the total summer volume. Fruits of huckleberries (Gaylussacia sp.) and

blueberries (Vaccinium sp.) were eaten during the late summer. Apples (Malus sp.) were a preferred food of hogs in local situations.

Roots were eaten more than any other food during the fall, followed by oak mast and grasses, respectively. Hickory (Carya sp.) mast was eaten in lesser amounts than the above foods.

Roots were again the most important food item during the winter months. Oak mast was eaten in greater amounts than during the fall. Grasses were eaten less in winter than any other season.

Plant matter comprised 90.2 percent of the total volume of foods eaten by hogs during the study period. Roots were the major type of plant food consumed. No discernible trend in seasonal utilization of animal matter was found. Invertebrates were the most frequently eaten animal matter in every season.

Observations of rooting sites were made in order to obtain additional information on hog feeding habits. Field observations should not be relied upon primarily for complete food habits information, however, due to the subjectivity of such evaluations.

Comparisons of food habits information obtained from trapped and shot hogs were made. Both of these methods may be used effectively for food habits studies, depending on the accessibility of an area and seasonal movements of hogs.

European wild hogs are considered to be competitors with some native wildlife for oak mast, particularly in years of low mast production. No evidence of hog predation on the nests of ground-nesting birds was found, and hogs apparently were not significant predators of salamanders or small mammals in the GSMNP.

CHAPTER VI

RECOMMENDATIONS

In order to fully evaluate the impact of European wild hogs on the GSMNP, food habits knowledge should be expanded. The following investigations would aid in accomplishing this goal.

1. Collection of stomachs should be extended through a period of several years to better determine annual trends in food habits.

2. More efficient techniques to identify finely masticated material in hog stomachs should be developed.

3. Methods of determining the annual production of important mast crops in the GSMNP should be developed.

4. The relationships between European wild hog condition, movements, reproduction, and population dynamics, and the seasonal availability and abundance of foods in the GSMNP should be more fully explored.

5. The extent of competition for food between hogs and native wildlife in the Park, including seasonal food habits studies of white-tailed deer, turkey, and other species should be thoroughly investigated.

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