

SEASONAL FOOD HABITS OF THE EUROPEAN WILD HOG IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

by

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ABSTRACT

Information on seasonal food habits of the European wild hog (*Sus scrofa*) was obtained by analyses of stomach contents of 128 animals collected in the Great Smoky Mountains National Park from 1971 to 1973. Hogs ate primarily plant material in all seasons. Grasses (Gramineae) were the most important food item in the spring and were also important to hogs in the summer, as were the fruits *Gaylussacia* spp., and *Malus* spp. Roots were the major food item in the fall and winter months, although the mast of *Quercus* spp. and *Carya* spp. was important when available. Animal matter consumed consisted primarily of invertebrates, salamanders and small mammals. Invertebrates were the most frequently occurring animal food. Total volume of animal matter was small. However, the apparent more than random searching for animal matter indicates the possible importance of these higher protein food sources in the diet of hogs. An evaluation of rooting sites supplemented the stomach analyses in determining some foods eaten. Such evaluations were highly subjective, however, and the delineation of specific food items was difficult. Outer roots tissue of *Pinus* spp. contributed to the diet of hogs, but this food source alone is apparently not adequate for both maintenance and reproduction. Increased rooting, which may result in extensive disturbance to various important wild flower habitats, may be associated with years of mast scarcity.

INTRODUCTION

The European wild hog (*Sus scrofa*) was introduced into the Southern Appalachian Mountains in 1912 (Jones 1959). Since its introduction, this exotic has established populations in the Great Smoky Mountains National Park and adjacent areas. There is growing concern over the possible detrimental effects the animal may have on the natural habitats of the Park. The European wild hog's presence is not in keeping with the National Park Service policy of maintaining native flora and fauna in their natural state. Therefore, control efforts began in 1959 to greatly reduce or eventually eliminate the wild hogs from the Park. More data are needed on movements, home range, food habits, reproduction and other factors in order to successfully control European wild hogs.

Food habits research on this species in the Southern Appalachians has been limited to general observations on feeding habits (Jones 1959, Stegeman 1938, Belden 1972), studies of hog predation on groundnesting birds (Matschke 1965, Henry 1969) and a fall (October-November) food habits study conducted on the adjacent Tellico Wildlife Management Area in Monroe County, Tennessee (Henry and Conley 1972). This study represents the first year-round food habits study of this species in the Southeast.

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MATERIALS AND METHODS

The Great Smoky Mountains National Park is located along the Tennessee-North Carolina border, extending in a general northeasterly direction. The area contains 2,072 km² of mountainous terrain located in Blount, Sevier and Cocke counties in Tennessee and Swain and Haywood counties in North Carolina. This study was conducted on the Tennessee side and southwestern portion of the Park.

The Park is part of the Unaka Mountain Range section of the Blue Ridge Province, located in the southern division of the Appalachian Highlands (Fenneman 1938). The topography of the area is characterized by high mountains and narrow ridges separated by steep-sloped, V-shaped valleys.

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Numerous swift-flowing streams are present over the entire area. Small cove sites, characterized by relatively flat topography are also present in the area. Elevations in the Park range from 271 m above sea level to 2,026 m on Clingmans Dome, the second highest point in the Eastern United States.

The climate of the Park 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 5.5 to 9.0°C cooler than those of the lower elevations, with an average rate of 1.24°C decrease in temperature for every 305 m rise in elevation. Precipitation averages 137 cm per year at the lower elevations, and 216 cm per year at Clingmans Dome.

The Park is a densely forested area of complex vegetation patterns. Most of the vegetation is either topographic climax or secondary succession, as primary succession is nearly completed over much of the area. Shanks (1954) categorized the vegetation into six relatively distinct physiognomic types on the basis of the sites occupied and differences in minor vegetation. These six vegetation types include cove hardwood forests, hemlock forests, northern hardwood forests, spruce-fir forests, closed oak forests, open oak and pine stands — heath balds. For the purposes of this study, grassy balds and fields were considered as separate vegetation types.

Cove hardwood forests occur in sheltered, deep-soiled coves below 1,373 m elevation. The hemlock forests occupy sheltered topography along streams to 915 m and to a lesser extent on exposed slopes and lead ridges to 1,373 m. The northern hardwood forest type is typically restricted to the heads of coves, in gaps, and other mesic sites above 1,373 m. The spruce-fir forest type also occurs above 1,373 m and is dominated by fir above 1,830 m. Closed oak forests are characteristic of intermediate to dry slopes at low and middle elevations. The open oak and pine forest type occurs on steep, exposed slopes and ridges with shallow, rocky soils. Heath and grassy balds occur on exposed sites above 1,220 m.

Important mast-producing species include white oak (*Quercus alba*), post oak (*Q. stellata*), chestnut oak (*Q. prinus*), yellow oak (*Q. muhlenbergii*), northern red oak (*Q. rubra*), black oak (*Q. velutina*) and scarlet oak (*Q. coccinea*). Important hickories present on the area are shagbark (*Carya ovata*), mockernut (*C. tomentosa*), pignut (*C. glabra*) and bitternut (*C. cordiformis*). Other important mast-producing species occurring on the study area include beech (*Fagus grandifolia*), yellow buckeye (*Aesculus octandra*) and black walnut (*Juglans nigra*).

European wild hogs were collected from September 1971 to May 1973 by a combination of live-trapping and hunting. Semi-portable box traps described by Williamson and Pelton (1971) were used, as were permanent trap structures (Fox 1972). Shelled corn was used exclusively as bait. 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 wherever hog activity was noted.

Whole stomachs were collected and most were preserved by freezing; a few, however, were preserved in a 10 percent formalin solution.

The total volume of the stomach contents was measured in graduated beakers and a homogeneous 900cc sample was analyzed. The entire contents of stomachs containing less than 900cc of food was analyzed. The volume of corn in stomachs taken from trapped animals was measured and used in 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 (2.00mm, 0.85mm, and 0.42mm) to segregate identifiable items and remove very fine unidentifiable particles. Food items were identified macroscopically and with the use of a variable power dissecting microscope. Volumes below 0.1cc were recorded as trace (tr). The remaining finely masticated material was apportioned by ocular estimate and on the basis of the measured volumes of identified items (Korschgen 1962). The loss of diagnostic characters due to thorough mastication of some items made specific identification impractical 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 of occurrence (in percent) of all food items was calculated seasonally.

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

RESULTS AND DISCUSSION

A total of 128 European wild hogs was collected from September 1971 to May 1973; 66 were males and 62 were females. The age ratio was 73 adults to 55 juveniles, separated on the basis of tooth

eruption (Matschke 1967). Foods eaten by hogs did not appear to differ between sexes or between adults and juveniles. Plant materials comprised 99.1 percent of the total volume of foods consumed during the study period, and animal matter comprised 0.3 percent (Table 1). Roots were the major plant food consumed (44.3 percent by volume) during the study period (Fig. 1). Root consumption by hogs increased in volume from spring to the fall and winter. Consumption of leaves and stems was greatest in the spring (62.2 percent by volume) and decreased to the smallest amounts in the winter (7.3 percent). Acorns, hickory nuts and other mast comprised the major volume of fruits and seeds recorded for the winter season.

Table 1. Seasonal food items of European wild hogs in the Great Smoky Mountains National Park, 1971-1973, by percentage of total volume and occurrence.

<i>Food Item</i>	<i>Spring</i> (30) ^a	<i>Summer</i> (14)	<i>Fall</i> (48)	<i>Winter</i> (36)	<i>Total</i> (128)
VEGETABLE					
Mainly Roots					
Roots	0.2 ^b	11.4	62.2	61.6	44.3
	26.7	64.3	79.2	75.0	64.1
Unidentified tubers	—	3.1	—	tr	0.4
	—	21.4	—	2.8	3.1
Mainly Leaves and Stems					
Gramineae	61.1	25.3	11.1	7.3	20.7
	86.7	71.4	50.0	55.6	62.5
Unidentified green vegetation	15.7	12.9	5.8	2.8	7.3
	40.0	57.1	27.1	38.9	36.7
<i>Vaccinium</i> spp.	0.8	5.5	—	—	0.8
	6.7	14.3	—	—	3.1
Dried vegetation	0.8	2.6	0.3	0.5	0.8
	46.7	64.3	50.0	52.8	51.6
<i>Liriodendron tulipifera</i>	0.8	—	—	—	0.2
	10.0	—	—	—	2.3
<i>Trifolium</i> spp.	0.8	—	—	tr	0.2
	10.0	—	—	2.8	3.1
<i>Viola</i> spp.	tr	—	—	—	tr
	3.3	—	—	—	0.8
<i>Pinus</i> spp.	—	—	tr	tr	tr
	—	—	2.1	2.8	1.6
<i>Tsuga canadensis</i>	tr	—	tr	tr	tr
	3.3	—	2.1	5.6	1.6
Mainly Fruits and Seeds					
<i>Quercus</i> spp.	15.6	—	16.1	22.8	16.6
	36.7	—	20.8	33.3	25.8
<i>Malus</i> spp.	—	25.3	—	—	3.1
	—	14.3	—	—	1.6

<i>Food Item</i>	<i>Spring (30)^a</i>	<i>Summer (14)</i>	<i>Fall (48)</i>	<i>Winter (36)</i>	<i>Total (128)</i>
<i>Carya</i> spp.	3.0 13.3	— —	2.4 18.8	1.9 16.7	2.1 14.8
<i>Gaylussacia</i> spp.	— —	7.6 14.3	— —	— —	0.9 1.6
<i>Vaccinium</i> spp.	— —	6.1 14.3	— —	— —	0.7 1.6
<i>Juglans nigra</i>	tr 6.7	— —	0.4 2.1	0.6 8.3	0.4 4.7
<i>Vitis</i> spp.	— —	— —	— —	0.4 2.8	0.2 0.8
<i>Liriodendron tulipifera</i>	— —	— —	0.5 4.2	— —	0.2 1.6
<i>Amaranthus blitoides</i>	0.8 3.3	— —	— —	— —	0.2 0.8
<i>Pyrularia pubera</i>	— —	— —	tr 2.1	— —	tr 0.8
<i>Prunus</i> spp.	— —	tr 7.1	— —	— —	tr 0.8
Gramineae	— —	— —	tr 2.1	tr 5.6	tr 2.3
<i>Ilex opaca</i>	— —	tr 7.1	— —	— —	tr 0.8
Unidentified seeds	— —	— —	tr 2.1	tr 2.8	tr 1.6
Subtotal	99.6	99.8	98.8	97.9	99.1
ANIMAL					
Invertebrates	tr 30.0	tr 64.3	0.3 52.1	0.2 72.2	0.2 52.3
Vertebrates	tr 16.7	tr 14.3	0.2 20.8	0.2 36.1	tr 23.4
Unidentified animal	0.1 20.0	tr 14.3	0.1 14.6	0.1 2.8	0.1 15.6
Subtotal	0.1	tr	0.6	0.5	0.3

<i>Food Item</i>	<i>Spring (30)^a</i>	<i>Summer (14)</i>	<i>Fall (48)</i>	<i>Winter (36)</i>	<i>Total (128)</i>
OTHER					
Gravel	tr 10.0	— —	tr 4.2	tr 2.8	tr 4.7
Garbage	— —	tr 7.1	— —	tr 2.8	tr 1.6
Unidentified Material	— —	— —	0.6 2.1	0.2 13.9	0.2 4.7
Total	99.7	99.8	100.0	98.6	99.6

^a Sample size.

^b Percentage of total volume is above the line, and relative percentage frequency of occurrence is below the line.

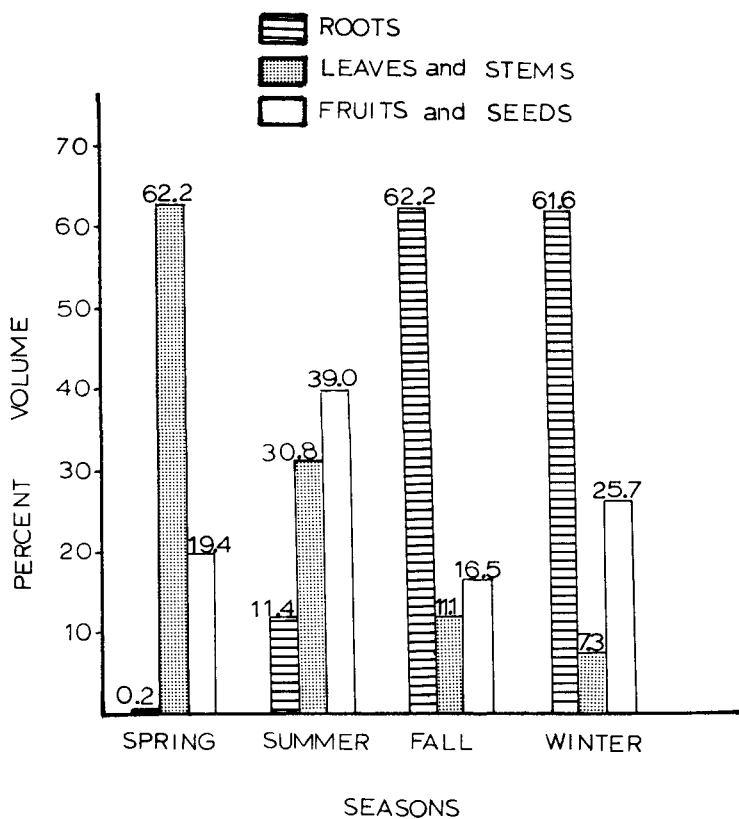


Figure 1. Seasonal trends in consumption of plant materials by European wild hogs in the Great Smoky Mountains National Park, 1971-1973.

Animal foods were consumed in all seasons, but amounted to only a minor portion (0.3 percent) of the total volume of foods eaten by hogs (Table 1). Invertebrates occurred in 52.3 percent of the stomachs examined, although the percentage of total volume was small (0.2 percent). There was no apparent seasonal trend in consumption of invertebrates. Earthworms were often more difficult to detect than other invertebrates consumed because of mastication and digestion, and their importance as food may not have been sufficiently determined by analyses of stomach contents. Centipedes (Chilopoda) and the larval stages of Coleoptera and Diptera were the invertebrates most commonly found in all seasons. The low volume of animal foods found in this study suggests that the importance of these foods may have been overestimated by previous researchers. However, it is possible that animal material is more rapidly digested than plant material. Our field observations indicate that hogs do occasionally search for animal foods, especially some kinds of invertebrates. Salamander remains were observed in five stomachs, and snake remains occurred in one stomach. Bird remains were found in two stomachs; mammal remains also occurred in six stomachs in addition to unidentified animal matter, possibly carrion. No evidence of predation on the nests of ground-nesting birds was found during the study period. Henry (1969) concluded that the European wild hog is a minor nest predator.

Spring Diet

Grasses (*Gramineae*) were the major food item for the spring (March-May) season, comprising 61.1 percent by total volume. Field observations indicated an increase in feeding in pastures in April 1973. Pastures in which feeding was observed contained mostly fescue (*Festuca* spp.), orchard grass (*Dactylis glomerata*) and/or clover (*Trifolium* spp.). Grasses are common but not always abundant in the Park. Pastured areas are rare, although old home sites, trail sides and grassy balds contain grasses. Grasses were found in a relatively large proportion of the total volume of foods found in two stomachs collected in May above 1,373 m. However, no evidence was found of hogs feeding on mountain oat grass (*Danthonia compressa*), which is common on several of the grassy balds at higher elevations. Pine and Gerdes (1973) reported that grasses were an important food item for wild pigs in the spring and summer in California.

Roots were consumed in the least amounts by volume during spring, comprising only 0.2 percent of the total volume of foods eaten. Some oak and hickory mast was still available at this time (Table 1).

Summer Diet

Grass consumption declined during the summer months. The percent volume and frequency of occurrence of roots consumed increased in the summer (June-August) (Table 1). The small amount of tuberous roots observed in the stomach contents may be misleading, since these foods were finely masticated in most cases, and could not be consistently identified. However, field observations at this season indicated that hogs were utilizing the tubers of several understory plants, including yellow adder's-tongue (*Erythronium americanum*) and spring-beauty (*Claytonia virginica*), two common species in the northern hardwood forest type.

Belden (1972) noted a general upward shift in elevation of hog activity during the early summer. Hogs moving up into the narrow band of northern hardwood forest (1,370 m) are thus more concentrated and rooting activities become more noticeable. A reason for such movements may be the increased availability of food at these elevations. Blueberries (*Vaccinium* spp.) and huckleberries (*Gaylussacia* spp.) are available at higher elevations, particularly on some of the grassy balds where they are juxtaposed to the northern hardwoods. Examination of the stomach contents of two hogs collected in the vicinity of Gregory Bald (1,649 m) in late summer indicated almost exclusive feeding on the fruits of these species.

Hog activity increased in late summer at the lower elevations, particularly 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 despite frequent harassment. It is likely that hogs will also concentrate in old orchards or home sites where apple trees persist.

Fall Diet

Roots were the major food item consumed by hogs in the fall (September-November). Grass consumption was less than in spring and summer, although grasses occurred in 50.0 percent of the stomachs examined (Table 1). Oak and hickory mast began to first appear in the stomach contents in October. These two foods comprised 18.5 percent of the total volume of fall foods. Henry and Conley (1972) found that oak mast accounted for 47.6 percent of the total volume of foods consumed by hogs

during October and November on the Tellico Wildlife Management Area (Monroe County, Tennessee). During the present study, consumption of oak mast during the fall and winter of 1971-72 was significantly greater than during a comparable period in 1972-73. Root consumption increased during the 1972-73 period of fair to low mast production over the proportion of roots consumed during the 1971-72 year of higher mast production (Fig. 2). Oak mast production indices for the Tellico Wildlife Management Area show the 1972 season is rated only a "fair" year (Tennessee Game and Fish Commission 1972). Additional data for the Tellico Wildlife Management Area showed a 93.8 percent and a 97.3 percent decrease in the numbers of well-formed white and northern red oak acorns, respectively, from 1971 to 1972 (Minser unpublished data).

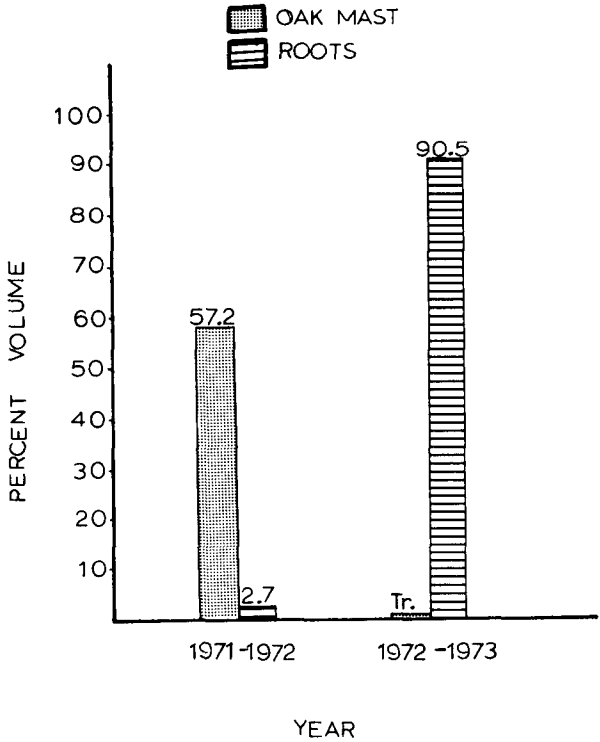


Figure 2. Utilization of oak mast and roots by European wild hogs in the Great Smoky Mountains National Park during the fall and winter, 1971-1973.

Winter Diet

Roots were the major food item eaten during the winter season (December-February), comprising 61.6 percent of the total volume of foods. Field observations indicated that hogs often fed on the outer covering of pitch pine (*Pinus rigida*) roots during the winter months, although the roots of Virginia pine (*P. virginiana*), white pine (*P. strobus*) and yellow poplar (*Liriodendron tulipifera*) were occasionally utilized. As indicated by the increase in consumption of roots during the "fair" year of mast production in 1972, roots of the above species are apparently important in the diet of hogs in years of low mast production. Observations of roots of *Pinus* spp., uprooted and stripped of outer tissues by hogs, were common during the 1972-73 winter months. It is likely that hogs prefer the phloem tissue of roots because the sap of this tissue contains 15-25 percent sucrose, more than 100 times the sucrose concentration in the xylem tissue (Huber 1958). The nutritive value of such food is apparently of a subsistence nature only and not enough for both maintenance and reproduction since

reproductive data collected in connection with this study also showed a positive relationship between reproductive failure and oak mast shortages. Low ovarian activity was noted for sows examined during the fall and winter of the year of low mast production, 1972-73 (Duncan 1974). Matschke (1964) also found that subsistence on energy deficient rations, as in years of shortages of oak mast, produced anestrus conditions in European wild hogs.

Field observations of the feeding activity of hogs provided some additional information on 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. Field observations alone are not adequate for accurate information on food habits since rooting may result in large disturbed areas with numerous plant species uprooted. However, a thorough examination of root sites during the present study indicated that hogs do eat certain tuberous roots. Evidence of feeding on wild yam (*Dioscorea* spp.), catbrier (*Smilax* spp.) and blackberry (*Rubus* spp.) was noted.

Rooting activity around certain species of plants indicated a more than random selection of these species. Rooting often appeared to be concentrated around white snakeroot (*Eupatorium rugosum*) and wood nettle (*Laportea canadensis*) at higher elevations in late summer. Christmas fern (*Poly-stichum acrostichoides*) was frequently uprooted by hogs in the winter and spring months.

Although the total volume of invertebrates in the stomachs was low, field observations indicate hogs may sometimes root for these animals. Hogs frequently overturned cattle manure piles in the pastured Cades Cove area (the only Park area where non-native fauna are permitted) during the winter months, apparently searching for earthworms or other invertebrates. This also may explain the rooting in shallow ditches, and in leaves and humus washed up along trails and roadsides. Occasional rooting by hogs in shallow stream beds may be attempts to obtain aquatic invertebrates, as suggested by the occurrence of aquatic diptera larvae of the family Tipulidae in several stomachs. Even though animal matter made up only 0.3 percent of the total volume of foods eaten, the apparent and more than random searching by hogs for such food emphasized the possible importance of such high protein foods in the diet of hogs.

European wild hog feeding activity may result in physical damage to certain areas of the Park. However, extensive rooting activity was not observed on the grassy balds in the study area during this investigation. Such activity did occur prior to the study and has occurred since with large areas of sod uprooted. Damage of this type was responsible for the initial realization by Park personnel that hog feeding activity might be detrimental to the Park ecosystem. Rooting occurred in some areas of the northern hardwood forests during both summers of the study period. This particular forest association is noted for the abundance and variety of herbaceous wild flowers in its understory. The initial disturbance to such sites by rooting is dramatic. However, long term effects have not been delineated. Rooting may result in significant alteration of species composition and local extinction of sensitive species (Bratton 1974). Visible signs of rooting may persist on grassy balds for months, reducing the aesthetic quality for Park visitors. Since hogs apparently root more in the fall and winter of years of low mast production, the availability of mast foods may affect the amount of visible rooting activity and concomitant disturbance to sites occupied by various wild flower species of importance to Park visitors.

Hog feeding activity poses additional problems in the Park. Possible habitat alteration of certain salamander populations which are more common in the Park than elsewhere is of concern to the National Park Service. Rooting and wallowing habits of hogs are another concern due to their possible detrimental effects on the native brook trout (*Salvelinus fontinalis*) populations through siltation and the possible contamination of water supplies.

The extent that the European wild hog competes with native wildlife species for food is not known. Results of this study indicate, however, that hogs may be competitive with the many species that utilize oak mast, particularly in years of low mast production. More detailed investigations of European wild hog ecology are needed to determine the extent of this species' impact on native vegetation and wildlife of the Great Smoky Mountains National Park and the Southern Appalachians.

^a Number of stomachs examined.

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