EUROPEAN WILD HOGS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Great Smoky Mountains National Park
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EUROPEAN WILD HOGS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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1. EUROPEAN WILD HOG GLOSSARY

boar - adult male swine; in this report specifically referred to as the European wild hog

sow - adult female swine

shoat - a young, weaned pig

feral hogs/wild pigs - descendants from domestic stock that was released, abandoned, or escaped (Bratton 1977)

wild hog - descendants from wild stock specifically introduced for hunting purposes (Bratton 1977)

wallowing - behavioral characteristics of hogs consisting of rolling about in mud and water to regulate body temperatures and rub off parasites

farrowing - period of pregnancy for hogs

mesic - moderately moist; having a balanced or intermediate supply of water

xeric - dry

mast - the fruit of oak, hickory, beech and other trees used as food by hogs and other animals; also hard mast

vernal flora - spring flora

aestival flora - summer flora

rhizomes - a rootlike subterranean stem, commonly horizontal, which usually produces roots below and sends up shoots progressively from the upper surface.

bulbs - a usually subterranean bud having fleshy leaves

tubers - a fleshy, usually oblong or rounded thickening or outgrowth, as the potato, of a subterranean stem or shoot

corms - enlarged fleshy bulblike base of a stem

phenology - influence of climate on the recurrence of annual phenomenon of animal and plant life.

2. IMPORTANCE OF EUROPEAN WILD HOGS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

A summer hike along the western crest of the Great Smoky Mountains National Park (GRSM) on the Appalachian Trail provides the best opportunity for seeing the European wild hog and the effect it is having on the ridgeline environment. Occasional hog wallows in the middle of the trail must be side-stepped, and in many areas the soil has been extensively turned over, giving the appearance of having just been tilled. These aesthetic impacts of the hog are obvious, but the effects on the natural ecosystem, its processes, communities, and species are less easy to determine.

Park officials first became concerned about the impacts of the wild hog on the ecosystem in 1958 when Gregory Bald and Parson Bald sustained severe rooting damage. Trapping and shooting of wild hogs by park rangers began in 1959 and 1960 in response to this damage. Since then, the population has continued to increase, with a corresponding increase in the extent of impacts. Visitor complaints about hog rooting damage have increased noticeably in just the last few years (GRSM 1978, 1983).

Scientific research on the park's wild hog population started in 1969, and the Uplands Field Research Laboratory focused a great deal of its efforts on the hog from 1975 until about 1981. Much was learned about the animal and its impacts on the park environment, and this report will summarize these results. All of the research helped lead to the development of an integrated wild hog management plan for the park in 1983. Like most major issues,

wild hog management in the park has been, and will probably continue to be, somewhat controversial. Nevertheless, the Park Service is charged to protect native plants and animals and, as an exotic species (non-native; no true swine are native to the New World) having negative impacts, the European wild hog is considered to be an undesirable resident in the park.

3. BACKGROUND INFORMATION - EUROPEAN WILD HOG

3.1 Origin

Unlike grassy balds, the origin of the European wild hog in the Southern Appalachian Mountains is known with greater certainty. The most commonly accepted version of the story begins with an English manufacturing company purchasing land in the Snowbird Mountains of Western North Carolina. In return for his services, an American advisor to the company, George Gordon Moore, was allowed to establish a private game preserve on the property. In April of 1912, ten sows and three boars completed the trip from Europe to Hooper Bald, North Carolina, where 600 acres had been enclosed for them. Other European game animals were brought over and put in an additional nearby enclosure. The hogs were left unmolested until 1920. At that time, Moore transferred the property rights to "Cotton" McGuire, his foreman, but McGuire was unable to keep the area as a preserve. As a parting gesture, McGuire arranged a hog hunt for some friends in that same year, 1920. It turned out to be a disaster. Several hunters barely escaped injury, many dogs were crippled, and only two hogs were

killed; about 100 escaped. The escapees adapted without any difficulty to their new environment. Hooper Bald is now part of the Nantahala National Forest and is less than 15 miles south of the border of GRSM as the crow flies (Tennessee Game and Fish Commission 1972).

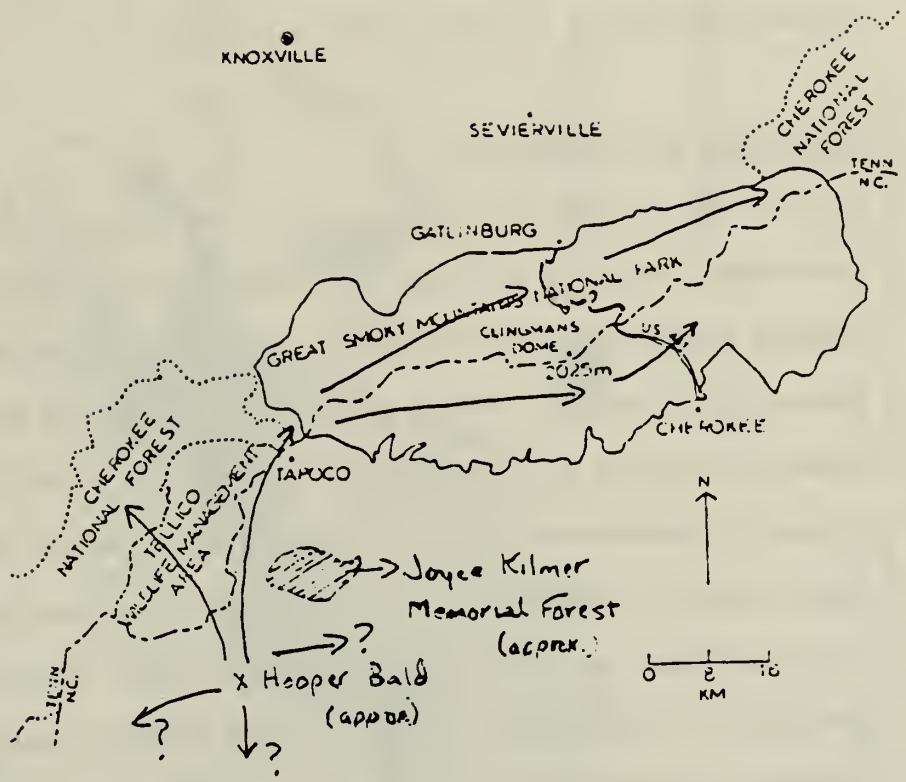
The European wild hogs were reputed to have come from Russia's Ural Mountains, and local settlers began to refer to them as "black Russians" or "rooshians". In fact, the Urals are beyond the original range of European wild hog, and those introduced here are probably of German or Polish extraction instead (Bratton 1977).

3.2 Geographical Distribution and Invasion of Great Smoky Mountains National Park

After its escape, the wild hog spread out from the Hooper Bald area and quickly became a popular game animal (see Figure 1). Dispersion was probably retarded somewhat by hunting in most areas, but in spreading north the animal reached the park. It was protected there and thus was able to increase its numbers and spread more easily through the park.

It was not until the 1940's or early 1950's that the hogs reached the southwestern corner of the park around Calderwood. Since then, the invasion of the hogs has proceeded from west to east. The population is now well established in all areas west of Newfound Gap Road. It is thought that the wild hog finally crossed Newfound Gap Road in 1972-73 and began settling the eastern half of the

Figure 1. Map of the Great Smoky Mountains National Park and vicinity.



(From Fox and Pelton 1977. An Evaluation of Control Techniques for the European Wild Hog in the Great Smoky Mountains National Park)

park. Populations in the east are scattered, but 3/4 of the park is now occupied to a significant extent (Fig. 2).

3.3 Other Wild Pig Populations

Wild pig populations are not unique to the Southern Appalachian mountains. They are found in 12 other NPS areas besides the Smokies in the states of Texas, Florida, South Carolina, Mississippi, Georgia, Hawaii and California (Singer 1981). Many of these are coastal plain areas, and populations arose from the escape or abandonment of the domestic stock of early settlers. Some, however, resulted from transplants of Southern Appalachian wild hog stocks to develop hunting populations. Feral pigs also persisted as free roaming animals in the Southern Appalachian mountains until this century, and the European wild hog, a more recent introduction specifically for hunting purposes (Bratton 1977), interbred with them early on. The current population is very much a mixed breed of domestic and wild stock. Domestic pigs and the Southern Appalachian European wild hog population probably have more genetic and behavioral similarities than differences (G. Wood 1983, pers. comm.). All NPS areas have stable populations of wild hog feral pigs, or crosses of the two, with the exception of GRSM, where expansion is still occurring.

3.4 Wild Hog Characteristics

Despite the mixed breeding noted above, many wild hog characteristics--long guard hairs, a mid-dorsal mane, split gray-

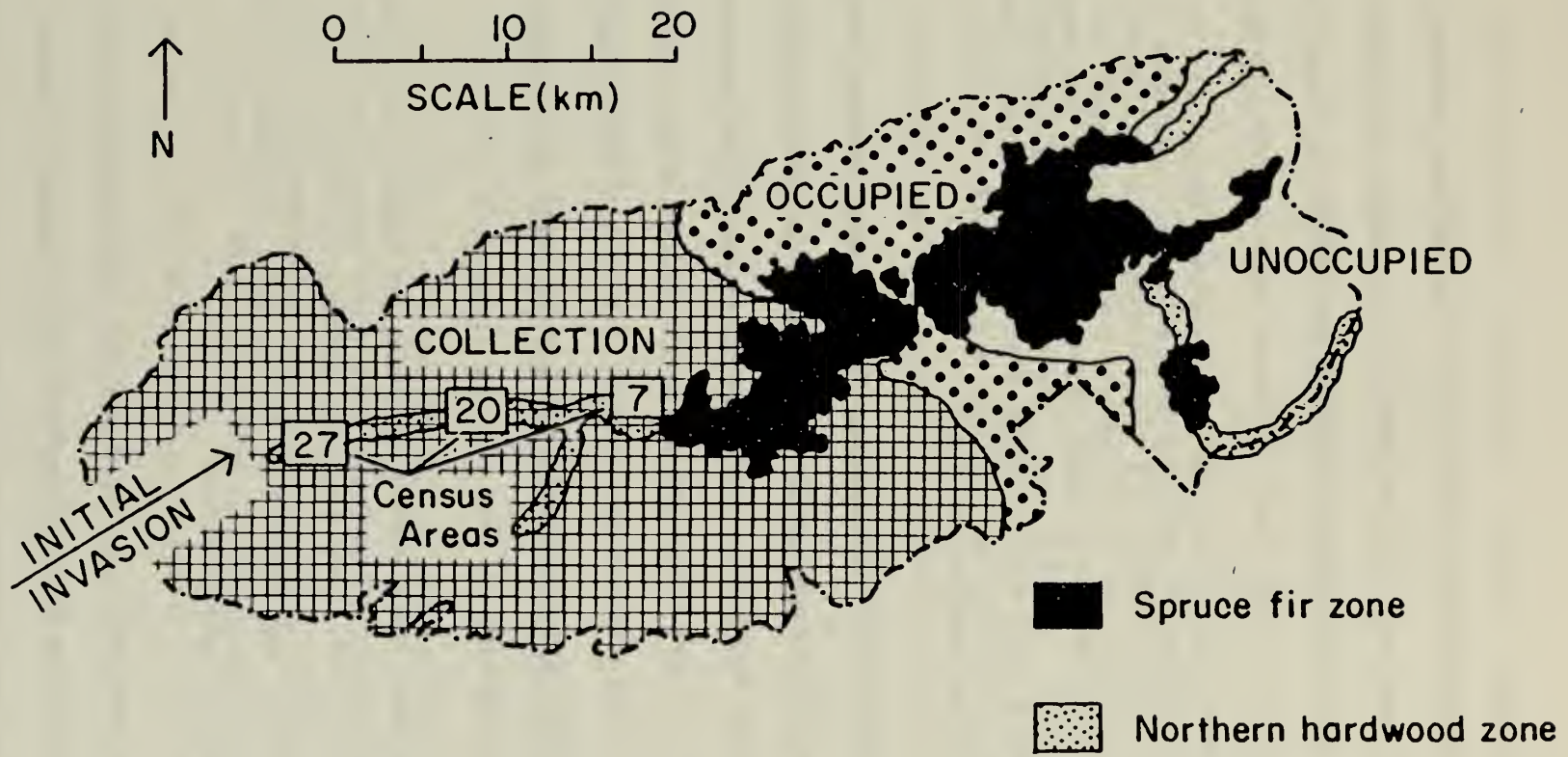


Figure 2. Map of Great Smoky Mountains National Park, showing collection area in the occupied western one-half of the park. Census areas occupied by wild hogs for 7, 20, and 27 year are indicated.

(From Singer and Ackerman 1981. Food Availability, Reproduction, and Condition of European wild hogs in Great Smoky Mountains National Park. SE Region Research/Resources Manage. Rep. 43)

brown hair tips, fewer teats, and longitudinally striped piglets--remained dominant. Piglet strips are usually gone by four months of age, with adult colors ranging from black to gray. Some have a white blaze on their snout, a characteristic probably held over from crosses with feral pigs. The maximum weight for the wild hog is close to 300 pounds, but the average adult is closer to 100 pounds. At birth, they weigh about 2 pounds and the average hog can expect a life span of about 8 years. (GRSM 1978, Tennessee Game and Fish Commission 1972).

Groups seen in the wild average 2-3 animals, usually a family unit. In Europe, wild hogs are known to travel in larger groups of several sows and young, called sounders. Possible explanations for the lack of these large groups in the United Stated include the lack of a well-defined rut period, the mild climate, and loss of social traits due to interbreeding with feral pigs (Singer and Coleman - no date).

Wild hogs have acute senses of smell and hearing, but their eyesight is poor. They are also largely nocturnal, intelligent, and secretive, and capable of moving great distances. They are seldom seen by park visitors.

They have reached as far as Cosby on the Tennessee side, but as yet the central ridge east of Newfound Gap (spruce-fir forest) and the Cataloochee area (see Figure 2) remain unpopulated. Isolated hogs have been in and out of Cataloochee, though over one hundred kilometers of preferred ridgeline habitat remain available in the

southeastern part of the park. Continued immigration of wild hogs into the park around Calderwood is probably small but still occurring. Water is no barrier. They have been seen swimming Fontana Lake (GRSM 1983; Singer and Ackerman 1981; Bratton 1974 and 1975).

Eventually, the wild hog is expected to occupy the entire park. The Blue Ridge Parkway and National Forest lands to the east can probably expect the hog to spread through them as well. The success of the hog in populating the park is attributed to the lack of hunting, the lack of natural predators, and the fact that they are habitat generalists. The Southern Appalachian region is also similar to their native range in Europe (GRSM 1983, Bratton 1975, Singer and Coleman - no date).

4. WILD HOG ECOLOGY

4.1 Population, Density, and Reproductive Characteristics

Determining the number of wild hogs in the park has been a difficult task for researchers, especially since the population can fluctuate dramatically with available food resources. To date, only rough estimates have been possible. Once the park is completely occupied (including Cataloochee), the population could exceed 2600 following good mast years and sink as low as 1400 following poor mast years. A 1981 estimate was 1500 hogs, and the recently released Wild Hog Management Plan for GRSM reported 1000-2000 individuals residing in the park (Singer and Ackerman 1981, National Park Service 1983).

The distribution of wild hogs throughout the park, however, is uneven. This is because of their seasonal migrations (see next section). Densities are highest along the high western ridgeline in the summer because of food availability. Many spring births occur in this area. High elevation densities in 1979 were around 7-9/km^2, among the highest in the world for the wild hog, and the western ridgeline was estimated to have a population of 1050±320 at that time. Low elevation densities of less than 2/km^2 were similar to locations just outside the park and in Europe. When feeding at night in preferred northern hardwood stands, densities can exceed 30/km^2. Densities were found to be greatest seven years after the initial occupation of an area, with stabilization of the population occurring 20-27 years after. Temporary population declines following invasion observed in other locales have not been observed in GRSM (Singer and Ackerman 1981, Howe et al 1979).

The rapid spread of the European wild hog through the park is due in part to its high reproductive potential. Sexual maturity is usually reached within a year of birth for both sexes, and when the food supply is adequate and the animals are healthy, it can be as early as 7-8 months of age. The average age of first conception for hogs in the park was found to occur at 16.7 months. The gestation period for the wild hog is not known with certainty but is estimated at 100-125 days. Average litter size in the park is about 4.8, and the usual range is between 3 and 8; the largest on record is 12. These larger litters are believed to be the result of mixed breeding with the feral pigs. There is also some evidence

suggesting lesser fertility and smaller litter size in younger and older sows (Howe and Bratton 1976, Tennessee Game and Fish Commission 1972, Singer and Ackerman 1981, National Park Service 1983).

While there is no distinct rutting season, two farrowing peaks have been detected--December-January and April-May. Births do occur year round, but they are least frequent from August to November. When food is abundant though, they can be almost continuous. In one study, 81% of females between 18 months and 6 years of age were either pregnant or lactating. Often, the females will build bush nests in which to give birth and suckle the young, which do not leave the nest until about six weeks of age. At 3-4 months, the piglets are weaned and independent of the sow, and family groups usually break up when the young reach sexual maturity. A characteristic not yet found to occur in wild hog populations surrounding the park is double breeding. It does occur in Europe. In GRSM, 3% of the sows were found to bear 2 surviving litters within one calendar year, further evidence of their reproductive potential. Some researchers suspect the actual double breeding rate may be even greater than this (Singer and Ackerman 1981; Tennessee Game and Fish Commission 1977; Singer et al. 1978; Singer et al. 1979; Wood 1983).

Reproduction is largely dependent on the available food supply. A separation of the sexes allows females to occupy prime habitat. Because of this, more gestating and lactating females will usually

be found along the high ridgeline where food resources are abundant. While reproduction is poor following a mast shortage, a rapid recovery of the population is possible because of the hogs' high reproductive rate (Tennessee Game and Fish Commission 1973; Singer et al. 1978; Singer and Ackerman 1981; Singer 1980).

4.2 Migration and Habitat Preference

Not surprisingly, wild hog movements, like those of other mammals, are largely a response to meeting their basic requirements for living--food, shelter, and especially for the hog, the regulation of body temperature--with a minimum expenditure of energy. Their migrations, home ranges, and daily activities are related to various habitat preferences which best meet these basic needs at different times of the year.

The migration of European wild hogs in GRSM is seasonal and altitudinal. In the spring, from late March through the middle of May, they move upward to the higher elevation ridgeline. Their return to lower elevations takes a shorter period of time, usually beginning around mid-August and finishing by early September. In either of these migrations, hogs will typically move anywhere between 5 and 10 kilometers in distance and 600 to 1100 meters in elevation. Piglets apparently learn this behavior from their mothers (Singer et al. 1979; Tipton and Otto 1979; Singer and Ackerman 1981; Singer et al. 1978).

This seasonal migratory pattern is related to the phenology of certain plant species. Hogs move upward in the spring to the gray beech forest and the northern hardwood forest because of their particularly appealing food resources. Gray beech forests have an especially rich herbaceous understory, and the hog migration upward takes advantage of emerging young plants. They feed on the foliage and subterranean plant parts, especially spring beauty corms, a favored root item. Cove hardwood forests are also used to some extent in summer, and all three forest types are occupied under a variety of moisture conditions and exposures, though mesic sites appear to be most desirable. The spruce-fir forest is not used much by wild hogs, since other habitats have more abundant food. However, in the hottest summer months, they will occupy it to a limited extent. Signs of hog activity (rooting and wallowing) in the spruce-fir forest are patchy and usually found along trails or under an occasional deciduous tree. Grassy balds are used by wild hogs each spring and summer to a limited extent, with some years sustaining worse rooting damage than others. Hogs prefer the upper elevation forests more than the grassy balds. Assessment of the impacts of the wild hog on grassy balds is only anecdotal, but visible rooting signs have been observed to persist for months (Ackerman et al. 1978; Tipton and Otto 1979; Howe et al. 1979; Beldon and Pelton 1975; Bratton 1974; Scott and Pelton 1975).

Downward movement at the end of the summer is to the oak and pine-oak forests to feed on the acorns as they drop. Warm, xeric, southwest-facing slopes are preferred as well as areas with a heath

understory for cover. These oak forest sites have greater solar radiation, less wind, and less snow cover, which makes meeting life requirements easier. Provided mast is abundant, warm bed sites and acorns are found in the same areas. During mast failures, migrations are more erratic, and hogs tend to move farther as well. In these acorn-poor years, valleys and draws with a tulip tree-silver bell overstory and northern aspects are occupied more often as the hogs leave the xeric, southwest oak-pine areas attempting to locate better food sources. In addition, the hogs will occupy old homesites and move to even lower elevation pastures where other foods are more available (Ackerman et al. 1978; Howe and Bratton 1976; Singer et al. 1979; Singer and Ackerman 1981; Tipton and Otto 1979).

Wild hog seasonal migrations are also thermoregulatory. A lack of sweat glands makes control of their internal body temperature difficult. Moving to higher and cooler areas at the hottest time of the year and to lower and warmer locales in winter helps them regulate body temperature more effectively to conserve energy (Beldon and Pelton 1976). Of course, in spite of these advantages (food and temperature regulations) to migration, some individuals remain at lower elevations through the summer, and in years of mast failure, some remain at higher elevations through the winter (Singer et al. 1979).

Wild hog invasions of new territory are sporadic in GRSM. The average linear rate of invasion is about 2.75 km/year, but the

major invasions follow mast shortages as the hogs move greater distances in search of food. Forays into the as-yet-unpopulated Cataloochee area by individuals in 1975 and 1979-80 followed such shortages. With their lack of sweat glands, hogs are better adapted for colder weather and have the capacity to invade colder and more mountainous terrain. There is a great deal of suitable habitat remaining in the Southern Appalachians for them to move into (Singer 1981).

4.3 Home Range and Daily Movement

With its biannual migration, the wild hog establishes summer and winter home ranges that are largely defined by food availability and temperature. Singer et al. (1979) found summer (3.67 km^2) and winter (3.10 km^2) home ranges to be comparable during good mast years. When mast was poor, winter ranges increased tremendously as the animals searched for food. Most mammals, however, will try to cut down their daily activities in cold weather as much as possible, and the wild hog is no exception. Poor mast years will result in an increase in daily activity that can cause a decline in health and eventual death as hogs try to cope with a negative energy balance.

Radio telemetry monitoring studies of the wild hog also revealed that male home ranges were slightly larger than female home ranges (3.46 km^2 versus 3.07 km^2). A female suckling piglet will reduce her home range substantially, to as little as 6% that of other females (Singer et al. 1979). Year to year occupation of the same

range by the same animal was noted, with departures from this pattern occurring generally in males during mast failure years. Apparently, no true homing instinct exists however, since, of the trapped animals relocated outside the park, only a few have returned (Matschke and Hardister 1965 and GRSM 1983).

Wild hogs show the greatest amount of daily activity within their home range from May to July. During the summer, this activity is primarily crepuscular and nocturnal, with a peak feeding time between 8:30 p.m. and 2:00 a.m. Typically, they will feed up to the northern hardwood forests in the early evening from the cove sites where they have spent the day, across the ridgeline, and down the same side back to the same bedding area. A circular or elliptical pattern is followed. Mid-day movements are usually between day beds and wallows. Wintertime activity is primarily during daylight hours and is minimized to help maintain a positive energy balance. In summer and during good mast winters, the straight linear distance moved by the hog within its home range is not great--0.5 km is the average. The amount of activity, of course, can be much greater than this (Ackerman et al. 1978; Tipton and Otto 1979; Singer et al. 1979).

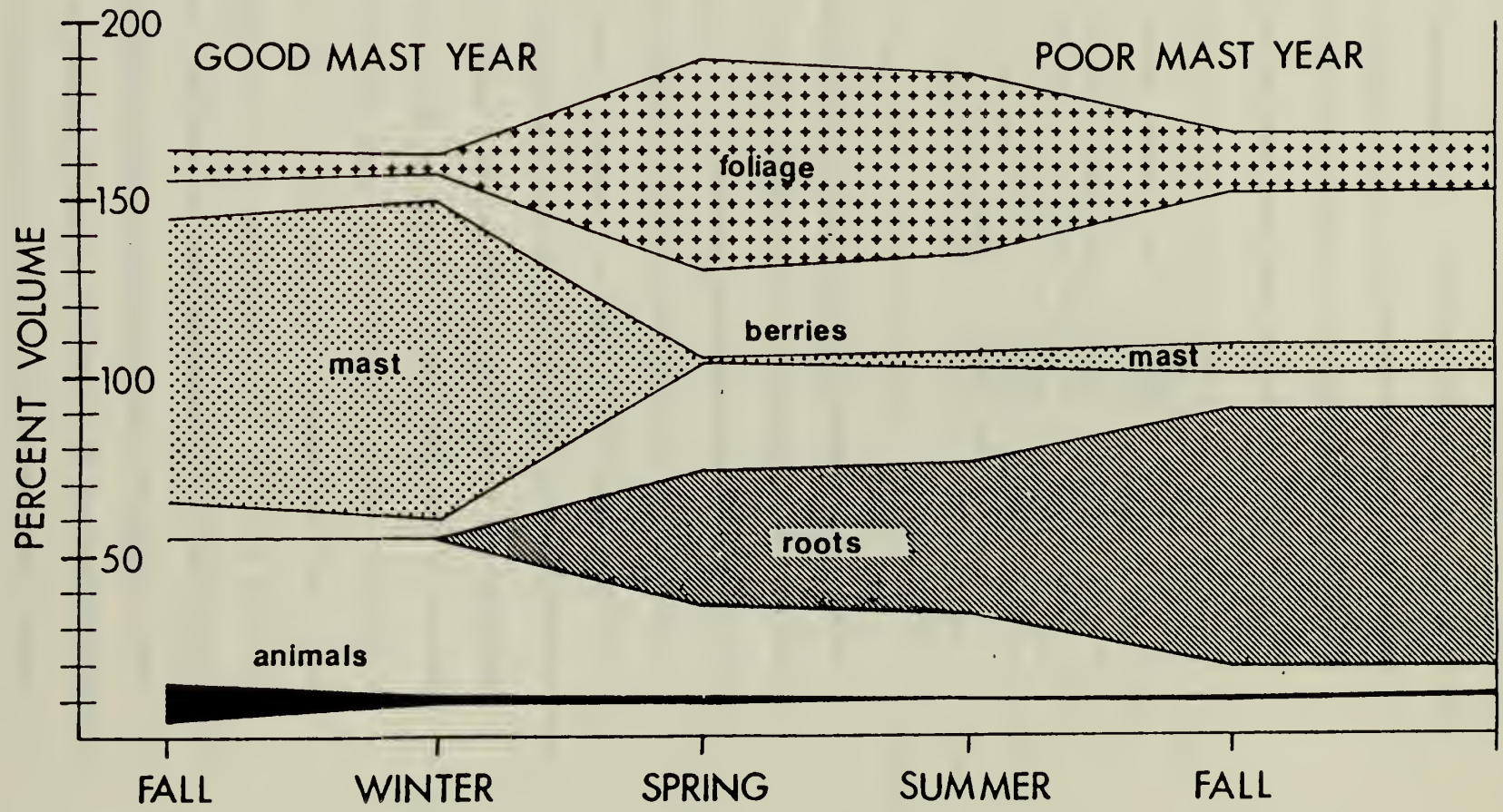
4.4 Food Habits

The European wild hog is an opportunistic and omnivorous feeder. Several scientific studies involved the dissection of hogs and a detailed analysis of stomach contents. No differences have been found in diets based on age or sex, but seasonal differences in

food items used were detected. The phenology of plant species also influences their selection of food at certain times of the year. The preference of hogs for certain foods also varies with the invasion gradient across the park from west to east. Western locations long occupied by hogs have been depleted of some food resources, and preferences have changed there. At the front of the invasion gradient, many of these same food resources are still abundant and still preferred (Bratton et al. 1982; Scott and Pelton 1974; Howe and Bratton 1976; Howe et al. 1979; Ackerman et al. 1978).

Figure 3 illustrates the seasonal change in wild hog food habits. When mast is abundant, it is the primary food source in fall and winter, with animals, foliage, and roots of minor importance. Mast is primarily the acorns of various oak trees (including husks to some extent) and hickory nuts. Unsound acorns are still ingested, as evidenced by boll weevils found in stomachs. Beech nuts are probably not an important food source. Sixty to eighty-five percent of the wild hog diet consists of hard mast when it is available. When the mast crop is poor, roots and tubers become the major fall and winter food items, with forage intake increasing somewhat as well. At these times, wild yam tubers (Dioscorea batata) and other roots may comprise 83%-91%, by volume, of the diet. Hogs will also turn often to the roots of pitch pine (Virginia pine, white pine, and tulip poplar to a lesser extent), probably because the sap of the phloem tissue has a high percentage

Figure 3. Major ingesta in wild hog stomachs during each of the four seasons combined for years 1976-78, GRSM.



(From T. D. Howe et al. 1979, Report for the Superintendent, Great Smoky Mountains National Park)

of sucrose (Howe et al. 1979; Ackerman et al. 1978; Scott and Pelton 1978; Singer and Ackerman 1981; Huff 1977).

In the spring, hogs feed primarily on green foliage (leaves and stems), with roots and tubers also of some importance. Spring beauty corms are by far the most important subterranean food source at this time. The rhizomes of trillium spp. and viola spp. are also quite popular, as are the tubers of the trout lily. Other plants whose various parts are eaten by the wild hog at various times of the year include great chickweed, white snakeroot, wood nettle, aster, and Turk's cap lily. Twenty-five species of herbs were noted by one author. Grasses are consumed year round but are most important to the diet in the spring; sedges are generally avoided. There is no evidence of feeding on mountain oat grass, the primary component of the grassy balds in the park. Some plants left untouched or seldom eaten include black cohosh, may apple, tree foliage, and all ferns but the silvery spleenwort (Howe et al. 1979; Ackerman et al. 1978; Scott and Pelton 1975).

During the summer months, roots (corms and tubers especially) get eaten a little more, and foliage a little less, than in the spring. The species, of course, change as the spring plants disappear and summer plants take hold. Blueberries and serviceberries are important diet components for a few weeks as they ripen and/or drop. At the lower elevations, fungi are occasionally eaten and apples are a favored item (Howe et al. 1979; Ackerman et al. 1978; Scott and Pelton 1975).

While the hog feeds primarily on plants throughout the year, numerous vertebrates and invertebrates are included in its diet. The creatures found have included earthworms, snails, walking sticks, helgrammites, adult and larval beetles, caterpillars, millipedes, centipedes, crayfish, fish, snakes, birds, bird eggs, mice, shrews, and salamanders. One study found animal matter to be only about 2% of the hog diet by volume, but it was found in 94% of all stomachs dissected. Some have suggested that high protein derived from animals may be important in their diet. There is no evidence of wild hog predation on ground nesting birds, but in a 1979 study, they were observed killing very young fawns on two occasions. Hog rooting in streambeds may be indicative of a search for aquatic insects also. Tables 1, 2, and 3 give an idea of some of the typical plants and animals ingested by wild hogs (Ackerman et al. 1978; Howe et al. 1979; Scott and Pelton 1975; Bratton et al. 1982).

4.5 Wallowing and Other Hog Behavior

The wallows made by the hogs are characteristically oval and located in muddy depressions of trails or small streams with slow moving water. Like migration up to the ridgeline, wallowing is a thermoregulatory mechanism attempting to compensate for heat load. It is also used to get rid of ectoparasites. There is no data on the continuing use of the same wallow by the same or different hogs over an extended period of time. A survey of hog wallows in GRSM and the Tellico Wildlife Management Area (Cherokee National Forest)

Table 1. Volumetric percentages in 47 stomachs of European wild hogs collected in northern hardwood forests, GRSM, Tennessee, spring - summer, 1977 - 1978.

Food Item	Years rooted 28 - 30 (n=17)	18 - 20 (n=19)	6 - 8 (n=11)	Mean (n=47)
HERBS				
Laportea canadensis	10.4	8.3	31.1	14.4
Stellaria pubera	8.6	12.4	1.7	8.6
Viola spp.	14.7	5.2	2.3	7.9
Aster divaricatus	1.5	14.0	0.6	6.4
Prenanthes altissima	6.2	2.8	0.8	3.6
Carex spp.	3.7	1.4	2.2	2.4
Rubus canadensis	0.4	1.5	3.6	1.6
Claytonia virginica	0.0	2.3	0.0	0.9
Disporum languinosum	0.0	0.0	3.2	0.8
Solidago curtissii	2.1	0.0	0.0	0.8
Trillium erectum	0.0	0.4	1.2	0.5
Others*	8.2	7.9	6.5	7.8
TOTAL HERBS	54.6	57.0	53.4	55.3
ROOTS				
Claytonia virginica	30.3	38.3	27.7	32.9
Trillium erectum	0.7	1.2	7.0	2.4
Erythronium americanum	0.2	1.0	6.2	2.0
Viola spp.	0.9	0.1	3.1	1.1
Others*	4.6	0.1	0.6	1.9
TOTAL ROOTS	36.9	40.7	44.9	40.2
FRUIT				
Vaccinium spp.	4.5	0.1	0.0	1.6
Amelanchier laevis	2.6	0.5	1.0	1.4
TOTAL FRUITS	7.1	0.6	1.1	3.1
INVERTEBRATES	1.4	1.3	0.3	1.1
VERTEBRATES	0.1	1.0	0.1	0.5

*Includes unknowns and others contributing < 1% to all diets.

(from Howe et al. 1979)

Table 2. Diet of European wild hogs in low elevations of Great Smoky Mountains National Park, 1977-1978, in percentage volumes.

Food Item	Fall (n=5)	Winter (n=5)	Spring (n=9)	Summer (n=10)
GRASSES	2.8	4.7	27.1	10.2
GREEN VEGETATION				
Laportea			0.5	
Trifolium			3.1	0.3
Liriodendron			3.0	
Viola			10.4	7.5
Plantago			2.6	6.7
Stellaria media				2.4
Taraxacum			0.4	0.8
Prenanthes			2.0	
Aster divaricatus			Trace	0.2
Smilax herbacea			0.4	
Unknown			7.4	6.3
ROOTS	Trace	Trace		
Viola			9.0	17.7
Apros			1.1	5.6
Unknown			4.9	9.7
FRUIT				
Quercus	77.7	89.5	13.5	
Rubus			Trace	
Gaylussacia			6.2	
Vaccinium				
Chaenomeles				16.3
Unknown			0.7	
MUSHROOMS			6.2	13.1
INVERTEBRATES	8.2	Trace	0.5	1.2
VERTEBRATES	10.8	.7	Trace	0.1
INERT	Trace	1.0	0.9	1.1

(From Howe et al. 1979)

Table 3. Plant and animal species found in stomach samples from European wild hogs, 1977

A = Acorn
F = Fruits
L = Leaves
N = Needles
R = Roots or tubers

Plants		Part Consumed
Smooth Shadbush	Amelanchier laevis	F
White Wood Aster	Aster divaricatus	F
Heart-leaved Aster	A. cordifolius	F
Sedges	Carex spp.	L
Japanese Quince*	Chaenomeles lagenaria	F
Narrow-leaved Spring-beauty	Claytonia virginica	L
Trout-lily	Erythronium americanum	R
White Snakeroot	Eupatorium rugosum	L
Wild Geranium	Geranium maculatum	L
St. Andrew's cross	Ascyrum hypericoides	F
Wood-nettle	Laportea canadensis	L
Lily	Lilium spp.	L
Wood-sorrel	Oxalis montana	L
Short-leaf Pine	Pinus echinata	N
White Pine	P. strobus	N
Virginia Smooth Pine	P. virginiana	N
Solomon's Seal	Polygonatum biflorum	L
Cinquefoil	Potentilla spp.	L
Rattlesnakeroot	Prenanthes spp.	L
White Oak	Quercus alba	A
Scarlet Oak	Q. coccinea	A
Southern Red Oak	Q. falcata	A
Chestnut Oak	Q. prinus	A
Red Oak	Q. rubra	A
Sheep sorrel*	Rumex acetosella	L
False Solomon's Seal	Smilacina racemosa	L
Greenbrier	Smilax rotundifolia	L
Star Chickweed	Stellaria pubera	L, F
Meadowrue	Thalictrum spp.	L
Wake Robin	Trillium erectum	L
Yellow Trillium	Trillium luteum	L
Eastern Hemlock	Tsuga canadensis	N
Tall Woodland Blueberry	Vaccinium constablaei	F, L
Hairy Blueberry	V. hirsutum	L, R (?)
Sweet White Violet	Viola blanda	L
Halbred-leaved Violet	V. hastata	L
Northern White Violet	V. macloskeyi ssp. pallens	L
Grasses		L
Mushrooms		Fruiting body or F (?)

*Introduced

Table 3. Plant and animal species found in stomach samples from European wild hogs, 1977 - Cont.

A = Adult
E = Egg
L = Lavae
P = Pupae

Animals

			Age Consumed Stomach Contents
Vertebrates			
Mouse	Mammalia -	Peromyscus	A
Shrew		Sorex	A
Bird	Aves		Feather
Eastern Box Turtle	Reptilia -	Terapene carolina	A
Snake, unidentified			Shell fragment
Mountain Salamander	Amphibia -	Desmognathus ochrophaeus	A
Pigmy Salamander		D. wrighti	A
Blue Ridge Two-lined Salamander		Eurycea bislineata	A
Shovel-nosed Salamander		Leurognathus marmoratus	A
Red-backed Salamander		Plethodon cinereus	A
Jordan's (Red-cheeked) Salamander		P. jordani	A
Black-chinned Red Salamander		Pseudotriton ruber	A
Invertebrates			
Walking-sticks	Orthoptera -	Phasmantidae	A
Dobsonflies (Hellgrammite)	Neuroptera -	Corydalidae	L
Ground Beetles	Coleoptera -	Carabidae	A
Snout Beetles (weevils)		Curculionidae	L
Blister Beetles		Meloidae	L
Scarab Beetles		Scarabaeidae	L
Darkling Beetles (mealworms)		Tenebrionidae	L
Noctuid Moths	Lepidoptera -	Noctuidae	L
Sphinx Moths		Sphingidae	L, P
March Flies	Diptera	Bibionidae	L
Long-legged Flies		Dolichopodidae	L
Dance Flies		Empidae	L
Horse Flies		Tabanidae	L
Crane Flies		Tipulidae	L
Ants	Hymenoptera -	Formicidae	A
Millipedes	Diplopoda -	Polydesmoidea	A
Millipedes		Juliformia	A
Centipedes	Chilopoda -	Scolopendromorpha	A
Crayfish	Crustacea -	Decapoda	A
Earthworms	Annelida -	Oligochaeta	A
Snails	Mollusca -	Gastropoda	A
Nematode worms	Aschelminthes -	Nematoda	A

found 57% of GRSM wallows to be on trails, and only 22% of TWMA wallows on trails. Trails in the Smokies are well worn and get muddy easier whereas trails in the TWMA are little used (Beldon and Pelton 1976; Tennessee Game and Fish Commission 1972).

Wild hogs will also rub trees, especially pitch pines, to rid themselves of ectoparasites. Oftentimes, telltale hairs can be found on the bark. The honing of tusks (tusking) on pines and hemlocks is another behavior whose purpose is uncertain, but it can damage trees. The pigs may simply be releasing energy or practicing for battles (Tennessee Game and Fish Commission 1972).

5. WILD HOG IMPACTS

Wild hog impacts are the direct result of their movements, habitat use, and food preferences. Impacts are most severe where densities are highest--along the high northern hardwood ridge in summertime. Impacts are also greater in areas that have been occupied longer by the wild hog.

The rooting habit of the wild hog in its search for food probably causes the most damage to flora and fauna of the park. More intensive rooting is often correlated with poor mast years. The same sites can be rooted three to seven times during one growing season. Mesic slopes and the ridgetops are rooted more than xeric slopes, though the cove hardwood forest escapes serious rooting impacts.

5.1 Flora

The loss of ground cover and increase in bare ground are obvious wild hog impacts that have been scientifically documented by several authors. Plant cover can be reduced as much as 80 percent. Wild hogs move two-thirds of all downed branches and logs; only the largest remain untouched. The same plant species are, for the most part, present before and after rooting, but individual populations have been reduced and the herbaceous community structure changes. For example: in the gray beech forest, beech sprouting is stimulated (4-45 times greater in rooted areas), possibly because of exposure or injury to roots. Patterns of dominance in the understory may also be changing. Few plants are capable of (adapted to) colonizing disturbed areas under the forest canopy. Most understory herbs are perennials not capable of colonizing in less than one growing season. The invasion of wild hogs is too recent to be able to verify any changes in long term successional trends (Howe et al. 1979; Singer et al. 1982; Huff 1977; Bratton 1974b, 1975).

The hog is responsible for the destruction of natural wildflower areas. Numerous herbaceous plants are eaten (roots, fruits, shoots, foliage) or trampled, or uprooted incidentally. Spring beauty blooms prior to canopy closure and before the arrival of the wild hog at the higher elevations, and it flowers at three years of age. Corms are usually rooted up after seed has been produced. Trout lily and spring beauty also replace their roots each spring

(perennial roots). Plants with fine woody root systems are unable to recover this quickly.

On the other hand, the adversely affected wake robin (Purple trillium) flowers after canopy closure when hogs are actively rooting and only flowers after seven years. When its leaves are eaten by the hog, the plant is usually killed before it has produced seed. Turk's cap lily is also heavily damaged because it too is poorly adapted to resprouting after rooting (Howe et al. 1979; Ackerman et al. 1978).

A number of unique and special concern plants on National and State lists are found in hog-rooted areas, serve as food species and experience habitat destruction. Among them are Virginia bluebell, purple phacelia, Cumberland azalea, and Roan's rattlesnakeroot. Important wetland areas in Cades Cove (the Chambers Pond and the Bee Gum Swamp) containing rare herbs and special plants are rooted to some extent by wild hogs. Local extinctions of certain plants are possible wherever hog damage is occurring, though none have been documented yet (Bratton et al. 1982; Bratton 1974b).

Studies of wild hog impacts have compared similar sites (gray beech forest, for example) in rooted and unoccupied locations in the park at the same time, and before/after soil and vegetation data were available for Double Springs Gap, which was invaded in 1971. Wild hog exclosures have also been erected at several locations. Exclosure experiments have indicated the greatest herbaceous

recovery in the first year, and the cover is within its normal range in three years. The longer an area has been disturbed, the longer it may take to recover. Most initial recovery is from corms, shoots, or seeds surviving disturbance, and some vegetative reproduction also occurs. On grassy balds, the grasses are slow to recolonize, and weedy forbs often invade the broken turf (Bratton et al. 1982; Singer 1981).

5.2 Fauna

Impacts of the wild hog on native animals of the park include direct consumption, habitat destruction, and competition. Animals which serve as food for the wild hog were listed in the discussion of food habits.

Only two species are even potentially threatened by the wild hog, the Jones Middle-tooth snail and the Red-cheeked salamander (endemic to the park), and evidence for this is sketchy. Neither is a "listed" species, though both might be called unusual. Snails characteristically dissolve quickly in hog stomachs so it is difficult to determine how popular they are as a food item. Salamanders are a common food item, and the Red-cheeked has been found in stomach contents often. However, no differences were found in salamander populations between disturbed and pristine sites. Though the litter layer is often destroyed, they apparently are able to find adequate alternate habitat (Ackerman et al. 1978; Singer et al. 1982).

An 80 percent decline in macroinvertebrates in the soil in some areas could not be safely attributed to direct consumption, and is probably also the result of habitat destruction. Surface tunnels of small mammals such as the red-backed vole and short-tailed shrew were absent from rooted areas and widespread pristine stands. Habitat changes are again the suspected culprit. Silting and/or contamination of streams, which can result from rooting and wallowing in or near them, also has the potential for detrimental effects on the native brook trout (Howe et al. 1979; Ackerman et al. 1978).

It has been suggested that wild hogs compete with native animals for food, particularly when the mast crop is poor. Deer, turkeys, bears, squirrels, and chipmunks may compete with hogs for acorns in these years. Wild hogs may also compete with bears for berries, with deer for grasses and herbs. They compete with skunks, raccoons, opossums, foxes, and bobcats for insects, crayfish, and carrion. The competition has not yet been documented by rigorous research (Bratton 1974a; GRSM 1983; Bratton 1974b).

5.3 Water Quality and Communicable Diseases

The possible contamination of water sources or courses has been noted as an important health consideration for recreationists in the heavily visited Great Smoky Mountains. Hog-occupied drainages have been found to have higher concentrations of fecal coliform bacteria than unoccupied drainages.

As mentioned, siltation is also a potential water quality problem (GRSM 1983, Beldon and Pelton 1976).

The wild hog has the potential to act as a reservoir for the transmission of parasites and diseases to man, wildlife, and livestock. Some of these diseases include hog cholera, brucellosis, leptospirosis, and trichinosis. The habit of wallowing is conducive to disease spread. The park hogs have not yet been evaluated for potential in the transmission of Giardia lamblia, a parasite that has been found in backcountry areas throughout the United States, which causes extreme discomfort to those who contract its associated disease. Overall, hogs in the park are relatively healthy, although leptospirosis has been documented (it is not life threatening) and contracted by some people (S. Coleman 1983, personal communication). A reserve in South Carolina has been quarantined for brucellosis and pseudorabies in feral hogs; the meat has been determined to be inedible and hunting for them is prohibited. The situation is probably not correctable. Other wildlife, of course, can carry these diseases as well but are less likely to spread them to human beings than wild hogs (Beldon and Pelton 1976, GRSM 1983).

5.4 Soil Erosion and Nutrient Cycles

Contrary to what might be expected, the evidence for soil erosion is not very strong. Early researchers had logically predicted that widespread rooting would result in soil loss and siltation of streams during storm events. Black and white photos in the park

archives do depict erosion resulting from severe rooting on grassy balds, and soil loss and siltation does occur for areas adjacent to streams and springs, but one study found that sediment loads were not greater in rooted watersheds. The explanation given was that the decreased bulk density of the soil (due to rooting) encouraged rapid infiltration.

Though soil erosion may be less of a problem than once thought, soil layers are seriously disturbed by hog rooting. A 93 percent reduction in the depth of the humic layer or O1 horizon has been observed, and the A1 and A2 horizons become mixed and indistinguishable (Howe et al. 1979; Singer et al. 1982).

The level of many plant nutrients was consistently lower in rooted stands. Rooting also disrupts the nitrogen cycle. Nitrates (NO_3) and ammonia (NH_4) were greater in rooted soils and streams of rooted watersheds. Researchers suspect that exposure of rooted soils to air either accelerated the nitrification process or slowed the denitrification process. Disturbed soil also freezes more readily, which increases nitrates. These changes are evidence for the acceleration of the nutrient cycle via breakdown of the litter layers (increased decomposition of organic material). This is a disruption of natural processes that is unacceptable in National Park Service areas. Soil nitrate losses through leaching and stream run-off could result in reduced plant growth and productivity. Studies have shown that three years of exclosure from wild hogs were inadequate for nutrient recovery.

5.5 Impacts Outside the Park

Wild hog damage is not restricted to the park. Park neighbors have registered complaints about "park" boars damaging lawns, gardens, golf courses, corn and other crops. Wild hogs from the park have been transplanted to other Wildlife Management areas, notably West Tennessee and Mississippi, where agricultural losses have also been noted.

6. MANAGEMENT

National Park Service policy toward exotic animals is clear. Native resources and historical features must be protected, and complete eradication is the desirable alternative. Complete eradication is probably an unreachable goal, economically impractical if not physically impossible. Keeping the population down in critical areas is perhaps a more reasonable objective. It has been estimated that a 25 percent annual harvest would be necessary to stabilize the population, and a 50 percent harvest to substantially reduce it (GRSM 1983, Wood 1978).

6.1 History and Effectiveness of Wild Hog Reduction Techniques

Trapping of wild hogs was initiated in the park in 1959 and shooting (by Rangers) in 1960 in response to severe rooting damage on Gregory and Parson's Balds. Approximately 1200 hogs had been removed by the end of 1977. From 1978-1982 about the same number of animals were taken, making a total of about 2400 for the past 23 years (see Tables 4 and 5). Two man-years are now spent each year

on control activities. Trapped animals are now, and have been in the past, transferred to the states in which they were captured to stock game areas. They have also been used in the past for research and eliminated when the states were unable to take them (GRSM 1978, 1983).

Trapping success varies with the season, available mast and manpower, and accessibility to the area to be trapped. It is concentrated at the higher elevations in summer and lower elevations in winter and is most successful in summer where the ridgeline density is high. The more the wild hog moves, the better are the chances for trapping it. When mast is abundant (and they move less) trapping success is poor. When mast is scarce, success is better, and an economy of effort can be realized in these years by increasing the effort. Mast surveys were initated a few years ago to help direct control efforts. Portable traps were developed for use in the less accessible backcountry areas (ridgeline). Most trap captures are of single animals. Group traps have been tried but not found to be effective. Raccoons and crows are the most common non-target animals which spring traps (GRSM 1978, 1983).

A mixture of shelled corn, molasses, sugar, water, and yeast that has fermented a few days is now used as trap bait to attract hogs. Chemical attractants, sex pheromones, females in estrus, and vocalizations of hog sounds have been occasionally attempted without good results (GRSM 1983).

Table 4. Number of wild hogs removed from population (broken down by year and subdistrict)

Year	Cades Cove	Cosby	Little River	Lake & 20-Mile	Luftee	A.T.	No Info	Total
1959	2	0	0	0	0	0	0	2
1960	19	0	0	1	0	0	1	21
1961	8	0	0	22	0	0	0	30
1962	11	0	0	24	0	0	0	35
1963	5	0	0	8	0	0	0	13
1964	43	0	0	33	0	0	0	76
1965	15	0	0	3	0	0	0	18
1966	21	0	0	8	0	0	0	29
1967	16	0	1	15	0	3	0	35
1968	75	0	0	80	0	0	0	155
1969	28	0	0	16	0	8	0	52
1970	22	0	8	15	0	0	0	45
1971	46	0	26	51	0	2	0	125
1972	91	0	23	26	0	9	0	149
1973	26	0	9	59	1	1	0	96
1974	10	1	22	12	0	0	0	45
1975	14	2	19	43	0	0	0	78
1976	21	1	8	18	1	0	0	49
1977	28	0	22	23	3	58	0	134
TOTAL	501	4	138	457	5	81	1	1,187

NOTE:

These figures are not absolute. Prior to 1976, some animals may have been killed or translocated without record, by NPS, University or State personnel. Others undoubtedly have been taken by poachers. The records for some years vary with the sources, and the figures given here are those felt to be most nearly reliable.

(From Great Smoky Mountains National Park 1978)

Table 5. European wild hogs removed from Great Smoky Mountains National Park - 1981 Direct reduction and trapping

	TRAPPING			DIRECT REDUCTION		
1981	No. of Manhours	No. of Wild hogs	Manhours per hog	No. of Manhours	No. of Wild hogs	Manhours per hog
January	-	22	-	-	1	-
February*	190	3	63.3	7	6	1.16
March*	183	7	26.1	24	6	3.5
April	58	6	9.66	80	19	4.21
May	28	12	2.33	115.5	23	5.02
June	120	29	4.14	88	21	4.2
July	112	28	4.0	32	4	8.0
August	80	8	10.0	100	5	20.0
September	29	0	-	18	6	3.0
October	0	0	0	100	3	33.3
November*	0	0	0	0	0	0
December	110.5	25	4.42	43	20	2.15

* Majority of time spent building traps or engaged in other resource management activities.

Total European wild hogs removed by direct reduction and trapping during 1978, 1979, 1980 and 1981:

1978 - 207
1979 - 160
1980 - 155
1981 - 259
1982 - 401
1182

(From Great Smoky Mountains National Park 1983)

Direct reduction is practiced by qualified personnel using the utmost caution and with the primary concern of visitor safety. In one study comparing day hunting, night hunting from vehicles, and night hunting on foot, the latter was found to be the most effective method. At present, however, a combination of trapping and shooting is now felt to be the most cost effective method (GRSM 1983; Fox and Pelton 1977).

6.2 The Social Issue

Local residents have long felt antagonistic towards the park about its management efforts, especially in North Carolina. The wild hog is considered a prize game animal, and the park practice of shooting hogs and allowing the carcass to return to the ecosystem is viewed as a waste of meat. This faction contends that the hog is native since it has maintained itself and flourished in the area for forty years. In general, however, area residents are not in favor of hunting in the park as the North Carolina Wildlife Commission is. The main objection of these residents is to the waste of game animals, and they are in favor of trapping and releasing outside the park. Unfortunately, the control program in the park has been met by sabotage, vandalism, and threats against personnel and property. Poaching of wild hogs continues to occur, with local residents taking the view that they are doing the park a

favor. The effect of poaching on the population is largely an unknown quantity, though an interview with a former poacher indicated that between 100 and 300 hogs were taken from the park illegally in 1973 (GRSM 1978, 1983, Minor 1977, Bratton 1974a).

The antagonism came to a head in August 1977. Park officials had unsuccessfully attempted to find a local hunter for a contract to test the feasibility of hunting wild hogs in the park with dogs. Subsequently, a purchase order was issued to a Georgia man for a 14-day hunt in an effort to capture 100 hogs. The dogs were to be strictly controlled, the use of firearms prohibited, and the meat was not to be used. Four days of hunting netted one animal, and the effort ignited a controversy. A moratorium on shooting hogs in the park was put into effect that lasted eight months, and they still are not taken this way in North Carolina. The legality of this hunt in the National Park was questionable (Minor 1977, GRSM 1978).

6.3 Other Control Options

There is no doubt that additional techniques must be developed for the control of wild hogs in the park. There are numerous other possibilities but none has reached the stage of usefulness yet. The use of toxicants is one of these alternatives. The cost is high, and it needs to be safe for other animals, yet deadly to the hogs. Similarly, the introduction of diseases must be host specific, and there is the ever present danger of spread to domestic stock outside the park. Hog cholera is swine specific,

but there is no known disease specific only to wild hogs. Chemosterilants exist that will inhibit reproduction, but they are carcinogenic to humans and extremely dangerous to handle. Improved trap baits attractive only to hogs could make the use of toxins or diseases more effective. Other possibilities are the use of pheromones, contraceptive hormones, abortion-inducing substances or lactation inhibitors, sprays to manipulate preferred habitat reduce the usability of the area for hogs but are not detrimental to other fauna and flora. The technology for these various options is not available yet, and it would be most helpful if research was directed at them (GRSM 1983, Pelton and Kalla 1982).

Public hunting is not allowed in GRSM by law and cannot be considered an alternative control of wild hogs. It is used in Grand Teton National Park (legislative mandate) to manage the elk herd and in Hawaii National Park (no legislative mandate) for the control of feral pigs but is not considered an effective method in either area. With or without appropriate prior legislation, there are several other important considerations to public hunting and serious problems associated with it. Inevitably, non-target species will be harvested to some extent, and there are many non-target species in GRSM. User conflicts will occur, and any restriction of other recreational activities will be met by complaints; this problem would probably be at its worst in GRSM, with over 8,000,000 visitors a year. While hunting is a management technique from the standpoint of the park, the public comes to view

it as sport hunting in intent. Once initiated, such a program would be politically difficult to terminate. Even if allowed, there is no guarantee of effectiveness, and a hunting program, just like any other, would only be useful if it were cost effective for the park. In the Catoosa Wildlife Management Area in East Tennessee, a no-bag-limit season was established to combat agricultural damage of wild hogs. Hunting has not yet been able to eliminate hogs and their impact in this area. The wild hog is an elusive game animal and, based on success ratios in National Forest areas, a tremendous number of hunters would be needed to reduce the park population appreciably (GRSM 1983, Coleman 1983).

The reintroduction of native predators to control wild hogs is permissible under current Park Service policy. The gray wolf and the mountain lion are the only two possibilities. The mountain lion has been reported in the park, but there is no concrete evidence for its existence. Deer would be their primary prey, though piglets would be taken on an opportunistic basis. For the gray wolf, the park habitat alone is insufficient to support a viable population. Cooperation from managers of land surrounding the park would be required, and some are opposed to the gray wolf's reintroduction. Among the potential problems are animosity among local sportsmen and unknown impacts on domestic livestock. Coyotes, which were first sighted in the park in Cades Cove in June 1982, would only prey to a limited extent on piglets (GRSM 1983).

Bear-hog conflicts are infrequent, and hogs are not considered as prey for the bear. Researchers have observed bear attacks on trapped yearling pigs. Encouraging, but probably the exception to the rule, was the observation by a seasonal ranger in 1982 of a bear-hog fight. A 200-pound bear was having its way with a 175-pound hog near the Mount Collins Shelter. There were indications, however, that the hog may have been somewhat crippled prior to the encounter. The mobility of the hog is probably what keeps it from becoming a common prey of the bear (Brewer 1982: Singer et al. 1978).

6.4 Management in Other Areas

Four of the 13 National Park Service units with wild pig populations are recreation areas where sport hunting is allowed, and in three of these, the harvest significantly reduces populations. Only one area reported a successful trapping program. It was already noted how a no-bag-limit hunting season was unsuccessful in eliminating a damage-causing hog population in an East Tennessee Wildlife Area (Singer 1981, GRSM 1983).

Wild hogs are managed as a game animal by the Forest Service in Tennessee and North Carolina, and they have noted damage to pine roots, restriction to oak reproduction, and recreational conflicts. In recognition of this, on Forest Service lands hogs can only be relocated in already occupied areas. Introductions to new areas are no longer allowed (GRSM 1983).

6.5 1983 European Wild Hog Management Plan - Recommended Action

The new wild hog management plan considers reduction efforts as just one part of the overall program. It should be continued in Tennessee and special efforts made in poor mast years. Hog-proof fencing of special plant and/or animal areas or cultural areas (cemeteries) should be used when those areas warrant protection and the impact of the fencing is not greater than that of the hog. Since the states want wild hogs for stocking purposes, they should bear the brunt of trapping costs. Volunteer assistance in trapping, supervised by park staff, is also called for to help reduce the hog population, stock State game areas, and defuse anti-park sentiment on the issue. In fact, this volunteer effort has been going on for more than a year on a trial two-year program in Graham County, North Carolina. It has been successful in both respects, particularly in the southern part of the park along Fontana Lake. It is beset with the usual problems of volunteer time and resources but appears to be serving its purpose well (GRSM 1983).

Protective fencing along the boundary of the park, where immigration is still occurring, is a possibility as well. The fence must be hog-proof, yet not interfere with the movement of other animals in and out of the park. A commitment to inspection and maintenance of any fences would also be necessary. If the technology becomes available to use diseases or toxins, it becomes doubly important. Continued monitoring and research is emphasized as important, since the reduction program is unlikely to be able to

do the job alone. Monitoring includes vegetation (through exclosures), indicator and unique species, mast surveys, population indices, and also cultural impacts. Research includes not only new control technologies but determining population densities; investigating disease interactions with humans, wildlife, and domestic animals; continued evaluation of ecosystem effects and methods of restoration; and defining special plant and/or animal communities that need special protection (GRSM 1983).

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