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Rooting and Wallowing Activities of the European Wild Hog (*Sus scrofa*) in the Mountains of East Tennessee

Robert Christopher Belden
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To the Graduate Council:

I am submitting herewith a thesis written by Robert Christopher Belden entitled "Rooting and Wallowing Activities of the European Wild Hog (*Sus scrofa*) in the Mountains of East Tennessee." 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:

R. L. Murphree, Ralph W. Dimmick

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 2, 1972

To the Graduate Council:

I am submitting herewith a thesis written by Robert Christopher Belden entitled "Rooting and Wallowing Activities of the European Wild Hog (Sus scrofa) in the Mountains of East Tennessee." 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.

Major Professor

We have read this thesis
and recommend its acceptance:

R. L. Murphree

Ralph W. Dimmick

Accepted for the Council:

Vice Chancellor for
Graduate Studies and Research

ROOTING AND WALLOWING ACTIVITIES OF THE EUROPEAN WILD HOG (*SUS SCROFA*) IN THE MOUNTAINS OF EAST TENNESSEE

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

Robert Christopher Belden

August 1972

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ABSTRACT

European wild hog rooting and wallowing were studied in the mountains of East Tennessee in order to determine its seasonal, ecological, and altitudinal occurrence and extent.

From April, 1971, through March, 1972, the monthly occurrence and extent of European wild hog rooting and wallowing at different elevations and in different vegetation types were studied along established trails, cross-country trails, and roads in three watersheds in the Great Smoky Mountains National Park (65.7 miles) and in three watersheds in the Tellico Wildlife Management Area, Cherokee National Forest (34.4 miles).

European wild hog rooting and wallowing were found to occur most frequently and most extensively at the higher elevations in the warmer months and at the lower elevations in the cooler months. Fluctuations in the elevational occurrence of rooting and wallowing were greater in the Great Smoky Mountains National Park than they were in the Tellico Wildlife Management Area due to the greater elevational range available to this animal in the Park. The elevational movement of European wild hogs appeared to be a thermoregulatory response to increasing temperature and to food availability.

The vegetational occurrence of rooting appeared to be related to the elevational movement in response to increasing temperature, to food availability, and to the peaks in farrowing activity. The vegetational occurrence of European wild hog wallows appeared to be

related to the more mesic site characteristics of the cove hardwood forest type and the northern hardwood forest type, with wallows being observed in the cove hardwood type during the cooler months and in the northern hardwood type during the warmer months.

In the lower elevations, the monthly extent of rooting (REI) appeared to be determined by the average monthly temperature, by food availability, and by a European wild hog control program, whereas in the higher elevations, the REI appeared to be determined by the average monthly temperature and the extent of the elevational range available to wild hogs.

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CHAPTER I

INTRODUCTION

Since its introduction into the North Carolina-Tennessee mountain area in 1912, (Jones, 1959), the European wild hog (Sus scrofa) has become an animal with two faces. On the one hand, it is a prized trophy for hunters, and on the other, it is an unwanted intruder.

The European wild hog has been hunted on the Tellico Wildlife Management Area of the Cherokee National Forest in Tennessee since 1936. The Tennessee Game and Fish Commission considers this animal to be an important big game species in their management program. Because of the animals importance, a research project was begun in 1959 to determine its life history, population dynamics, and ecology (Matschke, 1964). This animal has also been the object of stocking programs in other areas of Tennessee as well as surrounding states. Lewis (1966) states that these stocking programs reflect the interest of sportsmen's groups in increasing opportunities to hunt this animal.

The National Park Service (Great Smoky Mountains National Park) considers the European wild hog as a destructive exotic in the natural ecosystem. In accordance with National Park Service policy concerning the elimination of exotics, a control program with the aim of eventual elimination from the Park boundaries has been conducted since 1959. The National Park Service recently initiated a five year ecological investigation of the European wild hog "to include observations of movements,

range, food habits, adaptation to various environments, migration tendencies, reproduction rate, and other pertinent factors that may result from this study that will eventually lead to the elimination of this exotic" (National Park Service, 1969).

Even though the European wild hog was introduced into this country over 60 years ago, all of the research, other than a three month study by Stegeman (1938) in the summer of 1937, has been carried out since 1959. This research has focused on basic life history information (Henry, 1966, 1968a, 1968b, 1969b, 1969c, 1970; Henry and Conley, 1970, 1972; Jones, 1959; Lewis, 1966; Matschke, 1963, 1964, 1967; Matschke and Hardister, 1966; Rary et al., 1968) plus ways and means of obtaining such information (Henry, 1969d; Henry and Matschke, 1968; Matschke, 1962; Matschke and Henry, 1969; Williamson and Pelton, 1971). The only studies concerning the habitat preferences of this animal and its impact on the natural flora and fauna were those of Henry (1969a), Matschke (1965), Stegeman (1938), and Strickland (1972). Whether the question is to control, eradicate, or propagate the European wild hog, intelligent evaluations and recommendations are needed.

This study dealt with the rooting and wallowing habits of the European wild hog in the mountains of East Tennessee. The major objectives of the study were to: (1) determine the seasonal, ecological, and altitudinal occurrence of European wild hog rooting and wallowing; and (2) determine the extent of rooting and wallowing activity by this animal. This study was a part of an overall research project being carried out by the Department of Forestry, The University of Tennessee, to study the biology and ecology of the European wild hog in the mountains of East Tennessee.

CHAPTER II

DESCRIPTION OF STUDY AREAS

Location and Physiography

The research for this study was conducted concurrently on two areas in East Tennessee. These were the Great Smoky Mountains National Park (GSMNP) and the Tellico Wildlife Management Area (TWMA), Cherokee National Forest.

The GSMNP is an 800 square mile (512,000 acre) area located within Blount, Sevier, and Cocke counties in Tennessee and Swain and Haywood counties in North Carolina (Figure 1). This area extends northeast along the Tennessee-North Carolina line from the Little Tennessee River and the southern portion of the Cherokee National Forest. It is approximately 15 miles from Sevierville (population 2,890) and approximately 25-50 miles southwest of the city of Knoxville (population 181,000). Wildlife management on the area is controlled by National Park Service policies (National Park Service, 1969).

The TWMA is an 80,000 acre tract of land within the 187,973 acre Tellico Ranger District of the Cherokee National Forest. This area, which lies entirely within Monroe County, Tennessee, extends south from the Little Tennessee River and the GSMNP and west from the North Carolina state line. It is approximately 15 miles from Tellico Plains (population 800), and approximately 70 and 72 miles from Knoxville and Chattanooga (population 127,500), respectively. Wildlife management

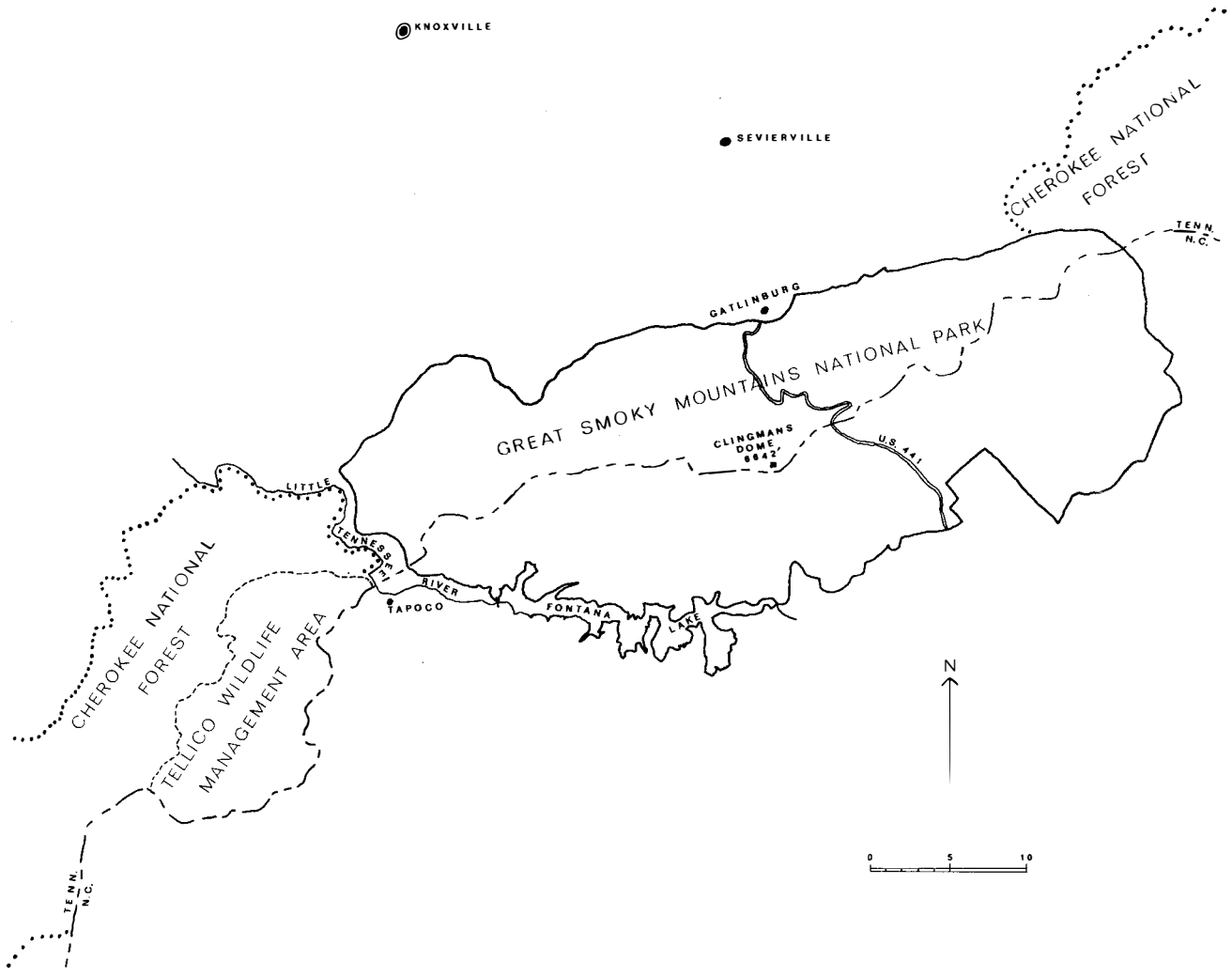

Figure 1. Map showing the geographical locations of the Great Smoky Mountains National Park and the Tellico Wildlife Management Area, Cherokee National Forest.

on the area is a cooperative endeavor between the U.S. Forest Service and the Tennessee Game and Fish Commission (U.S. Forest Service, 1970).

These two areas are located in the southern portion of the physiographic division known as the Great Smoky Mountains (the Unaka Mountain Range). Typical of this rugged division are the steep-walled, V-shaped valleys and narrow winding ridge crests with sharp peaks. Elevations in the GSMNP range from 888 feet above sea level where Abrams Creek flows into Chilhowee Lake, to 6,643 feet on Clingmans Dome, the second-highest point in the Eastern United States. The elevations in the TWMA range from 1,550 feet near Tellico Plains to 5,462 feet at Haw Knob. The GSMNP and TWMA are drained by approximately 600 miles and 135 miles of streams, respectively. These streams are mostly small, cold, fast-flowing, rocky, and margined with vegetation (National Park Service, 1969; U.S. Forest Service, 1970).

Geology and Soils

Both the GSMNP and the TWMA are underlain by rocks classified as belonging to the Great Smoky formation of the Ocoee series of late Precambrian age. These are sedimentary rocks of unusual complexity that have been metamorphosed and greatly folded and faulted. The rocks are principally composed of graywacks (quartz, feldspar, and slate fragments), with lesser amounts of slate, schist, and limestone (King et al., 1968; TVA et al., 1967).

The soils of these areas, typical of the soils of the upland, were derived from the underlying bedrock. The majority of this soil is classified as the Ramsey Soil type (Ramsey slates, silt loam, very

steep phase), and is derived from slates and quartzites. These Ramsey soils vary considerably in depth and distinctively developed soil horizons. The deep soils occur in local alluvial deposits at the base of steep slopes and along drainageways, while the shallow soils occupy narrow ridgetops and the steeper slopes. Some characteristics of Ramsey soils are their moderate natural fertility, medium to high acidity, rapid water percolation, and low water storage capacity (U.S. Forest Service, 1970). Cain (1931) found that the cove soils were moderately acid (pH 4.8-5.1), the middle slope soils intermediate in acidity (pH 4.1-4.3), and the ridge top soils highly acidic (pH 2.9-3.6).

Climate

The study areas have a humid general climate. There is, however, a marked variation in local climates due to the high relief of the mountainous terrain. Temperature decreases at the average rate of 2.23°F. per thousand feet rise in elevation. The higher peaks in the GSMNP average 10 to 15°F. cooler than the base of the mountain during the growing season. This difference is approximately 4 to 6°F. for the TWMA. There is a marked contrast between the six warm months and the six cold months of the year with a rapid warming between April and May and a sharp cooling between October and November. The average temperatures for January and July are 39.3° and 73.6°F. respectively for the GSMNP and 42° and 77°F. respectively for the TWMA (Shanks, 1954; U.S. Forest Service, 1970).

The precipitation at the base of the mountains is not far different from that of the adjacent valley areas. The precipitation

at 4,500 to 5,000 feet elevation, however, is approximately 50 percent greater than at the base of the mountains. The summer season is the period of greatest precipitation, while the fall is the driest time of the year. Precipitation averages 54 inches per year at the lower elevations and 85 inches per year at Clingmans Dome in the GSMNP. The average annual precipitation on Clingmans Dome is the highest in the United States outside the Northwest Coast. Precipitation averages 56 inches per year at the lower elevations and 70 inches per year at the higher elevations on the TWMA (Shanks, 1954; U.S. Forest Service, 1970). Weather data collected at Gatlinburg, Tennessee (elevation 1,460 feet) and at Tapoco, North Carolina (elevation 1,117 feet) are presented in Tables 1 and 2.

Vegetation

The vegetation of the Great Smoky Mountains in particularly rich in species and varied in community types. Stupka (1960) states that there are more than 1,300 kinds of flowering plants, almost 350 mosses and liverworts, 230 lichens, and more than 2,000 fungi in the GSMNP. Whittaker (1956) described this vegetational variety by the use of 15 vegetation types which he derived from studying the vegetation along the environmental gradients of moisture and elevation. Shanks (1954) lumped the numerous specific vegetation types into six broad physiognomic types which are relatively distinct, which occupy obviously different sites, and which are characterized by marked differences in the minor vegetation. These six vegetation types

TABLE 1

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]	1971	1972	1971	1972
January	39.3	35.3	41.2	39.0	--
February	41.9	37.1	36.2	40.4	40.1
March	47.8	41.4	45.7	44.9	48.9
April	56.8	54.0		57.6	
May	64.8	60.1		63.1	
June	72.0	71.4		73.6	
July	73.6	72.0		73.1	
August	73.7	71.2		73.4	
September	68.9	69.2		71.1	
October	57.9	60.7		63.9	
November	46.7	46.7		48.7	
December	40.2	47.8		51.2	

[a]Source: U.S. Weather Bureau, Climatological Data, U.S. Dept. Comm. Annual Summary, 1971, 1972. Vols. 76, 77.

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

TABLE 2

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]	1971	1972	1971	1972
January	4.84	7.03	6.53	6.98	--
February	4.76	4.66	4.88	6.66	4.80
March	5.32	4.82	5.40	5.70	6.33
April	4.50	3.53		3.58	
May	4.50	3.75		2.68	
June	5.20	6.77		1.91	
July	5.66	14.74		12.89	
August	5.29	5.43		2.81	
September	2.98	3.40		3.93	
October	3.12	6.46		4.08	
November	3.42	2.16		1.95	
December	4.46	4.18		2.93	
Annual	54.05	66.93		56.10	

[a]Source: U.S. Weather Bureau, Climatological Data, U.S. Dept. Comm. Annual Summary, 1971, 1972. Vols. 76, 77.

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

include cove hardwood forests, hemlock forests, northern hardwood forests, spruce-fir forests, closed oak forests, open oak and pine stands-heath balds. Figure 2 shows the general altitudinal and topographic position of these broad vegetation types. The effect of altitude is mainly on temperature and length of growing season, while effective moisture and soil depth are correlated with topographic position. The classification of the vegetation types by Shanks (1954) is followed in the description below, except that heath balds are considered as a separate vegetation type and grassy balds and fields are added to make a total of nine vegetation types.

The cove hardwood forest type occurs in the sheltered, deep-soiled drainages below 4,500 feet. On the North Carolina side of the GSMNP, which has a general south exposure, the cove forests are narrow and finger up each drainage, whereas on the Tennessee side, with a general north exposure, the cove forests often broaden out, occasionally extend over ridge crests, and extend to much higher elevations. Seven tree species make up 80 to 90 percent of the cove forest canopy (Table 3). There is no shrub grouping characteristic of the cove forests as a whole. The herb stratum is the richest in the mountains, and summer herb coverage is as high as 80 percent in some sites (National Park Service, 1969; Shanks, 1954; Whittaker, 1956).

The hemlock forest type is typically restricted to sheltered topography along streams up to 3,000 feet. It also occurs on the more exposed slopes and lead ridges up to 4,500 feet. The most important associates of hemlock are listed in Table 3. A low-tree layer of small-tree species of the submesic and ecotonal-mesic unions is well

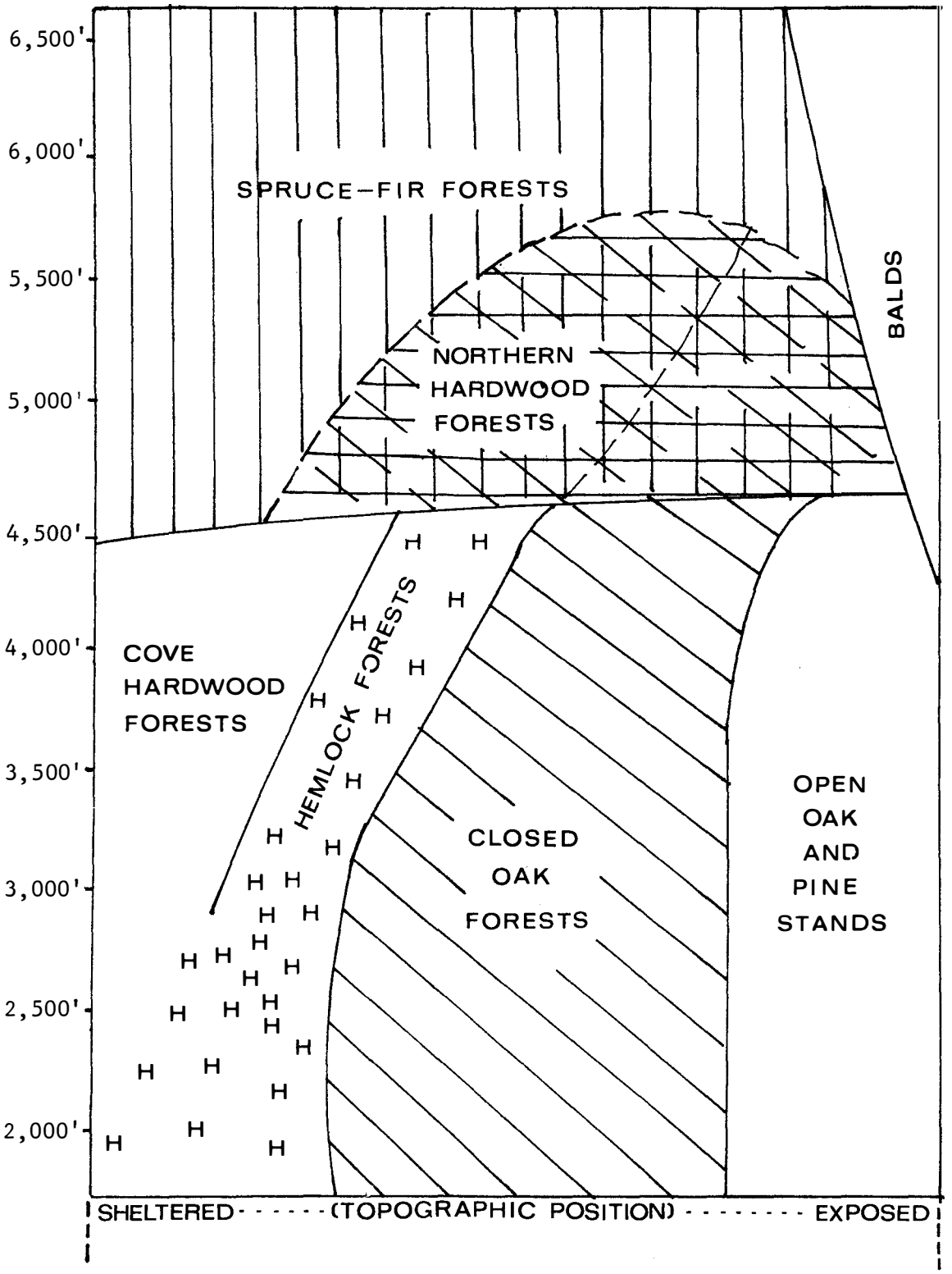

Figure 2. Vegetation pattern of the Great Smoky Mountains based on pattern diagrams by R. H. Whittaker, 1952.

TABLE 3

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 Yellow birch Silverbell Fraser magnolia (Magnolia fraseri) Rhododendron (Rhododendron spp.) Mountain laurel (Kalmia latifolia)
Northern hardwood	Beech Yellow birch Yellow buckeye Sugar maple Mountain maple (Acer spicatum)
Closed oak	White oak (Quercus alba) Chesnut oak (Q. prinus) Northern red oak (Q. rubra) Black oak (Q. velutina) Pignut hickory (Carya glabra) Mokernut hickory (C. tomentosa) Sourwood (Oxydendrum arboreum) Black locust (Robinia pseudoacacia)
Open oak and pine	Scarlet oak (Quercus coccinea) Virginia pine (Pinus virginiana) Pitch pine (P. rigida) Table mountain pine (P. 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 Dept., The University of Tennessee, 1954. (Mimeographed.)

developed in some stands, but relatively unimportant in others. The development of a low-tree layer is dependent upon the extent to which rhododendron dominates the undergrowth. Herb coverage varies from zero to approximately 60 percent, and is related to the proportion of hardwoods and the development of heath. The hemlock forest type is most distinctive (has the heaviest hemlock dominance, densest heath growth, and lowest amount of herb coverage) on steep slopes at higher elevations. At lower elevations, the hemlock stands are more mixed with hardwoods, have less heath, and contain more herbs. Below 2,500 feet the hemlock forest gradually merges with the cove forests, and hemlock becomes only one of the dominants (Shanks, 1954; Whittaker, 1956).

Above 4,500 feet the cove hardwood forest type merges with the northern hardwood forest type. The northern hardwood forest type is distinguished as a type only by larger numbers of beech stems, limitation of tree size, and more subalpine cast of the flora. It is found mainly at the head of coves, in gaps, and other mesic sites. The main tree species are listed in Table 3. The undergrowth is sparse with few seedlings and few or no shurbs above a floor of sedges, ferns, and other herbs. Herb coverage is 40 to 60 percent, and is essentially like that of the upper cove forests with the exception that seges (Carex sp.) are nearly always present in small coverage (Whittaker, 1956).

The lower limits of the spruce-fir type (4,500 feet) is dominated by red spruce (Picea rubens), the middle by a combination of red spruce

and Fraser fir (Abies fraseri), and the upper elevation--above 6,000 feet--by Fraser fir. The canopy composition of the spruce-fir type is relatively uniform, compared with the forests of lower elevations, but undergrowths vary greatly in structure and floristic composition along the moisture gradient (National Park Service, 1969; Whittaker, 1956).

The closed oak forest type is found on the intermediate to dry slopes at low and middle elevations. The moisture on these sites is sufficient to maintain a high and continuous canopy. The main tree species of this forest type are listed in Table 3, page 12. The understory is usually dense, but not continuous. It varies from mountain laurel (Kalmia latifolia) and rhododendron thickets to stands of young oaks, locusts, catbrier (Smilax rotundifolia) and oil nut (Pyrularia pubera). The understory coverage varies from 50-80 percent at the middle elevations to 20-50 percent below 2,500 feet. 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).

Most steep, south- and southwest-facing slopes with rocky soils are occupied by the open oak and pine type. The tree canopy is not continuous due to the xeric site conditions, but these conditions do result in a continuous tall shrub layer dominated by mountain laurel (Kalmia latifolia). The main tree species of the open oak and pine type are listed in Table 3, page 12. The most xeric scarlet oak (Quercus coccinea) replaces the northern red oak (Q. rubra) of the closed oak forest. Virginia pine (Pinus virginiana) is found on the

driest sites below 2,200 feet, pitch pine (P. rigida) between 2,200 and 3,200 feet, and table mountain (P. pungens) above 3,200 feet. Composition of the herb and ground heath layer is similar to that of the closed oak forest, but the density is greater (National Park Service, 1969; Shanks, 1954).

The heath balds are dominated by evergreen ericaceous shrubs which approach not only full coverage, but complete impenetrability in their dense thickets of tough stems. These balds occur above 4,000 feet, and show considerable difference in composition with altitude. At the lower elevations mountain laurel (Kalmia latifolia) and rhododendron (Rhododendron maximum) are the most important species, whereas the high-elevation balds are dominated by rhododendron (Rhododendron catawbienese and R. carolinianum) and vaccinium (Vaccinium constablaei). The herb stratum is limited, with coverage below 5 percent and in denser stands approaching zero (Whittaker, 1956).

The dominating plant cover on the grassy balds is mountain oat grass (Danthonia compressa), red sorrel (Rumex acetosella), old-field cinquefoil (Potentilla canadensis), and creeping aster (Aster surculosus). The most common tree invader is serviceberry (Amelanchier laevis), and the most common shrub invaders are the blueberries (Vaccinium spp.) (National Park Service, 1969).

Some pastures and fields are maintained in the GSMNP to preserve the open effect as it was in the days of the early settlers. These areas are kept in pastures and fields by allowing leasees to graze cattle and grow hay in accordance with recognized criteria of good range management. These techniques include periodic plowing, fertilizing,

and seeding of the pasture areas. Most of this area is planted to fescue, orchard grass, timothy, red top grasses, red clover, and ladino clover (National Park Service, 1969). Scattered fields are maintained on the TWMA to serve as food plots for wildlife. These have been planted in clover and fescue (Dick Conley, personal communication, 1971).

CHAPTER III

METHODS

Sampling Method

From April, 1971, through March, 1972, the monthly occurrence and extent of European wild hog rooting and wallowing at different elevations and in different vegetation types were noted along established trails, cross-country trails, and roads in three watersheds in the GSMNP (65.7 miles) and in three watersheds in the TWMA (34.4 miles). The three watersheds in the GSMNP--Hannah Mountain, Tremont, and Elkmont--were chosen because of their geographic locations. It was ascertained before the project started that the entire European wild hog population was south of the transmountain highway (U.S. 441), which divides the Park almost in half (Figure 1, page 4). Since the project was to be only on the Tennessee side of the Park, the area to be sampled was limited to the southwestern portion of the Park. The watersheds were chosen to represent this area by picking one on the southern end--Hannah Mountain, one in the middle--Tremont, and one at the northern end--Elkmont. The three watersheds on the TWMA were chosen because they were known to contain hogs. These watersheds were North Fork of Citico Creek (Jeffrey Hell), Sycamore Creek, and North River.

Classification of Vegetation

The vegetation types were classified by an ocular estimate of the proportion in which the various species occurred. These

vegetation types were marked on a topographic map (contour interval 40 feet), and the distance traveled through each vegetation type was measured. These distances and the distances traveled in 1,000 foot elevation classes are listed in Tables 4 and 5 respectively.

Rooting Observations and Analysis

When a rooting site was observed, the location, an estimate of its length, width, and depth, and the plants in the overstory, understory, and groundcover were recorded. Also recorded were the conditions of the rooting site (wet area, under litter, rotten wood, and rocks, under turf, and down into mineral soil) and the probable reasons for rooting (as determined by the conditions and the sign left at the rooting site). The elevation for that site was determined by locating the point on a topographic map (contour interval 40 feet). Each rooting site was classified according to its size and shape as determined from an ocular estimate of its length and width. These rooting site categories are presented in Table 6. The rooting observations were also placed into one of the nine vegetation types described earlier. The above was done on the basis of the plants recorded in the vicinity of the rooting site and by noting its location on a topographic map on which the vegetation types were marked.

The mean elevation for European wild hog rooting was calculated for each month by adding the elevation for each rooting observation in that month. These monthly mean elevations were tested with the Student-Newman-Keuls multiple comparisons test to determine any significant differences between the mean elevations for each month (Sokal and Rohlf, 1969).

TABLE 4

DISTANCE OF TRAILS AND ROADS IN EACH VEGETATION TYPE FOR EACH STUDY AREA

Vegetation Type	GSMNP		TWMA		Total	
	Miles	Percent	Miles	Percent	Miles	Percent
Cove hardwood	19.2	29.2	22.4	65.1	41.6	41.5
Hemlock	0.2	0.3	0.5	1.5	0.7	0.7
Northern hardwood	10.2	15.6	0.9	2.6	11.1	11.1
Spruce-fir	8.1	12.3	0.0	0.0	8.1	8.1
Closed oak	3.3	5.0	7.8	22.7	11.1	11.1
Open oak and pine	19.9	30.3	1.1	3.2	21.0	1.7
Heath balds	1.7	2.6	0.2	0.6	1.9	1.9
Grassy balds	1.7	2.6	0.0	0.0	1.7	1.7
Fields	1.4	2.1	1.5	4.3	2.9	2.9
Totals	65.7	100.0	34.4	100.0	100.1	100.0

TABLE 5

DISTANCE OF TRAILS AND ROADS IN EACH ELEVATION CLASS FOR EACH STUDY AREA

Elevation Class	GSMNP		TWMA		Total	
	Miles	Percent	Miles	Percent	Miles	Percent
1500 - 2500	22.0	33.5	12.4	36.1	34.4	34.3
2500 - 3500	14.1	21.5	9.8	28.5	23.9	23.9
3500 - 4500	8.3	12.6	11.4	33.1	19.7	19.7
4500 - 5500	13.3	20.2	0.8	2.3	14.1	14.1
5500 - 6500	8.0	12.2	0.0	0.0	8.0	8.0
Totals	65.7	100.0	34.4	100.0	100.1	100.0

TABLE 6

ROOTING CLASSIFICATIONS AND THEIR WEIGHTING FACTORS

Rooting Classification	Average Area Covered (sq. ft.)[a]	Weighting factor[b]
Large area - solid	3,000	3.000
Large area - spots and lines	2,500	2.500
Small area - solid	600	.600
Small area - spots and lines	550	.550
Large area - linear	400	.400
Large area - spotty	400	.400
Small area - linear	120	.120
Small area - spotty	60	.060
Small lines in a line	32	.032
Small spots in a line	24	.024
One small line	10	.010
Hole dug	8	.008
One small spot	2	.002

[a]Based on a conservative estimate of the average area actually covered with rooting.

[b]Average Area Covered/1,000.

The monthly mean elevations do not take into account the extent of the rooting at any one site; all rooting observations are given equal weight. To adjust for the differences in the extent of rooting at any one site and the differences between the distances traveled in the different study areas, elevations, and covertypes, a weighted average was determined. The formula for calculating the weighted average is

$$\overline{X}_w = \sum_i^n w_i X_i / \sum_i^n w_i$$

where w represents the weighting factors for the different rooting classifications (Table 6), and X is the number of rooting observations in that classification per mile for each study area, elevation class, or vegetation type. This weighted average, termed the Rooting Extent Index (REI), was calculated for each month and season for each study area, each elevation class within each study area, and each vegetation type within each study area. These REIs were not tested statistically because of the subjectivity involved in their computation.

The depth of the rootings, conditions of the rootings, and the possible reasons for rooting were tabulated to determine differences in these attributes between the months.

Correlation coefficients were calculated to test the degree of relationship between the monthly mean elevations for rooting for each study area and the average monthly temperature, average maximum monthly temperature, and average minimum monthly temperature.

Wallowing Observations and Analysis

The location, an ocular estimate of the length, width, and depth, the plants in the overstory, understory, and ground cover, and the area conditions (muddy spot in trail or in a small branch) were recorded when a hog wallow was observed. The elevation for the wallow was determined through the use of a topographic map (contour interval 40 feet). The wallowing sites were placed into one of the nine vegetation types described earlier.

The mean elevation for European wild hog wallowing was calculated for each month in the GSMNP and the TWMA. Due to the low number of wallowing observations (48), the means were not tested statistically for the separate study areas. The average length, width, and depth of the wallows was calculated for the GSMNP, the TWMA, and for both areas combined.

Observations, other than those pertaining to European wild hog rooting and wallowing, are presented in Appendixes A and B.

CHAPTER IV

RESULTS AND DISCUSSION

Description of Rooting

During this study, 1,419 rooting sites were observed. These rooting sites ranged in size from small spots that appeared to be where a hog had stuck his snout under the litter to those that were solid areas covering entire hillsides. Tables 7 and 8 present the number of rooting sites per mile for each month in the GSMNP and the TWMA after the sties were classified according to their size and shape (Table 6, page 20). The most common rooting classifications in the GSMNP were large linear areas, small spots in a line, small linear areas, and large areas of spots and lines. In the TWMA the most common rooting classifications were small spots in a line, large areas in spots and lines, small areas in spots and lines, and single small spots. It is possible that the reason that the most common rooting classification observed in the GSMNP was large linear areas is because most of the trails covered in the Park were well maintained and unobstructed. Therefore the hogs could root in long continuous lines without being stopped by obstacles. The majority of trails in the TWMA were cross-country trails. Hogs rooting along these trails would encounter many obstacles which they would have to go around the order to continue rooting.

The depth of rooting was also quite variable among the rooting sites. Depth ranged from just under the litter to approximately three

TABLE 7

NUMBER OF ROOTING SITES PER MILE BY MONTH AND ROOTING CLASSIFICATION FOR THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Rooting Classification	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Over All
Lg. area - solid	.00	.02	.01	.00	.10	.09	.32	.12	.00	.00	.00	.00	.05
Lg. area - spots and lines	.07	.15	.18	.05	.21	.24	.04	.23	.00	.05	.06	.17	.12
Sm. area - solid	.05	.06	.04	.03	.06	.08	.07	.16	.07	.11	.08	.10	.07
Sm. area - spots and lines	.05	.15	.14	.03	.12	.17	.12	.18	.03	.08	.10	.20	.11
Lg. area - linear	.21	.19	.15	.14	.14	.05	.02	.12	.10	.19	.27	.14	.14
Lg. area - spotty	.01	.02	.01	.03	.02	.00	.00	.05	.02	.00	.00	.00	.01
Sm. area - linear	.07	.17	.12	.08	.10	.05	.09	.11	.24	.14	.13	.14	.12
Sm. area - spotty	.00	.00	.00	.00	.02	.03	.02	.07	.00	.00	.00	.00	.01
Sm. lines in a line	.01	.06	.04	.10	.15	.00	.00	.11	.02	.08	.02	.05	.05
Sm. spots in a line	.13	.06	.05	.18	.38	.24	.16	.16	.17	.08	.06	.03	.14
One small line	.07	.06	.03	.05	.14	.19	.05	.14	.12	.06	.06	.05	.08
Hole dug	.00	.00	.00	.00	.04	.00	.00	.00	.00	.00	.00	.00	.00
One small spot	.03	.02	.05	.10	.33	.19	.12	.11	.22	.05	.08	.02	.10
Overall	.71	.96	.84	.96	1.79	1.32	1.01	1.56	.97	.71	.70	.71	1.02

TABLE 8

NUMBER OF ROOTING SITES PER MILE BY MONTH AND ROOTING CLASSIFICATION FOR THE TELLICO WILDLIFE MANAGEMENT AREA

Rooting Classification	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Over All
Lg. area - solid	.03	.00	.03	.14	.00	.03	.00	.00	.03	.00	.00	.00	.02
Lg. area - spots and lines	.14	.34	.44	.00	.24	.12	.06	.28	.06	.46	.17	.29	.23
Sm. area - solid	.06	.08	.32	.14	.04	.12	.17	.15	.09	.12	.09	.14	.13
Sm. area - spots and lines	.09	.16	.38	.00	.20	.12	.09	.31	.14	.44	.26	.38	.22
Lg. area - linear	.12	.10	.09	.00	.08	.06	.03	.00	.23	.17	.09	.09	.09
Lg. area - spotty	.00	.02	.00	.09	.00	.06	.03	.03	.03	.03	.00	.09	.03
Sm. area - linear	.09	.08	.03	.00	.20	.20	.06	.28	.17	.17	.03	.20	.13
Sm. area - spotty	.00	.02	.00	.00	.04	.14	.03	.00	.03	.03	.03	.03	.03
Sm. lines in a line	.12	.10	.06	.00	.04	.14	.00	.28	.06	.52	.12	.14	.14
Sm. spots in a line	.14	.04	.14	.00	.59	.64	.46	.31	.23	.49	.09	.29	.28
One small line	.06	.14	.23	.00	.04	.12	.06	.37	.09	.29	.12	.14	.14
Hole dug	.00	.00	.20	.05	.16	.09	.09	.00	.00	.00	.03	.00	.05
One small spot	.09	.02	.03	.00	.35	.41	.26	.40	.20	.14	.00	.00	.15
Overall	.93	1.12	1.95	.42	1.97	2.24	1.34	2.41	1.37	2.88	1.02	1.80	1.63

feet deep. The rooting sites per mile for each depth class for each month in the GSMNP and the TWMA are presented in Tables 9 and 10 respectively. Even though the depth class of litter to one inch was the most common, there was a tendency for the deeper classes to become more frequent in the warmer months.

The conditions of the rooting sites, even though quite variable, were classified as wet areas; under leaves, rotten wood, and rocks; under the turf in fields and balds; and down into the mineral soil. The number of rooting sites per mile for each of these area conditions are presented in Table 11 for the GSMNP and the TWMA on a per month basis. The wet areas and the areas under leaves, rotten wood and rocks were the most important area conditions for all months in both study areas.

Reasons for rooting at specific sites (where it was possible to evaluate) are presented per month for the GSMNP and the TWMA in Tables 12 and 13 respectively. Although the food habits of European wild hogs cannot be determined by observing rooting sites, certain probable food items become evident as well as the general trends in the utilization of these items.

Hogs are considered to root in wet areas for two reasons; one is for the thermoregulatory effect of wet areas (Hafez et al., 1962) and the other is their search for salamanders and aquatic invertebrates (Lewis, 1966; Henry and Conley, 1972; Sweeney, 1970). The months of December, October, August, and June all had a high occurrence of rooting in wet areas in both study areas (Table 11, page 29).

TABLE 9

NUMBER OF ROOTING SITES PER MILE BY MONTH AND DEPTH CLASS FOR THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Month	Depth In Inches											
	Litter	Litter to 1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-10	10-12	12+
January	.01	.56	.11	.01	.01	.00	.00	.00	.00	.00	.00	.00
February	.00	.77	.14	.06	.00	.00	.00	.00	.00	.00	.00	.00
March	.00	.60	.12	.04	.02	.02	.00	.01	.01	.01	.00	.00
April	.05	.38	.21	.05	.05	.00	.02	.00	.05	.00	.00	.00
May	.00	.79	.58	.17	.12	.02	.10	.00	.02	.00	.00	.00
June	.00	.53	.46	.17	.02	.03	.06	.00	.03	.02	.00	.00
July	.00	.59	.30	.07	.04	.00	.00	.00	.02	.00	.00	.00
August	.00	.69	.50	.11	.07	.02	.12	.00	.00	.00	.02	.04
September	.00	.70	.13	.08	.03	.02	.00	.00	.00	.00	.00	.00
October	.00	.50	.27	.03	.05	.00	.00	.00	.00	.00	.00	.00
November	.00	.57	.17	.08	.02	.00	.00	.00	.00	.00	.00	.00
December	.00	.61	.12	.05	.03	.03	.03	.00	.02	.00	.00	.00
Overall	.01	.60	.25	.07	.04	.01	.03	.00	.01	.00	.00	.00

TABLE 10

NUMBER OF ROOTING SITES PER MILE BY MONTH AND DEPTH CLASS FOR THE TELLICO WILDLIFE MANAGEMENT AREA

Month	Depth In Inches											
	Litter	Litter to 1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-10	10-12	12+
January	.00	.58	.26	.06	.03	.00	.00	.00	.00	.00	.00	.00
February	.02	.72	.12	.08	.06	.00	.06	.00	.04	.00	.00	.02
March	.00	1.28	.12	.12	.03	.03	.12	.00	.09	.03	.09	.06
April	.05	.19	.09	.05	.00	.00	.00	.00	.00	.00	.00	.00
May	.00	.87	.47	.08	.28	.00	.04	.00	.04	.16	.00	.04
June	.00	.84	.78	.23	.06	.03	.14	.03	.06	.00	.00	.06
July	.00	.76	.26	.14	.09	.00	.00	.00	.00	.00	.00	.09
August	.00	.90	.83	.43	.18	.03	.03	.00	.00	.00	.00	.00
September	.00	.93	.20	.12	.12	.00	.00	.00	.00	.00	.00	.00
October	.00	2.04	.58	.14	.09	.00	.03	.00	.00	.00	.00	.00
November	.00	.58	.23	.12	.00	.06	.00	.00	.00	.03	.00	.00
December	.00	1.40	.26	.09	.03	.00	.03	.00	.00	.00	.00	.00
Overall	.00	.94	.35	.14	.08	.01	.04	.00	.02	.01	.01	.02

TABLE 11

NUMBER OF ROOTING SITES PER MILE BY MONTH AND AREA CONDITION CLASS FOR THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Month	GSMNP				TWMA			
	Wet Areas	Under Leaves, Rotten Woods, and Rocks	Under Turf	Into Mineral Soil	Wet Areas	Under Leaves, Rotten Wood, and Rocks	Under Turf	Into Mineral Soil
January	.01	.57	.08	.01	.03	.84	.03	.00
February	.04	.81	.08	.00	.08	.96	.06	.02
March	.06	.62	.08	.06	.17	1.60	.06	.12
April	.02	.69	.08	.02	.05	.23	.09	.05
May	.12	1.13	.29	.25	.39	1.26	.08	.24
June	.14	.86	.14	.17	.47	1.45	.03	.29
July	.12	.69	.09	.05	.00	.99	.06	.17
August	.14	.90	.18	.28	.40	1.67	.19	.12
September	.07	.79	.08	.02	.32	.87	.03	.09
October	.18	.58	.05	.02	.55	2.21	.06	.03
November	.10	.63	.08	.02	.26	.70	.06	.00
December	.20	.63	.07	.00	.49	1.28	.03	.00
Overall	.10	.73	.10	.07	.26	1.19	.06	.09

TABLE 12

PROBABLE REASONS FOR ROOTING AND THE NUMBER OF OCCURRENCES FOR EACH REASON BY MONTHS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK[a]

Month	Salamanders or Aquatic Invertebrates	Insects or Grubs	Milli-pedes	Earth-worms	Acorns	Hickory Nuts	Grapes	Vegeta-tion	Roots
January					6	3	4	1	3
February					20	2			
March	2	2		1	12	5	1	3	9
April					2	4		2	6
May	2	10	1	1				2	6
June	6	7	1			1			11
July	4	4							3
August	5	8					3	1	3
September		19	2		3	1	1	3	1
October	7	6			6	2	3		1
November	2	3			11	4	1		1
December	8	6		1	10	1	6		3

[a]Determined by conditions and sign left at the rooting site.

TABLE 13

PROBABLE REASONS FOR ROOTING AND THE NUMBER OF OCCURRENCES FOR EACH REASON BY MONTHS IN THE TELLICO WILDLIFE MANAGEMENT AREA[a]

Month	Salamanders or Aquatic Invertebrates	Insects or Grubs	Milli-pedes	Earth-worms	Acorns	Hickory Nuts	Grapes	Vegeta-tion	Roots
January					2		1		1
February	1	1		1	11				1
March	4	6			16				1
April					1				
May	7	7	1	1					4
June		3			1			3	10
July		6						2	4
August	8	14	3		3			1	3
September	1	7			3				2
October	11	26	1		8		1	1	4
November	5	2	1		4	2	2	1	
December	15	6			12	1	4		4

[a]Determined by conditions and sign left at the rooting site.

The number of rooting observations per mile in wet areas in October and December were greater than those for August and June. Since the breeding season of several salamanders occurs in the late fall and early winter months, and since salamanders tend to congregate around wet areas to breed (Huheey and Stupka, 1967), the increased amount of rooting in wet areas may be due to the hogs feeding on salamanders during this period. The increases in the amount of rooting in wet areas during August and June is probably due to the hogs rooting for salamanders, aquatic invertebrates, and for the thermoregulatory effects of the moist conditions.

Insects, insect larvae, millipedes, mast, and grapes are reported by Henry and Conley (1972) to be consumed by the European wild hog. One would expect to find these food items under leaves, rotten wood, and rocks. The greatest occurrence of rooting observations in these situations in the GSMNP was in May, June, February, and September. The increase in rooting under leaves, rotten wood, and rocks during the months of May and June was probably the result of hogs searching for insects, insect larvae, and millipedes, whereas the increase in February and September was probably due to the hogs utilization of mast and grapes. The greatest occurrence of rooting observations under leaves, rotten wood, and rocks in the TWMA was in October, March, August, and December. The increase in rooting in these situations in October, March, and December may have been due to the hogs utilization of mast and grapes, whereas the increase in August may have been due to the hogs search for insects, insect larvae, and millipedes.

Henry and Conley (1972) also reported that European wild hogs consume roots. During this study, roots appeared to be utilized by hogs during all months of the year, but the highest utilization on both study areas appeared to be in the warmer months. This corresponds with the general increase in the depth of rooting during this period.

During the month of March, a number of holes dug by hogs in the TWMA was noted (Table 8, page 25). These holes were almost always located next to logs, stumps, or trees, and a small pile of acorn hulls and pieces of acorn meat were usually present. These rooting sites appeared to be the result of hogs searching for acorns in small mammal caches.

The food items noted for the fall months correspond closely with those found by Henry and Conley (1972) when they examined 73 stomaches from European wild hogs killed on managed hunts on the TWMA. They found, however, a greater utilization of mast than was determined by observing rooting sites in this study. This discrepancy can be explained by the fact that when mast first begins falling in the late summer and early fall months (Strickland, 1972), the hogs can probably pick it off the ground without rooting, whereas later on in the fall and early winter, the hogs have to root under recently fallen leaves for the mast. The other food items mentioned by Henry and Conley (1972) were not noted to be the objects for rooting during this study. However, these were items that the European wild hog could feed on without rooting. Judging from the conditions of the rooting sites and the probable reasons for rooting, it appears that

the season of the year and food availability are the main factors influencing European wild hog feeding habits.

Monthly Occurrence of Rooting by Elevation

Graphs exhibiting the monthly mean elevations, the elevational range for each month, and the overall elevational mean for European wild hog rooting in the GSMNP and the TWMA are presented in Figure 3. The monthly means for rooting were above the overall mean during the months of April through August in the GSMNP and the months of March and May through September in the TWMA. The fluctuations of the monthly means around the overall mean for rooting was greater in the GSMNP than it was in the TWMA. The mean elevations for rooting in the GSMNP for April, May, June, July, and August were significantly ($P<.05$) higher than the mean elevations for January, February, March, September, October, November, and December. In the TWMA, the mean elevations for rooting in March, May, June, and September were significantly higher ($P<.05$) than the mean elevations for January, February, and December. The maximum nonsignificant ($P>.05$) ranges for the monthly mean elevations for rooting are presented in Table 14 for the GSMNP and the TWMA. The overall elevational mean for hog rooting in the TWMA was 271 feet below that of the GSMNP.

The greater fluctuation of the monthly mean elevations about the overall mean elevation for rooting in the GSMNP was probably due to the fact that considerably more area is at the higher elevations in the GSMNP than there is in the TWMA; and, therefore, the European wild hogs in the Park have a greater altitudinal distance in which

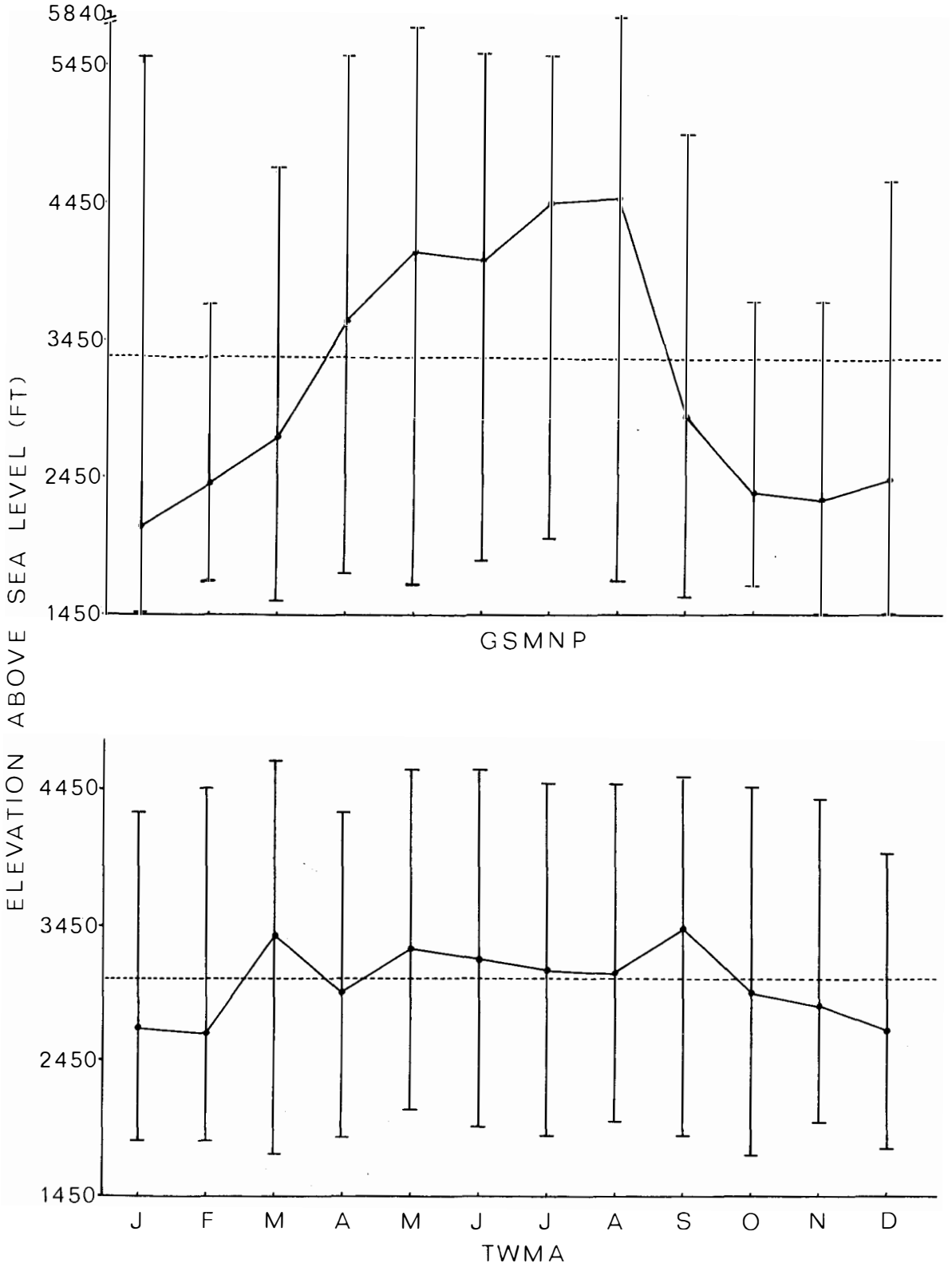

Figure 3. Monthly mean elevations, the elevational range for each month, and the overall elevational mean for rooting in the Great Smoky Mountains National Park and the Tellico Wildlife Management Area.

TABLE 14

STUDENT-NEWMAN-KEULS MULTIPLE COMPARISONS TEST BETWEEN MONTHLY MEAN ELEVATIONS FOR ROOTING FOR THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

GSMNP				TWMA			
Non-Significant Ranges[a]	Month	(N)	Mean	Non-Significant Ranges[a]	Month	(N)	Mean
	January	53	2108		February	56	2657
	November	44	2314		December	62	2681
	October	53	2368		January	32	2702
	February	50	2419		November	35	2865
	December	53	2464		April	9	2962
	March	78	2746		October	99	2991
	September	58	2924		August	78	3117
	April	50	3598		July	46	3127
	June	84	4056		June	77	3217
	May	93	4110		May	50	3289
	July	57	4474		March	67	3395
	August	88	4539		September	47	3448
Totals and Overall Means		761	3327			658	3060

[a]At the 0.05 level of probability.

to range. The highest and lowest points on the trails and roads traveled in the GSMNP during this study were 6,642 feet and 1,460 feet respectively. The highest and lowest points on the trails and roads traveled in the TWMA during this study were 4,724 feet and 1,960 feet respectively. The fact that the monthly mean elevation for rooting in April on the TWMA was below the overall mean elevation may have been due to the small sample size for rooting observations in this month.

There appears to be a correlation between the monthly mean elevation and temperature. In the GSMNP, the correlations between the mean elevation for rooting and average monthly temperature ($r=.773$), average maximum monthly temperature ($r=.795$), and average minimum monthly temperature ($r=.743$) were highly significant ($P<.01$). The correlations between average monthly temperature ($r=.588$) and average minimum monthly temperature ($r=.563$) in the TWMA were non-significant ($P>.05$), but the correlation between the mean elevation for rooting and average maximum monthly temperature ($r=.603$) was significant ($P<.05$).

The correlations between the mean elevations for rooting and the average maximum monthly temperature appear to be generally consistent with the behavior patterns of swine in relation to temperature. The sparse, bristly hair of swine is inadequate protection from both cold and solar radiation, and the skin temperature tends to change with the temperature of the surroundings. Because the bodies of swine are well insulated by a thick layer of subdermal fat, and because of the lack of any apparent thermoregulatory sweat glands, swine are

better able to cope with cold temperatures than they are with hot temperatures (Mount, 1968). Hafez et al. (1962) stated that in temperate climates domestic hogs will feed and move around at night during the hottest weather, and are quiet at night and active during the daylight hours during the cooler months. This tendency was also found in feral hogs on the Savannah River Plant in South Carolina by Kurz (1971). In tropical or subtropical environments, domestic hogs are active at night throughout the year (Hafez et al., 1962). Since Shanks (1954) stated that there was a 2.23°F. drop in temperature with each 1,000 feet rise in elevation, it seems logical to conclude that European wild hogs in the mountains of East Tennessee move to and increase their activity in the higher elevations as the maximum monthly temperature increases.

The extent of rooting (REI) for the different elevation classes is presented by months for the GSMNP and the TWMA in Figure 4. The greatest REI was at the higher elevations (4,500-6,500) during May, June, July, and August in the GSMNP, and in July in the TWMA. The greatest REI in the lower elevations (1,500-3,500) occurred during December, February, and March in the GSMNP, and in October, December, February, and March in the TWMA. In the middle elevations (3,500-4,500), March and April had the greatest REI in the GSMNP, and March, August, and October in the TWMA.

Monthly Occurrence of Rooting by Vegetation Type

The REI for the different vegetation types in the GSMNP and the TWMA is illustrated by months in Figure 5. The REI in the cove

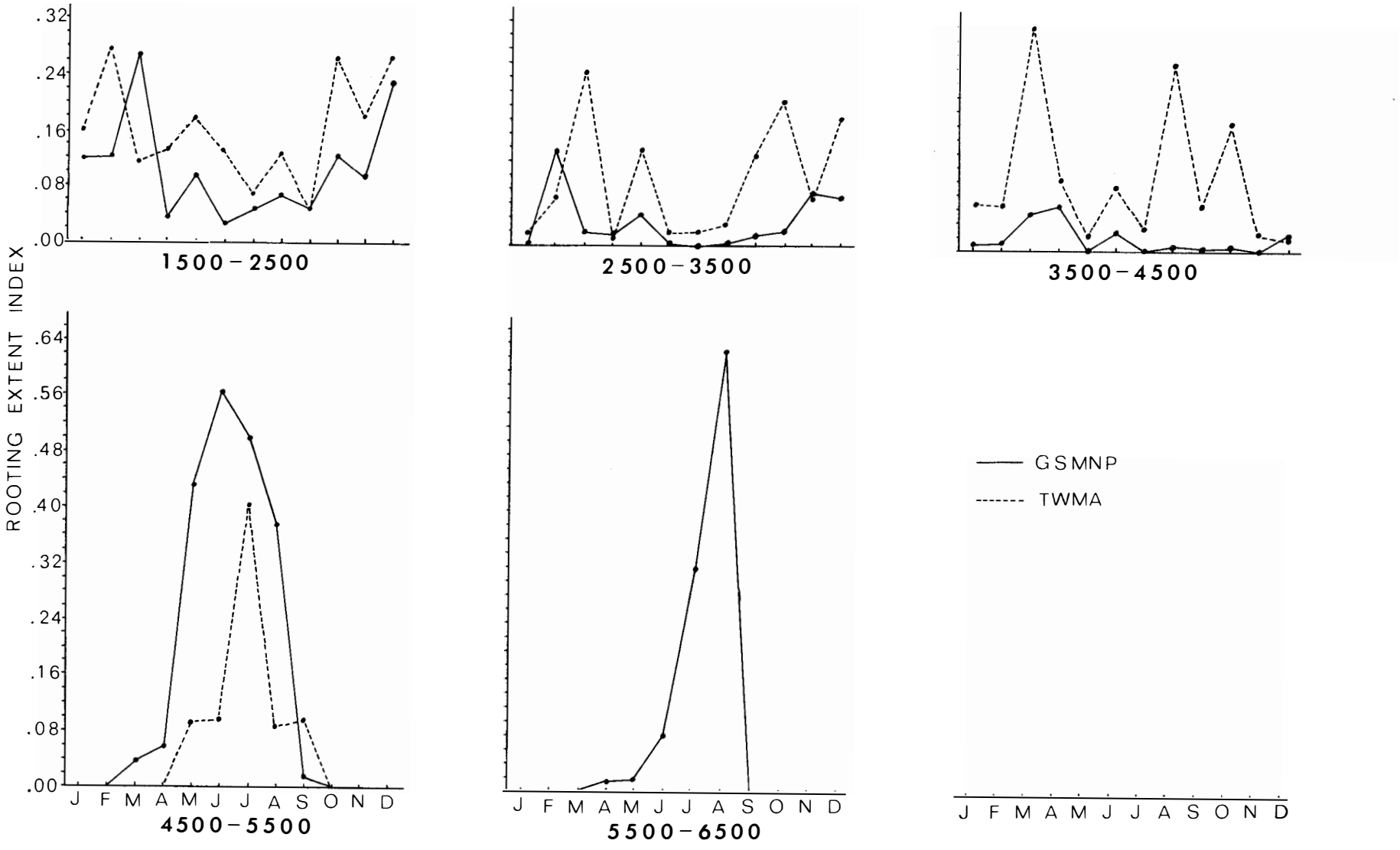

Figure 4. The extent of rooting within each elevation class for each month in the Great Smoky Mountains National Park and the Tellico Wildlife Management Area.

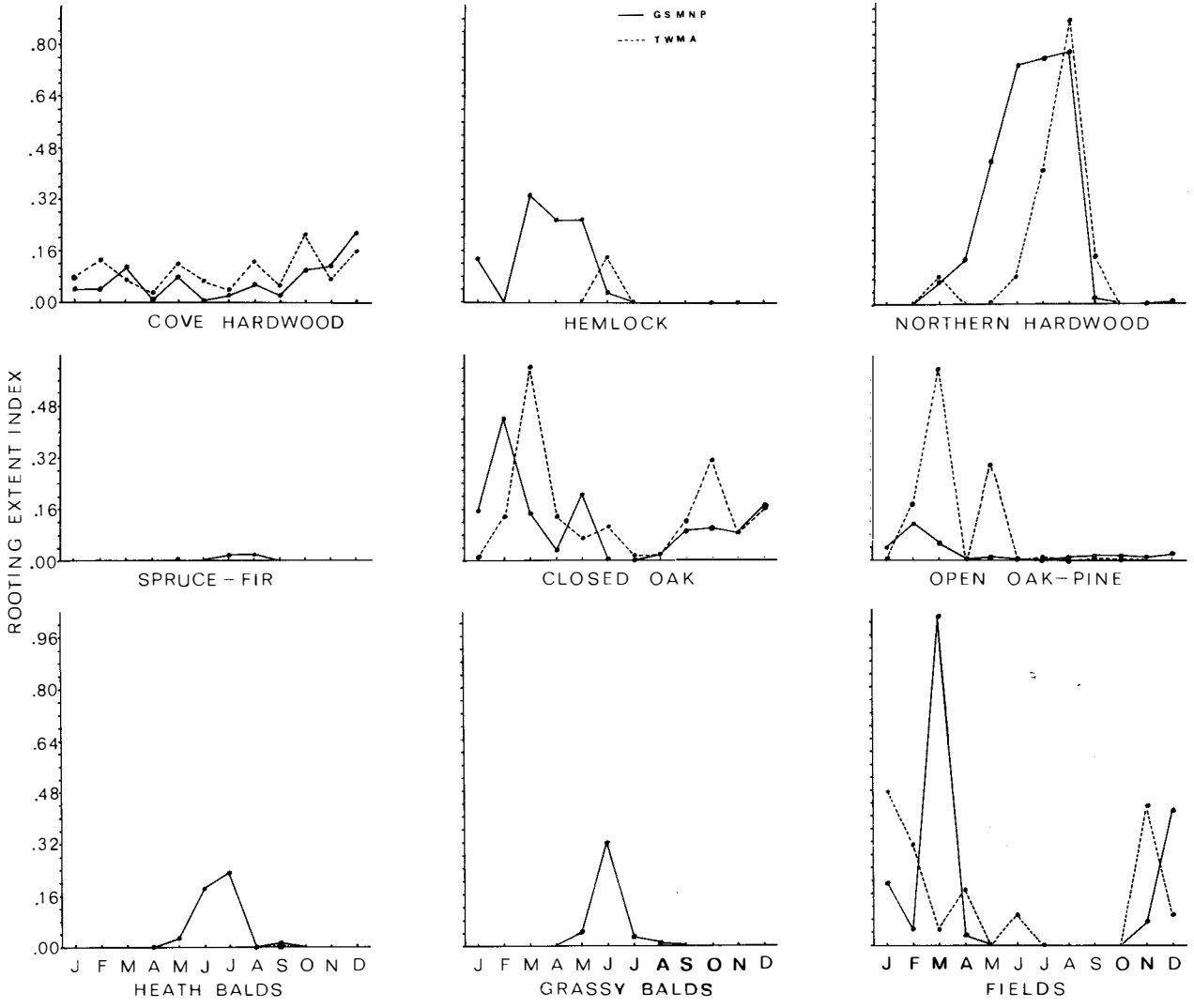

Figure 5. The extent of rooting within each vegetation type for each month in the Great Smoky Mountains National Park and the Tellico Wildlife Management Area.

hardwood type in the GSMNP started increasing in September and reached a peak in December. This increase in the REI in cove hardwoods, which occurs below 4,500 feet elevation, corresponds with the decrease in the monthly mean elevations for rooting during this period and is probably due to the immigration of European wild hogs from the higher elevations. The movement of hogs from the higher elevations during this period is probably due to the availability of mast in the adjoining closed oak vegetation type (Strickland, 1972). The increase in the REI in cove hardwoods in the TWMA during October and December through February may have been for the same reason.

In the GSMNP, there was an increase in the REI in the hemlock type during January, March, April, and May. In the TWMA, there was an increase in the REI in this type during June. These periods of increased rooting in the hemlock type correspond very closely with the peaks in European wild hog farrowing as reported by James R. Fox (personal communication, 1972) and Henry (1966), and may be due to the immigration of sows into this forest type to farrow. The hemlock type, with its usual thick heath understory, would probably offer seclusion, cover, safety, and other attributes which, according to Stegeman (1938), a sow might look for in a farrowing habitat.

The REI in the northern hardwood type in the GSMNP began to increase in March, reached a peak in August, and dropped off sharply in September. In the TWMA, the REI in the northern hardwood type started increasing in July, reached a peak in August, and dropped off in September. This increase in the REI in the northern hardwood type during the warmer months corresponds with the increase in the

monthly mean elevations for rooting during this period. This increase is probably due to the immigration of European wild hogs from the lower elevations in response to thermoregulatory behavior.

The spruce-fir type occurs only at the highest elevations in the GSMNP, and was only rooted to a very small extent during July and August. These were the two hottest months of the year, and the rooting in spruce-fir was probably incidental to the thermoregulatory response of the European wild hog to move into the higher elevations.

In the GSMNP, the REI in the closed oak type started increasing in August and reached a peak in February. There was also a smaller peak in May. Three peaks in rooting occurred in the TWMA in the closed oak type. These peaks were during October, December, and March. The increase in the REI in the closed oak type follows very closely with the chronology of red and white oak acorn fall as reported by Strickland (1972). Henry and Conley (1972) reported that acorns were utilized more than any other plant or animal food source during the fall months.

The REI in the open oak-pine type in the GSMNP started increasing in December, reached a peak in February, and gradually decreased to May. In the TWMA the peaks in the REI in the open oak-pine type occurred during March and May. These periods of increased rooting in the open oak-pine type, as in the hemlock type, follow very closely with the peaks in European wild hog farrowing. Since this type also tends to have a thick heath understory, it might have been used for farrowing for the same reasons as the hemlock type. The gradual increase in the REI in this type in the GSMNP during the cooler months of the year may also have been associated with a thermoregulatory response.

In heath balds in the GSMNP, the REI began to increase in May, reached a peak in July, and decreased in August. In the TWMA, only a very small extent of rooting occurred in September. This very small increase in the REI in heath balds during September also occurred in the GSMNP. The increase in the REI in this type, which occurs above 4,000 feet, generally follows the increase in the monthly mean elevations for rooting during this period, but no apparent reason could be found to explain the drop in the REI in July before the drop in the monthly mean elevations for rooting and the very small increase in the REI in September.

The GSMNP was the only study area through which grassy balds were traveled while observing rooting and wallowing in this study. Rooting was only noted on these balds in May, June, and July, with the peak in the REI occurring during June. It was noted while walking through the grassy balds that the rooting occurrences were mainly in the extreme western balds in the study area, and that the balds on the eastern end of the study area were not rooted even though rooting was extensive in the forest vegetation types surrounding the balds. The only apparent major differences between these bald situations are the differences in elevations. The balds occur at higher elevations as one progresses easterly from the western end of the study area.

The REI in the fields in the GSMNP was greatest during December and March, and during November and January in the TWMA. When rooting occurred in the fields in the GSMNP, it was usually associated with cow manure. It was thought that the European wild hogs were rooting after earthworms or insect larvae under the manure. When the European

wild hogs rooted in the fields on the TWMA, they usually rooted in small spots that covered large areas just under the turf. No apparent reasons could be found for the increased REI in these fields during only certain fall and winter months.

Monthly Extent of Rooting (REI)

The monthly REI in the GSMNP and the TWMA are shown in Figure 6. There appeared to be a tendency for the REI to increase with increasing temperature up to a certain point, beyond which it decreased with increasing temperature.

In January, February, and March, the REI increased in both study areas, but the REI was much greater in the TWMA than it was in the GSMNP. Two factors may explain this difference: (1) it is thought that the TWMA supports a larger population of European wild hogs on a per unit area basis, and (2) a control program was being carried out at the lower elevations in the GSMNP which involved the trapping of hogs and transplanting them to game management areas in Tennessee.

In April there was a drop in the REI on both study areas, but the REI in the TWMA was still higher than that in the GSMNP. No reasons for this decline were apparent.

During the months of May, June, July, and August, the REI in the GSMNP increased to its highest point, whereas the REI in the TWMA decreased to its lowest point in July and then increased in August. The probable reasons for the increase in the REI in the GSMNP during these months were that the European wild hogs were moving to higher elevations where the temperatures were milder and because there was

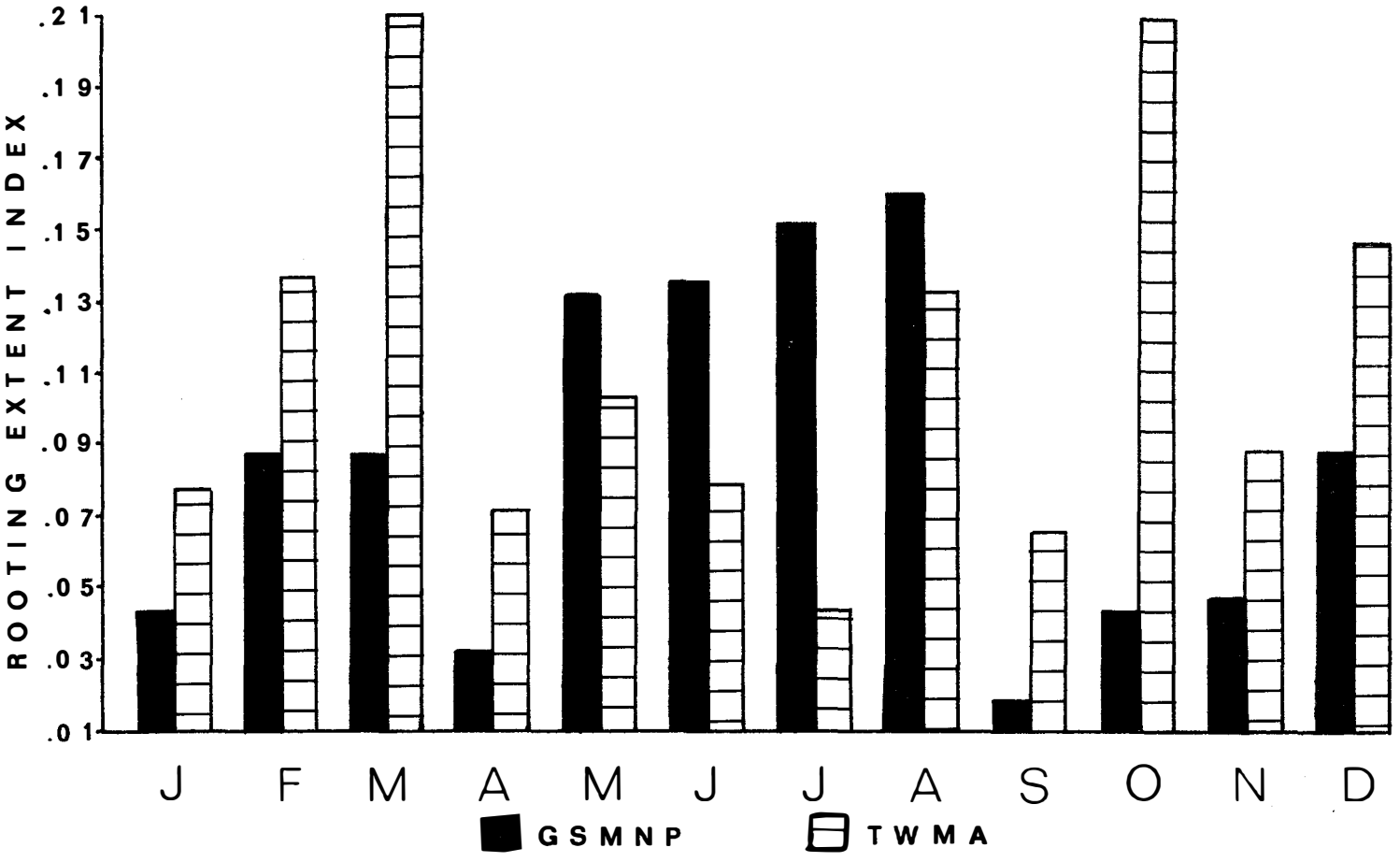

Figure 6. The monthly extent of rooting in the Great Smoky Mountains National Park and the Tellico Wildlife Management Area.

not a control program being carried out at these higher elevations. Heitmann and Hughes (1949), while working with domestic hogs, found that feed consumption decreased as the air temperature increased. They stated that the rate of gain was greatest and the amount of feed required to produce 100 pounds of gain was least at an average temperature of approximately 75°F. for domestic hogs weighing 70 to 144 pounds and approximately 60°F. for hogs weighing 166 to 260 pounds. They stated that as the air temperature was increased or decreased beyond these averages, the rate of gain declined and utilization of food was lowered. Since the average monthly temperatures were warmer in the TWMA than they were in the GSMNP (Table 1, page 8), and since the European wild hogs in the TWMA did not have as great of an elevational difference in which to range, it seems possible that the extent of rooting in the TWMA decreased from May to July due to a decline in the utilization of food. This, however, does not explain the increased REI during August in the TWMA.

The months of September through December had a general increase in the REI with the extent again being higher in the TWMA. The great increase in the REI during October in the TWMA is probably due to the fact that the acorn fall was greatest at this time (Strickland, 1972).

In summary, the hogs are mainly in the lower elevations in the closed oak and cove hardwood vegetation types during the fall and winter months. During this period they feed mainly on mast and grapes. The extent of rooting tends to increase as the temperature increases. In the spring and summer months, the distribution of hogs is more widely spread, but the majority tend to move into the higher elevations

as the temperature increases. In the higher elevations, most of their activity is centered around the northern hardwood vegetation type where they feed on the food items that are most available (salamanders, insects, grubs, millipedes, vegetation, and roots). The activity of those hogs that do not move into the higher elevations in the GSMNP and the hogs in the TWMA, where the range in elevation is not so great, tends to decrease with increasing temperature and is centered around the heads of moist coves in the cove hardwood vegetation type. This tendency was also noted by Ron Fox (personal communication, 1972) and Strickland (1972). In late August and early September, when mast again becomes available (Strickland, 1972), the hogs return to the lower elevations into the closed oak and cove hardwood vegetation types.

Description of Wallowing

During this study, 48 hog wallows were observed. These wallows were usually oval in shape and located in muddy depressions in trails, or in small branches with slow moving water. They were sometimes located to the side of branches where a muddy spot had been left following high water. The average size of wallows in the GSMNP was 4 feet by 3 feet by 9 inches, and the average size in the TWMA was 4 feet by 2 feet by 6 inches. The wallows in the GSMNP ranged in size from 2 feet by 2 feet to 7 feet by 5 feet, and the wallows in the TWMA ranged in size from 2 feet by 1 foot to 6 feet by 3 feet. The average size for all wallows combined was 4 feet by 3 feet by 8 inches. Seventeen of the 30 (57 percent) wallows observed in the

GSMNP were in a muddy depression in well traveled foot trails, and the remaining 13 (43 percent) were in or around a small branch. In the TWMA, only 4 of 18 (23 percent) of the wallows observed were in a muddy depression in trails, and the other 14 (78 percent) were in or around small branches. The probable reason for the difference between the two study areas in the observed locations of wallows is that the majority of the trails traveled in the GSMNP were very well worn with numerous muddy depressions, whereas the majority of trails traveled in the TWMA were little used by man and were covered with typical forest litter.

Monthly Occurrence of Wallowing by Elevation

The monthly mean elevations for wallowing are presented in Figure 7. The monthly means were at the higher elevations in the GSMNP from April to August, and at the lower elevations from September to March. This corresponds with the monthly mean elevations for rooting (Figure 3, page 35). The number of wallows observed on the TWMA were too few to distinguish monthly patterns in wallowing. The number of European wild hog wallowing observations per mile within elevation classes by months for the GSMNP and the TWMA are presented in Table 15. The fact that the greatest number of wallows per mile occur in the higher elevations during the warmer months of the year aid in support of the hypothesis that the European wild hog moves to the higher elevations for thermoregulatory reasons. Mount (1968) states that under natural conditions wallowing in water or mud makes up for the deficiency of any apparent sweating glands.

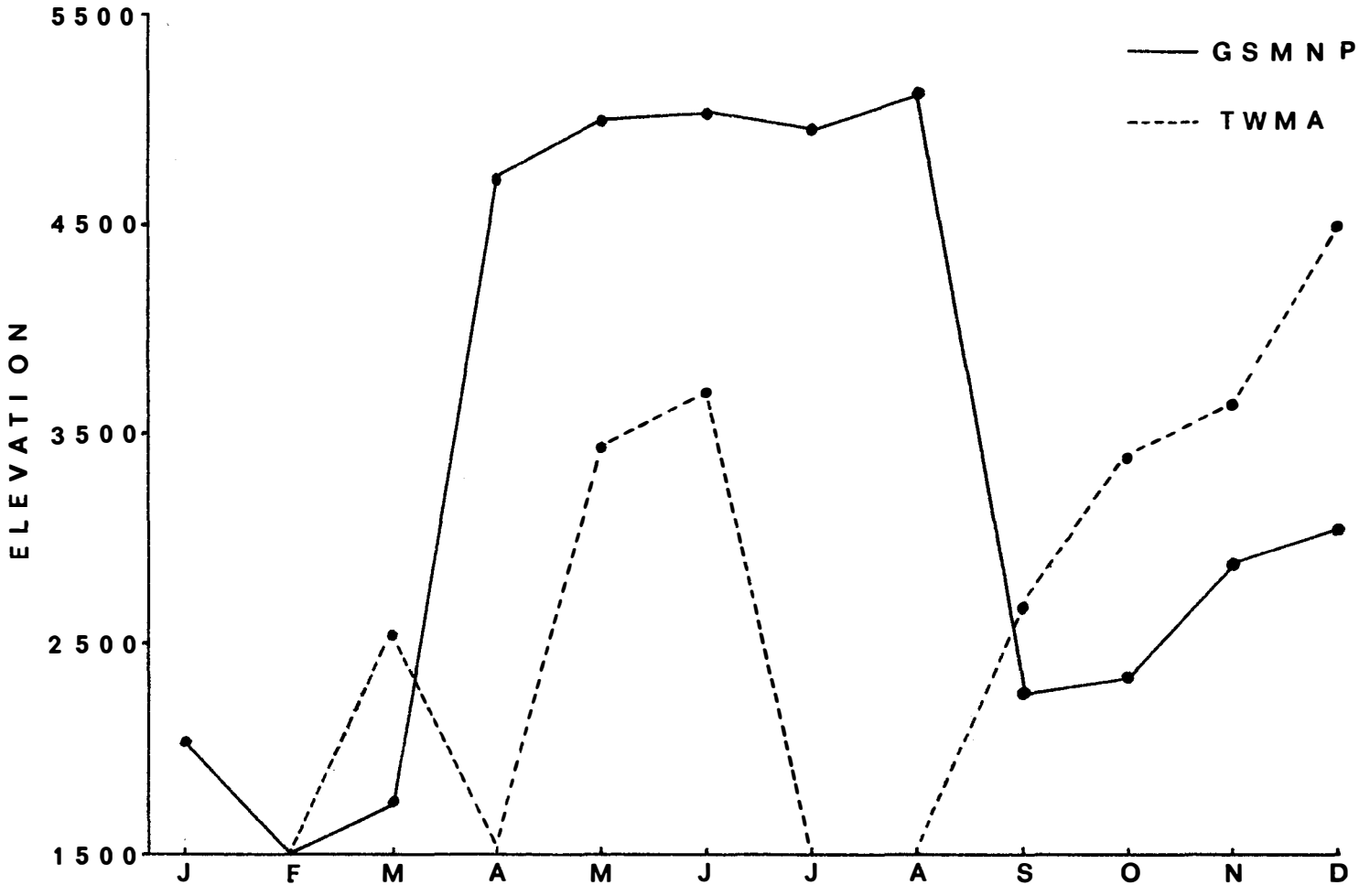

Figure 7. The monthly mean elevations for wallowing in the Great Smoky Mountains National Park and the Tellico Wildlife Management Area.

TABLE 15

NUMBER OF WALLOWS PER MILE BY ELEVATION CLASSES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

	GSMNP				TWMA			
Month	1500 2500	2500 3500	3500 4500	4500 5500	1500 2500	2500 3500	3500 4500	4500 5500
January	.03	.00	.00	.00	.00	.00	.00	.00
February	.00	.00	.00	.00	.00	.00	.00	.00
March	.04	.00	.00	.00	.40	.00	.18	.00
April	.00	.00	.00	.08	.00	.00	.00	.00
May	.00	.00	.00	.47	.00	.14	.11	.00
June	.00	.00	.00	.45	.00	.00	.09	.00
July	.00	.00	.00	.08	.00	.00	.00	.00
August	.00	.00	.00	.60	.00	.00	.00	.00
September	.05	.00	.00	.00	.08	.10	.00	.00
October	.14	.00	.00	.00	.00	.20	.09	.00
November	.00	.09	.00	.00	.00	.00	.09	.00
December	.05	.00	.12	.00	.00	.00	.18	.00
Overall	.03	.01	.01	.13	.04	.03	.06	.00

Monthly Occurrence of Wallowing by Vegetation Type

The number of wallowing observations per mile within vegetation types by months for the GSMNP and the TWMA are presented in Table 16. The only vegetation types in which wallows were observed were cove hardwoods and northern hardwoods. Wallows in the GSMNP were observed in northern hardwoods during April through August, and in cove hardwoods for the remaining months. Wallows in the TWMA were all located in cove hardwoods except for two wallows in December, which were located in northern hardwoods. The fact that wallows occurred only in cove hardwoods and northern hardwoods is probably because these two vegetation types occur on the more mesic sites.

TABLE 16

NUMBER OF WALLOWS PER MILE WITHIN VEGETATION TYPES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Month	GSMNP		TWMA	
	Cove Hdwd.	Northern Hdwd.	Cove Hdwd.	Northern Hdwd.
January	.05	.00	.00	.00
February	.00	.00	.00	.00
March	.04	.00	.31	.00
April	.00	.10	.00	.00
May	.00	.49	.14	.00
June	.00	.59	.04	.00
July	.00	.10	.00	.00
August	.00	.78	.00	.00
September	.06	.00	.09	.00
October	.16	.00	.13	.00
November	.06	.00	.04	.00
December	.12	.00	.00	2.22
Overall	.04	.17	.06	.20

CHAPTER V

SUMMARY

The rooting and wallowing habits of the European wild hog (Sus scrofa) in the mountains of East Tennessee were studied from April, 1971, through March, 1972. The major objectives of this study were: to determine the seasonal, elevational, and vegetational locations of European wild hog rooting and wallowing sites; and to determine the extent of rooting and wallowing activity by the European wild hog.

The research for this study was conducted in the Great Smoky Mountains National Park (GSMNP) and in the Tellico Wildlife Management Area (TWMA). These two areas are located in the Unaka Mountain Range on the common border between Tennessee and North Carolina. They contain a range in elevation from 888 feet to 6,643 feet. They also contain a variety of vegetation types.

The monthly occurrence and extent of European wild hog rooting and wallowing at different elevations and in different vegetation types were studied along established trails, cross-country trails, and roads in three watersheds in the GSMNP (65.7 miles) and in three watersheds in the TWMA (34.4 miles).

European wild hogs root mainly under the litter layer and down into the soil about one inch. This rooting occurs in a variety of situations, but is mainly in wet areas, and areas under leaves, rotten wood, and rocks.

Although it is difficult to determine why European wild hogs are rooting in certain situations, several food items appeared to be probable reasons for rooting. These food items include salamanders and aquatic invertebrates, insects and grubs, millipedes, earthworms, snails, acorns, hickory nuts, grapes, vegetation, and roots.

European wild hog rooting and wallowing occurs at the higher elevations in the warmer months and at the lower elevations in the cooler months. This altitudinal movement of European wild hogs appeared to be a thermoregulatory response to increasing temperature.

The vegetational location of European wild hog rooting appeared to be related to the elevational movement in response to increasing temperature, to food availability, and to the peaks in farrowing activity. European wild hog rooting was found most commonly in the cove hardwood type during the spring months, in the northern hardwood type during the warmer spring and summer months, and in the closed oak type during the fall and winter months when oak mast was on the ground. The extent of rooting (REI) in the hemlock and open oak and pine types was greatest during December to June, which is the period of the reported peaks in the farrowing activity.

The vegetational occurrence of European wild hog wallows appeared to be related to the elevational movement, and to the more mesic site conditions of cove hardwoods and northern hardwoods. Wallows were observed in the cove hardwood type during the cooler months and in the northern hardwood type during the warmer months.

The monthly REI appeared to be determined by the average monthly temperature, food availability, and a European wild hog

control program in the GSMNP at the lower elevations. At the higher elevations, the monthly REI appeared to be determined by the average monthly temperature and the extent of the elevational range.

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APPENDIXES

APPENDIX A

OTHER EUROPEAN WILD HOG OBSERVATIONS

TABLE 17

NUMBER OF TUSKED TREES PER MILE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Month	GSMNP	TWMA
January	.02	.00
February	.06	.09
March	.00	.23
April	.05	.00
May	.04	.04
June	.00	.14
July	.00	.00
August	.00	.00
September	.00	.00
October	.02	.00
November	.15	.00
December	.07	.44
Overall	.03	.08

TABLE 18

EUROPEAN WILD HOG OBSERVATIONS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Date	GSMNP Observation	Date	TWMA Observation
April 29	One adult	March 16	One adult
May 19	Two juveniles	May 31	One adult
May 28	One adult, two juveniles, and three piglets	June 8	Two adults
		July 15	One adult
July 23	One adult	December 8	One adult, and three juveniles
August 16	One adult, three juveniles, and two piglets	December 14	One adult, and three juveniles

APPENDIX B

OTHER WILDLIFE OBSERVATIONS

TABLE 19

NUMBER OF GROUSE OBSERVATIONS PER MILE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

	GSMNP			TWMA		
Month	Number Flushed	Number Drumming	Number w/Chicks	Number Flushed	Number Drumming	Number w/Chicks
January	.16	.02	.00	.12	.00	.00
February	.23	.00	.00	.09	.00	.00
March	.24	.12	.00	.32	.06	.00
April	.22	.05	.00	.70	.19	.00
May	.08	.04	.02	.08	.00	.04
June	.04	.02	.00	.17	.03	.00
July	.00	.00	.00	.26	.00	.00
August	.03	.00	.02	.09	.00	.00
September	.25	.02	.00	.14	.00	.00
October	.34	.10	.00	.35	.12	.00
November	.17	.06	.00	.14	.03	.00
December	.13	.02	.00	.23	.03	.00
Overall	.16	.04	.00	.21	.03	.00

TABLE 20

NUMBER OF BEAR SCAT AND BEAR OBSERVATIONS PER MILE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Month	GSMNP		TWMA	
	Bear Scat	Bear Observations	Bear Scat	Bear Observations
January	.18	.00	.12	.00
February	.00	.00	.00	.00
March	.00	.00	.00	.00
April	.03	.00	.00	.00
May	.40	.00	.32	.00
June	.24	.04	.41	.00
July	.21	.02	.03	.00
August	.55	.02	.12	.00
September	.77	.08	.17	.00
October	.16	.02	.55	.00
November	.10	.00	.32	.00
December	.07	.00	.32	.00
Overall	.19	.01	.19	.00

TABLE 21

NUMBER OF DEER OBSERVATIONS PER MILE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Month	GSMNP	TWMA
January	.00	.00
February	.00	.03
March	.05	.00
April	.08	.00
May	.02	.00
June	.02	.00
July	.04	.00
August	.02	.00
September	.10	.00
October	.11	.00
November	.04	.06
December	.02	.12
Overall	.04	.02

TABLE 22

NUMBER OF GRAY SQUIRREL OBSERVATIONS PER MILE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Month	GSMNP		TWMA	
	Squirrels Seen	Squirrels Barking	Squirrels Seen	Squirrels Barking
January	.00	.00	.03	.00
February	.06	.00	.03	.00
March	.10	.08	.03	.03
April	.00	.00	.00	.00
May	.00	.00	.00	.00
June	.00	.00	.12	.00
July	.02	.00	.00	.00
August	.02	.00	.00	.00
September	.00	.00	.00	.00
October	.00	.03	.12	.03
November	.00	.00	.09	.00
December	.10	.00	.00	.00
Overall	.02	.01	.04	.01

TABLE 23

MISCELLANEOUS WILDLIFE OBSERVATIONS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE TELLICO WILDLIFE MANAGEMENT AREA

Area	Species	J	F	M	A	M	J	J	A	S	O	N	D	Total
GSMNP	Chipmunks	15	1	1						1	5	1	1	25
	Rabbits					1	1							2
	Bobcats				1									1
	Bats											1		1
	Hawks	1	1		3				2		1			8
	Woodcocks				1		2							3
	Poisonous snakes					1		1	1					3
	Non-poisonous snakes			1			1		1		1			4
TWMA	Chipmunks		1	7			6		1	1	9	5	1	31
	Skunks				2									2
	Groundhogs					1		1	1	1				4
	Racoons						1							1
	Hawks			1				1	1	1	1			5
	Box turtles					1	1	2	2					6
	Snapping turtles							1						1
	Poisonous snakes							1						1
	Non-poisonous snakes					1			4					5

VITA

Robert Christopher Belden was born in Knoxville, Tennessee, on March 1, 1947. He attended elementary school in Knoxville and was graduated from Young High School in 1965. In June, 1965, he entered The University of Tennessee and received the degree of Bachelor of Science in Forestry in June, 1970.

In June of 1970, he accepted a position as Graduate Research Assistant in the Department of Forestry, The University of Tennessee and began study toward a Master of Science degree in Wildlife Management. He received this degree in August, 1972. He is a member of Xi Sigma Pi, national forestry honorary. He is married to the former Patricia Ann Horner of Knoxville, Tennessee.