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Techniques for Controlling Wild Hogs in Great Smoky Mountains National Park: Proceedings of a Workshop

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TECHNIQUES FOR CONTROLLING WILD HOGS IN GREAT SMOKY MOUNTAINS NATIONAL PARK: PROCEEDINGS OF A WORKSHOP, NOVEMBER 29-30, 1983

by Jane Tate

NATIONAL PARK SERVICE - Southeast Region

Research/Resources Management Report SER-72

Sponsored by the

UPLANDS FIELD RESEARCH LABORATORY
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FOREWORD

A Workshop on Control Methods for the European Wild Hog was sponsored by Uplands Field Research Laboratory of the Great Smoky Mountains National Park, November 29-30, 1983. Personnel in the park were deeply concerned about the negative effects of this exotic species on the natural ecosystem and felt the political atmosphere was appropriate for initiating new and expanded control efforts. Representatives were invited from all National Park Service units experiencing hog problems as well as scientists with past research and/or management interest in the species. The expertise of the participants, therefore, covered a variety of disciplines.

The program for the workshop was organized to allow all participants to become acquainted not only with problems created by the wild hog in Great Smoky Mountains National Park but also with management actions and research on hogs in other areas. The meeting began with introductory presentations by invited speakers on a variety of subjects relating to the hog. These were followed by a field trip conducted by the Resource Management Division. Participants had the opportunity to observe rooting damage as well as the dense vegetation of the Smokies which limits accessibility and makes control efforts more arduous. Bill Cook and Kim Delozier demonstrated the different traps used in the park and discussed the effectiveness of various firearms. In addition, Chris Belden and Bill Frankenberger, Florida Game and Freshwater Fish Commission, displayed a trap that has been very effective in capturing hogs in Florida.

The second day of the workshop was devoted to group discussions on alternative control methods for the wild hog. These discussions provide the basis of the management recommendations made in this report. A few suggestions may seem too impractical, too politically sensitive, or subject to a myriad of possible ramifications. However, participants were urged to be innovative--for that is often the realm of progress. Part of my role as project coordinator was to prepare a synopsis of all suggestions made by workshop participants. This I have attempted to do without interjecting bias. Hopefully, the real results of this workshop will not be limited to this report but will be shown by a successful management control program and a drastically reduced population of wild hogs in Great Smoky Mountains National Park.

One of the recommendations made by workshop participants was that data on wild hogs removed from the park be analyzed to determine if information contained therein could be utilized for better understanding population dynamics or evaluating the effectiveness of control actions. The final section of this report focuses on that task.

I. HISTORY OF THE WILD HOG IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Origin and Invasion of Great Smoky Mountains National Park

The European wild hog (Sus scrofa) was brought to the Southern Appalachians in 1912 to stock a private game reserve at Hooper Bald, North Carolina, an area which is now part of the Nantahala National Forest located approximately 15 miles south of Great Smoky Mountains National Park (GRSM) (Jones 1959, Conley et al. 1972). While these animals reportedly had come from Russia and were referred to by local settlers as "black Russians," they were more likely of German or Polish origin (Bratton 1977). In 1920, about 100 of these European wild hogs escaped from their enclosure and dispersed throughout the surrounding area, interbreeding with feral domestic swine that roamed freely (Bratton 1977, Conley et al. 1972). They entered the southwestern corner of the park near Calderwood in the late 1940's and early 1950's (Jones 1959). Since then the invasion has spread from west to east (Fox and Pelton 1977), averaging 2.75 km per year (Singer 1981).

Hogs in Other Parks

Captured and pen-reared animals from this Hooper Bald population were subsequently transported to several other locations: 1) Monterey County, California, in 1923 (Barrett 1977); 2) Texas in the 1930's (Ramsey 1968); 3) central Tennessee in 1971 (Conley 1977); 4) West Virginia in 1975 (Decker 1978); and 5) western Tennessee in 1979 (Singer 1981). Wild pigs--either European wild hogs, feral domestic swine, or crosses between the two--now inhabit several National Park Service areas. In addition, a small number of hogs is apparently present along the Blue Ridge Parkway, adjacent to GRSM. Because the Parkway adjoins the park, continued invasion is likely.

Distribution, Density, and Migration

Since entering the southwestern corner, wild hogs have spread throughout most of the park. The population is now well established in all areas west of Newfound Gap Road. In the early 1970's, the hogs began settling the eastern half of the park, and their expansion has now reached as far as Cosby, Tennessee. The central ridge east of Newfound Gap and the Cataloochee area are apparently thus far not extensively inhabited (GRSM 1982, Singer and Ackerman 1981, Bratton 1975).

The number of wild hogs inhabiting GRSM is not known, and population estimates have varied because of difficulties in censusing the species as well as fluctuations resulting from available food resources. However, Singer and Ackerman (1981) estimated the population to be approximately 1500, and the 1983 European Wild Hog Management Plan (GRSM 1982) cited 1000-2000 animals. Several authors (e.g., Howe et al. 1981; Singer and Ackerman 1981; Tipton and Otto 1979; Singer et al. 1979) have suggested that because of food availability the highest densities occur along the high western ridgeline in the summer. In 1979, densities for this northern hardwood area were estimated at 7-9 animals per km^2, compared to 2 animals per km^2 in low elevation pasture, oak-pine habitat (Singer 1981). Highest densities have been reported 7 years after the initial occupation of an area, with stabilization occurring after 20-27 years.

Earlier research indicated that the uneven distribution of wild hogs in the park is also influenced by their seasonal migration. Tipton and Otto (1979) reported that hogs have two distinct seasonal home ranges. While more recent data from control efforts suggest that not all animals exhibit this migrational pattern (see Coleman, page 18), it seems to be true for at least part of the population. Generally, in the spring (late March to mid-May) hogs move to higher elevation northern hardwood and gray beech forests, where they feed on rich herbaceous understory (especially spring beauty, _Claytonia caroliniana_, corms). Cove hardwood forests and grassy balds are also utilized to some extent during spring and summer months. In late summer, wild hogs begin their migration downslope; this movement is correlated with the drop of acorns, which are their principal food during this time (Tipton and Otto 1979, Scott and Pelton 1975, Conley et al. 1972). During fall and winter months, wild hogs prefer warm xeric slopes at low elevations with oak, pine, and oak-pine overstories and heath understories (Tipton and Otto 1979). During years of mast crop failures, migrations are more erratic and movements greater. At this time, they occupy a variety of forest types (including high elevation beech forests) as well as moving into low pastures and old homesites (Singer et al. 1979; Bratton et al. 1982). It is not only the search for available food but thermo-regulation as well that influence these movements. Their sparse, bristly hair, which provides inadequate protection from both temperature extremes, and a lack of any apparent sweat glands necessitate that European wild hogs seek cooler areas in warm months and vice versa (Belden and Pelton 1975).

Home Range and Activity Patterns

Summer and winter home ranges of wild hogs are comparable in size during good mast years, 3.67 km^2 and 3.10 km^2, respectively (Singer et al. 1979). Seasonal home ranges are smaller when mast is abundant during the winter at low elevations and when tubers and herbaceous plants are abundant during the summer at high elevations (Howe et al. 1979). During a mast failure, Singer et al. (1979) reported that winter home ranges were 320 percent larger and mean hourly movements increased 520 percent. With normal mast abundance the home range of males ($\bar{X}$ = 3.46 km^2) is not significantly larger than that of females ($\bar{X}$ = 3.07 km^2). However, one radiocollared female reduced her home range 94 percent while suckling piglets but resumed normal, larger movements when the piglets were only 11 weeks old.

In all seasons, wild hogs are significantly more active during crepuscular and nocturnal periods than during the day ($p < 0.05$) (Singer et al 1979). Mean hourly movements are least during winters with abundant mast ($\bar{X}$ = 0.08 km/hr), greater during summers at high elevation ($\bar{X}$ = 0.15 km/hr), and much greater during a winter following mast failure ($\bar{X}$ = 0.40 km/hr). Mean hourly movements of male and female hogs were not significantly different ($p > 0.10$). In winters of abundant mast, hogs move over only 11 percent of their home range during a 24-hour period, compared to 22 percent during summers or the winter after a mast failure (Singer et al. 1979). The reduction in winter activity during good mast years certainly helps the animals maintain a positive energy balance. Conversely, Singer and Ackerman (1981) reported starvation, reduced fat reserves, and reduced blood conditional parameters resulting from lack of food and their increased movements following mast failure.

Physical and Social Characteristics

Despite interbreeding with feral domestic stock, the population in GRSM retained many physical characteristics of the European wild hog: long guard hairs, a mid-dorsal mane, split gray-brown hair tips, high shoulders, long legs, narrow hooves, fewer teats, and longitudinally striped piglets. Piglets lose their stripes by four months of age, and adult coloration varies from gray to black, with some animals having a white snout blaze. At birth, piglets weigh about 2 pounds; the average adult weight is 100 pounds, and the maximum is close to 300 pounds (GRSM 1978, Conley et al. 1972). The average life expectancy is about eight years (Henson 1975).

While their European counterparts travel in large groups called sounders, hogs in the park appear to be either solitary males or family units of mother and piglets. Average group size for GRSM is two to three individuals (Singer and Coleman, n.d.).

Reproductive Characteristics

The wild hog has high reproductive potential, a factor which certainly aids its increasing population and range expansion within GRSM. Despite the absence of a distinct rutting season, two farrowing peaks have been noted in the Tellico Wildlife Management Area: December-January and April-May (Conley et al. 1972). Singer and Ackerman (1981) found no peaks in GRSM; births occur all year but are less frequent from August to November. Sexual maturity is usually reached at 12 months by both sexes and, under good conditions, it can occur even earlier. The average age of females at first conception in the park is 16.8 months, and the average litter size is 4.8. There is evidence suggesting that younger and older females are less fertile and produce smaller litters. During food abundance, Singer and Ackerman (1981) reported that 53 percent of females aged 18 months to 6 years were either lactating or pregnant; this figure dropped to 15 percent of all young females (6-17 months) and 17 percent of all old females (7+ years). Conversely, only 8 percent bred in 12 months following mast failure. Double breeding--producing two surviving litters per year--has been documented in 3 percent of the females in the park.

Successful reproduction is apparently dependent upon available food supply (Conley et al. 1972). However, the high reproductive potential of this species allows for a rapid recovery of population levels which quickly compensates for any reduction following food shortages. It has been estimated that a 25 percent annual harvest would stabilize the population but that a 50 percent annual harvest would be required to substantially reduce it (GRSM 1982). Singer and Ackerman (1981) estimated first year mortality for females at 61 percent and for males at 54 percent; after two years of age, these rates dropped to 24 percent and 30 percent, respectively.

Effects of Wild Hogs in GRSM

The detrimental effects of the wild hogs in GRSM are multifaceted and result from their movements, habitat utilization, and food habits. Their rooting is disrupting vegetative communities and successional patterns as well as altering nutrient cycling (Howe and Bratton 1976; Howe et al. 1981; Huff 1977; Singer et al. 1982; Bratton et al. 1982). They are having both direct and indirect effects on fauna in the park through predation on some species and alteration of the forest floor habitat of others. It also seems likely that they compete with native animals for available food resources, especially during years of poor mast crops. Wild hogs may contribute to the spread of infectious and parasitic diseases as well as provide a reservoir for diseases transmissible to domestic livestock. Furthermore, their rooting and wallowing are detrimentally affecting the aesthetic values of the park, and visitor complaints on this subject have been increasing (GRSM 1982).

Effects on Plant Communities. Hog rooting in the gray beech forests can reduce cover of herbaceous understory to less than 5 percent of its expected value (Bratton 1974a). Over 50 nonwoody species are known to be eaten, uprooted, or trampled. These disturbed species exhibit changes in population structure, including reduction in percentage of mature and flowering individuals. Changes in species composition favors plants with deep or poisonous roots (Bratton 1974a). Huff (1977) reported that rooting is stimulating vegetative reproduction of gray beech (*Fagus grandiflora*), with root suckers being 4 to 44 times greater than in undisturbed plots. Hog feeding may indirectly represent a potential threat to the reproduction of sugar maple (*Acer saccharum*) and is suppressing the foliar height of blackberry (*Rubus canadensis*).

In the northern hardwood forests hogs are significantly reducing herbaceous and subterranean forages in mesic herb communities as well as reducing populations if not numbers of species (Howe et al. 1981). Their spring and summer diet in these northern hardwood forests consisted of 55 percent herbaceous plant materials, 40 percent roots, 3 percent fruits, and 2 percent animal matter (vertebrate and invertebrate combined). While animal matter made up only a small percentage of their diet, it was present in 94 percent of the stomachs examined. Items included fly (Diptera) larvae, ground beetles (Carabidae), land snails (Polygridae), and salamanders (Plethodontidae). Spring beauty corms were the most important food during these seasons, occurring in 98 percent of the stomachs and accounting for an average volume of 33 percent (Howe et al. 1981).

Howe and Bratton (1976) reported that in winter rooting activity was concentrated in low-elevation successional Tulip Forests and Tulip-Silverbell Forests. At higher elevations, hogs rooted around shrubs on the grassy balds. Most foods involved in winter rooting had starchy tubers, bulbs, or rhizomes. However, the data for this study were collected following an abundant mast crop, and the authors suggested that the proportion of disturbance in different forest types may be influenced by annual availability of mast.

Bratton et al. (1982), utilizing vegetation survey plots from the western end of GRSM, found that rooting was present at all elevations but was concentrated in mesic sites except those having rhododendron (*Rhododendron maximum*) understories. Hogs had also disrupted wet areas in Cades Cove known for their rare herbs. Recovery in previously disturbed plots was greatest within the first year. While herbaceous cover for some exclosure plots was in normal range within three years, the species number remained less than expected.

Effects on Soils and Nutrient Cycling. Singer et al. (1982) found that rooting by wild hogs mixed the A_1 and A_2 soil horizons and reduced ground vegetative cover and leaf litter. It also accelerated leaching of Ca, P, Zn, Cu, and Mg from leaf litter and soil. Nitrate concentrations, however, were higher in soil, soil water, and stream water from rooted stands, suggesting alterations in ecosystem nitrogen transformation processes. Rooting did not appear to increase the sediment load, apparently because of high infiltration rate of loamy soils involved and because rooting decreased soil bulk density, thereby further promoting infiltration by rainfall.

Effects on Native Fauna. Through habitat alteration, possible food competition, and spread of disease, the wild hog has the potential for detrimentally affecting other animal species. Singer et al. (1982) reported that the red-backed vole (*Clethrionomys gapperi*) and short-tailed shrew (*Blarina brevicauda*)--two vertebrates depending largely on leaf litter for habitat--were nearly eliminated from intensely rooted stands. Other species sampled, which were more arboreal or subterranean, seemed unaffected by hog activities. Of species preyed upon by the wild hogs, only two are potentially threatened: the Jones middletooth snail *Mesodon jonesianus* and the red-cheeked salamander *Plethodon jordani* (endemic to the park). Concrete evidence for the extent of damage to these populations is not available; however, the red-cheeked salamander has often been found in the stomach contents of hogs. An 80 percent reduction in macroinvertebrates in the soil in some areas is probably the result of habitat destruction as well as direct predation. Siltation or contamination of streams which have rooting or wallowing areas near them could be detrimental to the native brook trout *Salvelinus fontinalis* (Howe et al. 1979; Ackerman et al. 1978).

Wild hogs may compete for available food resources with other species--deer (*Odocoileus virginianus*), turkeys (*Meleagris gallopava*), bears (*Ursus americanus*), squirrels (*Sciurus carloinensis*, *S. niger*, *Tamiasciurus hudsonicus*), and chipmunks (*Tamias striatus*). Evidence to support the hypothesis of competition is not available; however, if it does exist, effects would be worse during years of poor mast crops. Bratton (1974a, 1974b) suggested that hogs may also compete with bears for berries; with deer for grasses and herbs; and with skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), opossums (*Didelphis marsupialis*), foxes (*Vulpes vulpes, Urocyon cinereoargenteus*), and bobcats (*Lynx rufus*) for animal foods and carrion. Matschke (1965) documented predation on nests of ruffed grouse (*Bonasa umbellus*) and wild turkey in highly populated areas in the Tellico Wildlife Management Area (Cherokee National Forest) adjacent to the park.

Disease Transmission. Wild hogs serve as co-hosts with other wildlife and livestock for infectious and parasitic diseases. Higher concentrations of fecal coliform bacteria, which could be indicative of the presence of other disease pathogens, were found in areas occupied by this species. Blood samples collected from some animals in the park were positive for leptospirosis (GRSM 1982). Indeed, wild hogs may serve as a reservoir for diseases which can spread to domestic livestock: hog cholera, brucellosis, trichinosis, foot and mouth disease, African swine fever, and pseudorabies. A reserve in South Carolina which is inhabited by feral hogs has been quarantined for brucellosis and pseudorabies. While wild hogs in the park appear to be healthy at the present time, the possibility for disease transmission--and subsequent quarantine--certainly exists.

II. INTRODUCTORY PRESENTATIONS

Political Ramifications and Management Constraints

Roland Wauer, Assistant Superintendent for Resource Management and Science, Great Smoky Mountains National Park

It is difficult to separate political ramifications from management constraints because in this park, as most of you know, they often are one and the same. Recently, many changes have taken place here. We have had a complete re-organization of the resource management and science programs. We are working very diligently to develop resource management activities that utilize scientific information which is available or obtainable. By doing so, we hope to avoid mistakes in the future. We are in the process of re-evaluating every issue with which we must deal in this park, whether it is a true problem or a specific resource management activity. We have recently revised the project statement on the wild hog. This is a re-evaluation of where we were, where the vacuums are, and where we are going. It essentially establishes a new set of priorities for the future. We feel that because of the political ramifications--the management constraints--we must address the issues by a systematic process in both the short- and long-term.

In the long term we want to reduce to the very minimal any negative impact of the hogs on park values. We recognize that there may never be a time when all hogs are removed from GRSM. However, we do feel that we can restrict the impact of the hogs in certain areas.

Representatives from the Regional Office visited the Smokies about two months ago. One of the main interests of our Regional Director was the hog program. We seemed to receive a commitment at that time to provide monetary support for our efforts to control the wild hog. At the conclusion of this workshop, we intend to complete the revision of our project statement and to put together a special emergency request for additional money and manpower to accomplish our goals in this regard.

We also need to determine where our data base is lacking and to examine issues we may have neglected in the past. For example, we lack support for an overall control program from certain individuals--perhaps from some hunting groups or from people who have no opinion about our efforts. To deal with this, we probably need to collect different kinds of data than we have in the past. For example, how much do we know about the impacts of hogs on other huntable species? I realize that there is some data on wild turkeys and ruffed grouse, but what is their impact on woodcock or deer? We need information about the impact of hogs on other game species as soon as possible.

Another area of great importance is the protection of special zones within the park. We have already identified about 20 such areas to which we should give maximum protection. Although the legislation of Great Smoky Mountains National Park prevents fencing the boundary of the park, there are certain sites within the park--some caves, some bogs, some groves, some beech gaps--that we can fence to keep them as natural as possible. We need your suggestions on how best to control hogs in those places. Is there a fence that will keep hogs out of Albright Grove, as an example, but will still permit all other animals to move in and out?

I think that we currently have the kind of support we need to take new actions to control the wild hog, both from the park staff and from the Regional Office. Out of this meeting will evolve those recommendations and requests. I thank all of you.

Review of the 1978 Committee Report on Evaluation of Research and Management of the European Wild Hog in the Great Smoky Mountains National Park

Gene W. Wood, The Belle W. Baruch Forest Science Institute, Clemson University

In Spring, 1978 at the request of the Regional Chief Scientist (Southeast Region, National Park Service), a committee was organized to evaluate the research and management of the European wild hog in GRSM. The committee members and their affiliations are listed in Table 1. The National Park Service asked us to address the following five points: 1) appropriateness of the research, 2) quality of the research, 3) coordination of research effort with management needs, 4) suggestions for future research, 5) comments on management schemes. We later added a sixth topic which we felt should be addressed: the research organization at Great Smoky Mountains National Park.

The committee met on June 6-7, 1978, and began its deliberations. On June 6, we made a horseback trip from Cades Cove to Spence Field and back. The purpose of the trip was to view the types of terrain and vegetation in which hogs were being found in the park, the types of damage that these animals were causing, and the types of research being done on the hog in the park.

The information that we utilized for our evaluation came from the field trip, reviews of research reports and published papers, and interviews with Park Service personnel, one university graduate student, one university professor, one wildlife biologist from North Carolina, and one from Tennessee.

In the Preface to the report, the committee expressed a deep concern for the biological, human, and socio-political aspects of the wild hog problem in the park. It was pointed out that statements of agreement or disagreement with the philosophies of individuals, organizations, or agencies would be avoided in the report. It was our intent to make a presentation which candidly praised, criticized, and made recommendations.

In this report I synthesized all of the comments, and the general opinion of the committee was presented. If on any point there was notable disagreement among committee members, it was stated that the point being presented was a majority opinion. On two points, one committee member presented a minority opinion, which was noted in the text and included in the appendix without comment or editing. Each committee member approved the final report before it was presented to the Regional Chief Scientist.

Appropriateness of the Research

The committee agreed that the past and current research by Park Service personnel was appropriate. Duplication of previous work done either by the Park Service, universities, or other agencies was addressed. We felt that research topics were not overly duplicative because the objectives of the current projects were sufficiently different to justify the work. Documentation of plant community damage, studies on food habits, studies on production, and research on hog movements in the park were noted and complimented by the committee.

Table 1. 1978 Committee to Evaluate Research and Management of the European Wild Boar in Great Smoky Mountains National Park.

Name	Affiliation
Richard H. Conley	Tennessee Wildlife Resource Agency
Robert L. Downing	U.S. Fish and Wildlife Service
Robert E. Farmer	Tennessee Valley Authority
Jay J. Kennelly	U.S. Fish and Wildlife Service
Clyde Jones	U.S. Fish and Wildlife Service
Thomas R. Porterfield	North Carolina Wildlife Resource Agency
David H. Van Lear	Clemson University
Gene W. Wood (Chairman)	Clemson University

Quality of the Research

We commended the competence, ingenuity, initiative, and enthusiasm of the two principle scientists working on the European wild hog at Uplands Laboratory. However, we did have two concerns. First, while the European wild hog appeared to be the most important animal management problem in the park, decreases in the amount of research effort devoted to the subject were already underway. Secondly, it appeared that there had been an excessively heavy reliance on cheap and volunteer labor for collecting research information. The committee commented as follows: "To expect that students being paid $4.00 per day or nothing at all will produce the same quality of work as adequately paid, accountable employees on a sustained basis is sheer naivete."

Coordination of the Research Effort with Management Needs

We made the following statement: "Based on formal and informal discussions, the committee arrived at the opinion that communications and cooperation between the Superintendent and scientists were good. There were some indications that this same relationship did not extend to operational staff and scientists, however." The committee was deeply concerned that there were no obvious mechanisms through which management could relay its needs to the research staff. In addition, no one could tell the committee what the research priorities at the Uplands Field Laboratory were, how decisions on manpower effort and funding distribution among projects were made, or how the management's needs fitted into the decision-making process.

We commended the research staff for its efforts to keep management informed of research activities and progress through management reports to the Superintendent. On the other hand, the committee was critical of researchers for what appeared to be a high level of production of unnecessarily voluminous preliminary reports. It was felt that reporting research in this manner was both ineffective and inefficient.

Suggestions for Future Research

We felt strongly that while there might have been a need for rechanneling research effort on the wild hogs in the park, a decrease in effort was certainly not appropriate. The committee stated: "To completely ignore the presence, expansion, and population growth of the animal would be a violation of Park Service policies on exotic species and a rejection of research findings that the boar is modifying the natural environment in certain plant communities." The committee recommended an expanded and intensive effort to document the hog as an exotic agent on a park-wide basis and the extent to which its impact was antagonistic to the well being of vegetation, soil, water, and indigenous park populations of vertebrates and invertebrates. We recommended additional research on population dynamics that should include studies of reproduction, population growth, centers of activities, and range extension. The committee also recommended that research be carried out on methods of control which would address logistics, economics, and sociological impact.

We recommended that the Park Service make greater use of university resources through contracted research in the future. In this recommendation we also made some very specific points on requiring certain minimum levels of direct involvement by faculty members associated with the research as a means of bringing that level of expertise to bear on the problem. The committee also recommended the initiation of joint research efforts with the U.S. Fish and Wildlife Service.

The committee recommended that in addition to the on-going research the following topics be addressed: 1) water quality (particularly those aspects pertaining to potentially pathogenic bacteria), 2) endangered invertebrate and vertebrate species, 3) endangered plants, 4) exclosure studies, 5) control techniques, 6) impact on plant communities (concentrating on forest types not previously investigated), 7) beech sprouting, 8) litter breakdown (lysimeter studies to assess changes in nutrient cycling resulting from disruption of soil processes by rooting), 9) erosion studies (emphasis on silt loading in streams), 10) wild hog reproduction, 11) population indexes (emphasis on recruitment rates), 12) radiotelemetry studies (emphasis on range expansion resulting in invasion of new areas, habitat utilization, and reproduction).

Comments on Management Schemes

This section opened with the following statement: "It is the committee's opinion that the European wild boar is firmly established in the Great Smoky Mountains National Park and its eradication would be highly impractical, if not impossible, regardless of desirability." The committee realized the impracticality of eradication, but in view of the demonstrated disruptions of natural processes caused by this exotic animal, we were very much in favor of any program aimed at depopulation. We recognized the large area over which the animal was ranging, the difficulty of access, and limitations in funds and personnel to carry out a depopulation program. We, therefore, recommended that the following major points be considered when making decisions regarding the application of control measures: when and where damage was occurring, its nature, and what type and extent of control was warranted. This recommendation was made as a suggestion for the development of priority ratings as to where to spend money and time.

We felt strongly that the Park Service had no obligation to trap and transport hogs for control purposes; however, if this type of control mechanism had to be used, the recipients of the animals should have to bear all costs incurred. We were very concerned for trap and transport procedures that might be used in areas where movement of animals and traps by horsedrawn sleds could be damaging to park trails.

The majority of the committee felt that opening the park for public hunting administered by any method would not serve the purpose of control efficiently and would pose numerous other problems; e.g., user conflicts, feral dogs, and poaching of other animals. In addition, we felt that to begin hunting in the park could become an undesirable tradition.

There had been suggestions by Park Service personnel that chemosterilants should be tried for population control. We felt that this technique was unlikely to be acceptable to the public. Furthermore, there was no information available on the use of this technique on wild hog populations anywhere in the world, and the development and registration of a drug that would be safe and effective would be a major undertaking of its own.

Protection of "sensitive areas" in the park by fencing was suggested by research personnel as a management technique. We felt that the measure had some merit but was distasteful in a National Park, particularly in places where fences would be frequently encountered by visitors. We pointed out that fence maintenance would also be a major problem.

In 1978, the only control program of which we were aware that was being exercised by the management staff was the trap and transport measure. The research staff was shooting a number of hogs for research purposes, and this was functioning as a management measure in that these animals were being removed from the population.

Research Organization

The final point addressed by the committee was the research organization at Uplands Field Research Laboratory. We did not anticipate addressing this topic before the meeting began; however, the committee members were in unanimous agreement that part of the problem in effectively and efficiently carrying out research and communicating it to management was due to the organization in which administrators and scientists were working. We were very much in disagreement with the Leopold-Allen report which recommended that the Regional Chief Scientist could oversee, on a detailed basis, each research project in the Region. It seemed obvious to each of us that this was highly impractical, considering the amount of research being done in National Parks in the southeastern United States.

The committee's greatest concern was for the lack of a designated research administrator with on-site authority. We posed the following question: "How can a strong, well-defined research program be organized, objectives defined, personnel evaluated, personnel relations governed, program procedures adhered to, and coordination and communication with park and other agency administrators be carried out without an on-site administrator?" We then recommended that a full-time director, who was experienced in administrative matters as well as in carrying out research and communicating its findings, be appointed to the Uplands Field Laboratory.

We were also disconcerted by the fact that Uplands Laboratory, at that time, had no objectives that anyone could define during the interviews. Projects were simply developed as scientists perceived a need or desire to do them, and the objectives were apparently poorly related to any particular program goals. We recommended that the organization at Uplands Laboratory become more structured and the reasons for its existence be more clearly defined. Research projects should fall within the scope of the Park Service's goals for maintaining the Uplands Field Laboratory in the park.

We recommended that a formal agreement be reached between management and research on what the information needs for management were and how researchers were to communicate their findings to management personnel. There was considerable concern for the fact that, at that time, quality of the lines of communications were entirely personality dependent.

We were very concerned that so much of the research in the park was being done by part-time personnel and volunteers who were not being paid at all. We felt that this could only lower the quality of the research program and recommended that the Park Service develop a personnel management approach that might result in a more stable personnel turnover situation.

Finally, we suggested that the Park Service consider organizing an adhoc committee similar to ours to periodically review the Uplands program with respect to its objectives, progress, and plans for future work. Committee reviews of this type are standard approaches used by most university research programs as well as many government agencies. We felt that the Park Service could greatly benefit from periodic critical review and suggestions that could come from panels of scientists not directly concerned with the park.

Control Efforts in Great Smoky Mountains National Park since 1978

Stu Coleman, Chief, Resource Management Division, GRSM

The control of the European wild hog and/or its mitigation and impacts are well grounded in the legislative mandate and policy guidance of the National Park Service. This service-wide management action was defined and re-affirmed a few years ago on the strength of the controversy surrounding the park's hog control program. The mandating of control and mitigation of the animal is easier than the practical application of that directive. That is why we have asked for your assistance. It pleases me to see the response and concern expressed about the real and/or potential problem by the participation at this workshop.

There is no doubt that the hog is a superior game animal; our point is that the animal does not belong in this park, an area set aside and dedicated as a living museum and benchmark of native species for the appreciation and enjoyment of people of the United States. It is important for me to make this point to our many professional friends in the state wildlife resource agencies. The purpose here, then, is to generate in this session, strategies, direction, areas of study, and techniques that may serve us in our unresolved control problem. We seek both short-term research and management needs as well as long-term and comprehensive management solutions.

I will now brief you on strategies and techniques employed in the past few years, but I will not be pretentious and assume our methods are best. We have much to learn. No discussion of control techniques is complete without an overlay of the political and management atmosphere of the times as they definitely shaped control strategies that were and have been employed. Perhaps I can share part of the intricate web of biopolitics that has surrounded the management of this species in the park. Last, I challenge you to take into consideration when you discuss possible solutions and strategies the political implications and realities of the matter.

At the end of 1977 we were embroiled in a controversy that led to a moratorium on the killing of the wild hog in the park. This stemmed from an ill-conceived and jointly-sponsored attempt by Uplands Field Research Laboratory and Resource Management to conduct and evaluate a control technique using dogs to locate and catch hogs. The handlers and the dogs were not from this area, and hostility against this program developed immediately and still continues today. In hindsight, the timing, the choice of control, the personnel, and the target area for the experiment were probably all wrong. In any case, at the end of 1977, a moratorium was declared until a management plan was written and approved. Simultaneously, a cooperative agreement on hog management with the North Carolina Wildlife Resources Commission was signed. In April, 1978, the moratorium was lifted and direct reduction was again used in concert with the non-halted trapping procedures. During this time, four additional part-time people were allocated to the hog control program of the park. With this additional staff support, the number of hogs removed from the period 1978 to 1983 surpassed the total number removed in the previous 19 years.

The summer of 1978 and subsequent summers saw control emphasis placed on high elevation beech gaps and along ridgetops in the park. Research had indicated that hogs concentrated and segregated themselves by sex and dominance along these preferred sites during the summer months, with a corresponding decrease in numbers at lower elevations. For example, 25 of 36 (69 percent) animals taken in 1980 along the Appalachian Trail during the late spring and early summer months were sexually mature females. Control of this segment of the population was deemed important. Prime areas were occupied by dominant females, excellent target candidates from a recruitment standpoint. However, in the five years since 1978, we have found that this pattern does not always apply. During two of those five years, a tremendous number were trapped at lower elevations during the summer months. So the initial thinking of seasonal movement patterns and regimes is somewhat suspect.

Although direct reduction has been carried out in the North Carolina side of the park, it has never been fully supported by the North Carolina Wildlife Resources Commission and has been low key at best. With the constant barrage of charges hurled at hog management through the media and of other acts (sometimes taking the form of vandalism), direct reduction activities were curtailed or terminated on the North Carolina side of the park at least a portion of those years between 1978 and 1983.

High elevation trapping takes the form of an individual stationed at a camp along the ridgetops running from one to eight traps and hunting the surrounding area at night with the aid of an artificial light source. This is a very arduous task. Because of the nature of the nylon net traps used at higher elevations, they had to be inspected soon after morning light or they were quickly compromised. Bears become quite adept at monitoring these traps not only to eat the bait but to rob the prize, tripping or destroying the trap in the process. The lightweight trap was necessary because of the prohibition of mechanized and motorized vehicles in proposed wilderness areas. This nylon trap is portable and can be backpacked or horsepacked into the higher elevations.

At lower elevations, the trapping procedure involved single animal captures generally using a small, portable, metal trap. Trapping can take the form of a number of traps set for a short period of time or a few traps set for an extended period depending on the perceived number of animals in that area and trap success.

Shooting activities involved patrol from a vehicle using spotlights and night hikes into known concentration sites. Certain preferred areas of concentration continued to produce the most number of animals per unit of effort.

In the summer of 1981 a second flare up of hog controversy began with the publication of an article in the Wall Street Journal which described government hog hunting in the park. As the political temperature rose, the park was once more placed under a moratorium on the killing of hogs; however, this moratorium was in effect only in the state of North Carolina. Several stipulations were placed on the moratorium. Animals could be shot if they were directly threatening an endangered species or were in the Cataloochee area, which is the last remaining hog-free area in the park. Other than that, they were not to be taken by shooting. The trade-off was the formation of a citizen volunteer action group to trap hogs in the park. They were permitted, under the joint supervision of park personnel and the North Carolina Wildlife Resource Commission, to trap and remove as many hogs as possible. Resource support in the form of traps, bait, and sometimes boats was provided by the park. Animals were transported to acceptable release sites in National Forests in the state of North Carolina. Currently we have about 40 volunteers signed up for the program and an active core of 10-12 individuals. The volunteer program has successfully diffused much of the hostility toward the park regarding the hog issue. It has more than quadrupled the manpower that the park has had to devote to the problem. However, the project has had several drawbacks that are worth mentioning. 1) Volunteers work when they can work, leaving periods of no trapping effort. 2) There is some problem with the capture and release of non-target species. 3) Baiting techniques and trap success are less effective per unit effort than with government personnel. 4) Some hogs have been released, particularly when the whole family group was not captured but was known to be in the area. 5) Hog returns have been documented from volunteer efforts. 6) Trapping has been restricted to areas in close proximity to roads and lakeshores--areas of easy access--with little or no control in more remote areas. 7) Although candidates are screened, volunteers introduce the chance of illegal activity.

Several baits have been employed and evaluated. To date, dry kernel corn, whole kernel wheat, apples, apple pulp, and mash corn have been tested. Dry kernel corn has some application, but the most effective bait has been mash corn. The mixture is made by adding sugar or molasses and yeast to a prescribed amount of corn, allowing the mixture to ferment for 3-4 days, depending upon the ambient temperature. This mixture is then spread in a path leading into the trap.

Several weapons have proven effective in shooting activities. Either the .44 magnum or the .357 magnum is the preferred sidearm. Most rangers carry the .38, which does not seem to be as effective. The 12 gauge shotgun with 00 buck is preferred as the long gun. The .243 or larger calibre is effective in open areas. For night hunting, an artificial light source directly affixed to the gun has proven effective.

Figure 1 summarizes the number of hogs removed per year from 1978 to 1983. Thus far in 1983 we have removed about 500 animals (note: total for 1983 was 520), 262 of which have been the result of the North Carolina volunteer effort. Examining the average number of hogs removed by month for the same time period shows peaks in June and July (Figure 2). For the 1980 data, we compared hunting and trapping effectiveness (Table 2). Shooting/hunting required 6.6 manhours per hog removed and trapping 9.4 manhours per hog, indicating that shooting is the more effective method.

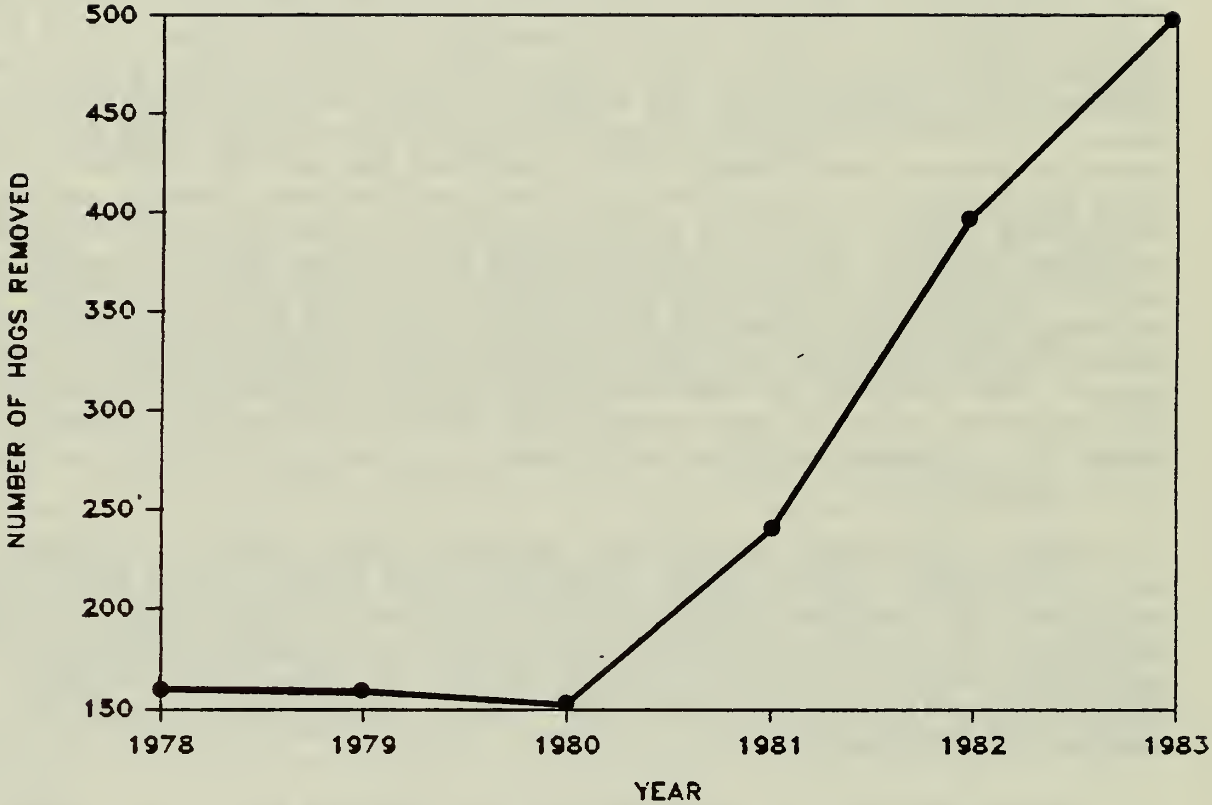

Figure 1. GRSM wild hog removals for the period 1978 - 1983

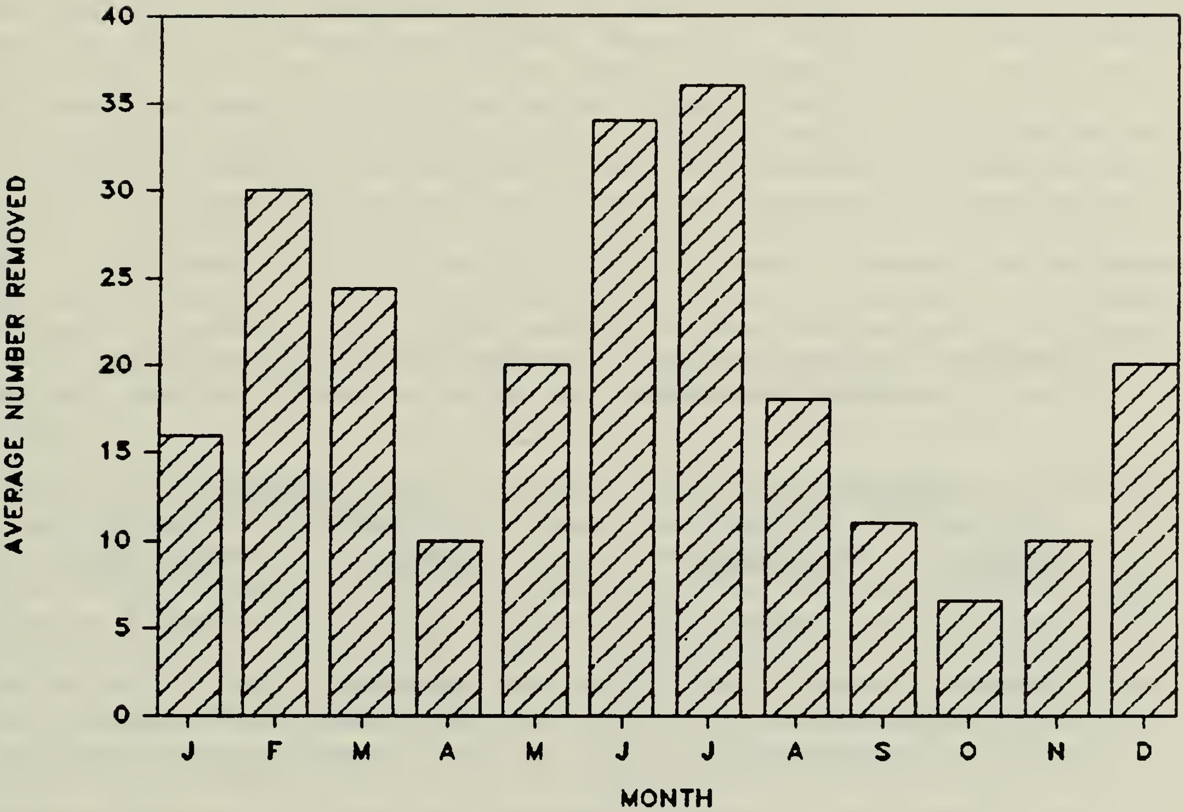

Figure 2. GRSM wild hog removals averaged by month for the period 1978 - 1983

Table 2. Number of manhours per hog in hunting and trapping operations, GRSM.

HUNTING		TRAPPING	
No. of Manhours	No. of Wild Hogs	No. of Manhours	No. of Wild Hogs
439	66	711.5	75.5
Average - 6.65 manhours/wild hog		Average - 9.4 manhours/wild hog	

Monitoring Wild Hog Rooting in Great Smoky Mountains National Park

Christopher Eagar, Ecologist, Uplands Field Research Laboratory

The European wild hog (Sus scrofa) has been a significant resource management problem in Great Smoky Mountains National Park (GRSM) since its invasion in the 1940's. Control activities have been conducted since the 1950's, and since 1976 there has been a gradual increase in control effort and numbers of animals removed (see Coleman, page 18). During this time there has been no means of evaluating the effectiveness of these efforts. Under ideal conditions, the population size and annual dynamics should be known and control results compared with these data. However, the habits of the hog and the terrain and vegetation in GRSM make this ideal condition impossible to attain within reasonable funding levels and time restraints. There is one behavioral trait of the hog which can be used to monitor its activity--the damage to the forest floor by rooting for food items. Although rooting damage should not be correlated to population size, changes in the extent of damage, determined by a statistically valid sampling scheme, can be used to evaluate the relative success of control efforts. Additionally, such a monitoring scheme can provide information on the best locations for focusing control activity.

This project was designed by Uplands Field Research Laboratory personnel in coordination with Dr. Gene Wood (Clemson University). The overall objective is to develop a method of monitoring hog rooting activity in GRSM. Specific efforts during summer 1983 have focused on two main questions which need to be addressed prior to the design and implementation of the park-wide monitoring program. 1) Does the trail system provide a valid representation of the extent of rooting activity when compared with randomly located cross-country routes? Many of the trails in GRSM are restricted to two topographic categories--coves or ridges--with only occasional traverses of the slopes between. From a cost effectiveness standpoint, trails have obvious advantages; however, if there is a misrepresentation of hog rooting due to less than random sampling of certain habitat types when using trails, these advantages are significantly compromised. 2) What subset of vegetation and terrain parameters best characterize the habitat utilized by the hog for rooting during summer? This information is necessary for extrapolation of the geographically restricted trails versus cross-country study to the entire park.

Two watersheds were selected as the study area: the Middle Prong of the Little River (Tremont) on the north side of the park and Hazel Creek on the south side. They are juxtaposed on either side of the state-line ridge, provide good representation of the broad range of community types and topography found within GRSM, and have long and similar histories of hog activity. Trails and cross-country routes were treated as 20m wide belt transects. All hog rooting and wallows within this belt were measured, assigned one of three severity categories, and their location marked on 1:24,000 USGS topographic maps. At each rooting site, both objective and subjective evaluations of the plant community and topographic features were made. Similar plant community and topographic data were also collected at systematic intervals along each route (every 200 ft elevation contour) in order to describe the entire transect and provide information about habitats not used by hogs. Additionally, measurements were made on topographic maps to determine total transect area and the area within topographic classes (ridges, open slopes, coves, etc.) and 1000 ft elevation classes. These measurements are needed in order to express area rooted in relative terms since field sampling restrictions did not provide equal sampling between trails and cross-country routes within all parameters of interest. (It would be desirable to include other habitat descriptors in these map measurements--e.g., area per transect by forest cover type and understory type--but current level of mapped resources prevent this.)

Analytical methods will include calculation of percent area rooted for each transect, as well as subdivisions by topographic class and elevation class. These relativized data will be used in testing how well the trails sample hog rooting when compared to random cross-country transects. Discriminant analysis will be used to identify plant communities and topographic parameters associated with several levels of hog rooting activity.

Results will be used in the design of the park-wide monitoring program. The subset of parameters which best describe rooting habitat will be used to evaluate trails throughout the park for their suitability as index routes. In areas of GRSM which have few trails, these results will be used to locate appropriate cross-country routes. We hope to accomplish this using the new Denver Service Center computerized data base for GRSM, which is in the final stages of development. This will include a digitized vegetation map; digitized terrain and elevation maps; and digitized roads, trails, streams, land use history, and other features. This digitized data base will also be used in evaluating other aspects of the index routes; e.g., the degree of proportionality within certain stratification parameters. This capability will significantly reduce the amount of field data that will have to be collected to characterize and validate each route. We hope to have the first park-wide hog rooting monitoring effort during 1984.

Exclosure Research in Great Smoky Mountains National Park

Peter White, Botanist, Uplands Field Research Laboratory

Objectives of the exclosure studies are twofold: 1) to document the impacts of wild hogs, and 2) to document recovery times and characteristics of plant communities with hog removal. The present study dates from 1981 and involves five sites which measure 8m x 18m, with two matching controls at each site. Additional exclosures are planned for the coming year. Exclosures were constructed of cyclone fence buried 6-8 inches below ground with corner posts and posts along the side set in concrete. An earlier exclosure study (1976-1979) was conducted by Frank Singer and Susan Bratton of Uplands Laboratory. It consisted of seven smaller exclosures measuring 8m x 8m. These were not constructed with strong enough materials and were broken into by the hogs during the year of mast failure in 1979. The Wood Report (see Wood, page 12) at that time recommended constructing larger exclosures of stronger materials, and we are still in the process of doing that.

Both the 1976 and 1981 studies centered on beech-dominated forests at high elevations. This is a phase of the northern hardwood forest and was used because: 1) rooting damage was concentrated there in the summer; 2) food habits studies had shown the importance of spring beauty (a spring-flowering understory herb in these stands, which has a starchy underground storage organ, a corm) in the diet of these animals; and 3) the beech forests are a unique Southern Appalachian community with a number of rare plants and animals of both national and state significance. The beech forests include a more restricted habitat called the beech gap, a name resulting from the dominance of beech and the topography in which it grows. We concentrated on high elevation, mesic, rich herbaceous understory forests, usually on gently, north-facing and ridgetop slopes. Because these forests are highly variable, we wanted to control for as much of the non-pig variability as possible. Within the beech forest type, sites were selected in terms of history of rooting impact. Two of the five sites were located near Spence Field (and represented the heaviest damage), two near the Double Springs area (representing intermediate damage), and one at Pretty Hollow (which had no rooting damage at the time the exclosure was established). A second factor in the establishment of the exclosures was to place them to minimize visibility from the trails.

The sampling regime consisted of contrasting data in the following ways: 1) exclosures versus controls on a given site for both spring and summer seasons, and 2) the number of years that recovery has been ongoing in an exclosure. Sampling is twice annually for shrub and sapling plots; twice annually for herbaceous and tree seedling plots; and less frequently for canopy stem diameter, growth, and composition. The kinds of data collected are: rooting cover and rooting depth, herbaceous cover and species frequency, shrub cover and frequency, tree seedlings and saplings cover frequency and density. In addition, within the exclosures and controls all tree stems are mapped and individual quadrats are permanently marked so that we can follow the behavior of the plot as a whole or the behavior of individual clumps of plants within the quadrat. Because of the natural variability in beech forests, we do not contrast one site to another but focus on internal contrasts at one site.

Preliminary analysis of 1983 data indicate that total herbaceous cover within the exclosures was approximately 70 percent while the range for the controls was 20-50 percent. Although total cover returned quickly to pre-disturbance levels, the species composition was slow to return to pre-impact levels. A few plants which were resistant or non-food items increased when the area was protected. However, some of the food items did not recover very quickly, particularly if they had been extirpated from a plot. Thus, there was a rather fast recovery in terms of cover but not in terms of species composition. Examination of the rooting values (the percentage of ground rooted) showed that exclosures had no rooting. Controls at Spence Field had between 65-95 percent rooting, Double Springs between 36-44 percent, and Pretty Hollow had no rooting. Contrasting food and non-food items at Spence Field, violets (a food item) composed 21 percent of the herbaceous understory in the exclosure and less than 1 percent in the controls. _Athyrium asplenoides_ (a non-food fern) was higher outside the exclosure. On another site, _Angelica triguinata_ (a food item) made up 8 percent of the cover in the exclosure but only 3-4 percent in the controls. This is in contrast to another non-food fern species which was the same inside and out of the exclosure.

Biological Implications for Control of European Wild Hogs: Some Reflections on the the Past and Present

Michael R. Pelton, Department of Forestry, Wildlife, and Fisheries, The University of Tennessee

My active involvement in research on the European wild hog in Great Smoky Mountains National Park spanned the years from 1971 to 1974. This effort produced eight M.S. theses in the Department of Forestry, Wildlife, and Fisheries, The University of Tennessee, on a variety of topics dealing with the biology of hogs.

At the outset we realized that one of the first and most important goals was to develop an index to abundance for hogs in the park. Some reliable assessment of population density was, and still is, the only way to adequately measure the impacts of any management actions. Rooting activity seemed the most obvious, economical, and reliable means of monitoring the population. Consequently, we developed a Rooting Extent Index (REI) (Chris Belden, M.S., 1972). At the present time I am unaware of any other biological "signs" left by hogs in the mountains that could be used as a reliable index other than rooting.

Another past project evaluated the effectiveness of control techniques being used by the National Park Service. In 1972 our report (Fox, M.S., 1972) concluded that extirpation was unlikely because of the basic biological potential of the species and relative inaccessibility of large portions of the park for application of adequate controls, boundary areas continually replenishing the population, and illegal restocking efforts by local hunters. However, we felt that there was a good possibility of hog control in critical, more accessible areas, using traditional techniques. These traditional techniques--trapping and shooting--in my opinion still have much room for improvement.

During 1971-1974 my graduate students were able to remove a lot of hogs in a short period of time with very limited resources. Animals collected generated other studies: Bob Duncan (M.S., 1974) on reproduction and Doug Scott (M.S., 1973) on food habits. We found many similarities between the hog population in the park and the population on the Tellico Wildlife Management Area, Cherokee National Forest (TWRA studies). Hogs in the park reach puberty at only a few months of age; however, this is influenced by mast crops each year. We were surprised by the relatively small litter sizes but, on the other hand, we collected data that indicated at least one female produced two litters in one year. Thus, it appears that the species does possess the potential of two litters per year. We also pointed out the possibility of using farrowing range or farrowing peaks as an aid in control techniques.

In terms of food habits, we recommended that an annual mast survey be conducted by NPS personnel; such surveys are now conducted in the park. One important missing ingredient is microhistological studies on food habits of the European wild hog. Only through such detailed analyses can the food habits be adequately assessed; such a study has not been accomplished to date.

In conjunction with collecting food habits and reproduction information, we also collected blood (Williamson, M.S., 1972) and other biological information to develop some picture of the relative seasonal condition of hogs (i.e., spleen and adrenal weights, parasite loads of gastro-intestinal tracts, and femur/mandible fat). The proposed application of such biological data was to delineate when the species was in its poorest condition and, thus, increase control efforts at that time. Because of lack of funding, this work was never completed.

In trying to develop more accurate and reliable age structures for the population, Tom Henson (M.S., 1975) worked out techniques for increasing the accuracy of aging hogs. Using a few known-age animals provided by the Tennessee Wildlife Resources Agency, we were able to devise a formula for extending the aging of animals beyond 26 months.

Other students working under Drs. Boyd Dearden and Ralph Dimmick in the Department of Forestry, Wildlife, and Fisheries (Strickland, M.S., 1972 and Cherry, M.S., 1975) analyzed mast survey information and developed a simulation model to assess the indirect competitive interaction between hogs and other native species. One of the conclusions was that mast consumption by hogs was relatively unimportant when compared to consumption by gray squirrels. The above outlines the extent of our research involvement on various aspects of the European wild hog in GRSM. This research was funded by Tennessee Wildlife Resources Agency, the Great Smoky Mountains Natural History Association, and the Department of Forestry, Wildlife, and Fisheries. No support was obtained from the National Park Service.

Some additional comments relating to the biology of the species and hog control follow:

There are some basic biological parameters that have been attributed to the hog population in the park that I feel are in error. One is that this population has been growing at an exponential rate of increase since its first appearance in the park. I do not feel that the population has ever grown at such a rate or ever will. In this instance the loss of the stable and staple food supplied by the American chestnut and its replacement by relatively unreliable oak mast is a blessing in disguise! Hogs do not reproduce at or near their potential during years of poor oak mast production. The above may be one of the keys to controlling hogs in the park; that is, increase control efforts during periods of poor mast production. The animals tend to be in poorer physical condition and forage closer to more accessible lower elevations, making them more vulnerable for removal.

Another biological assumption is that the park was invaded by naturally dispersing hogs. I do not feel the movement of hogs into the park has been a natural invasion. Occupation of park habitats can likely be compared to the so-called natural dispersal of coyotes into Tennessee in recent years; in both instances, humans have had a hand in such dispersals (or invasions) by releasing animals into previously unoccupied ranges. An underlying point here, also, is that such unnatural assistance could continue in the future and thwart efforts at extirpation.

There is also inherent danger in extrapolating from either limited data and/or extrapolating from data from other hog studies in the U.S., Europe, or Asia. While much can be learned from such bits of information, conclusions derived should be scrutinized carefully before application to GRSM situations.

Historically, there has been much discussion about the use of chemosterilants, antifertility agents, or the introduction of exotic diseases as potential methods for controlling hogs; a great deal of research already has been conducted in these areas on other species. To date we do not seem to be much closer to developing such a means of natural population control. Since the hog is a "generalist," it is difficult to conceive of a biological control technique that would be species-specific to only hogs and not affect other native wildlife. This appears to me to be an insurmountable problem.

My involvement with this species and its problems brings up some additional final points.

1) Because of the biological potential of hogs in the park, the NPS must be allowed to practice direct reduction in inaccessible areas of both North Carolina and Tennessee. It is vital that this be done in order to effect any semblance of control on the population.

2) Because of the indeterminate nature of growth rates of the population from year to year (varying food supply), a great deal of flexibility in manpower and a substantial budget will be required to effect any semblance of adequate controls.

3) Hunting and trapping are still <u>the best</u> means of control for a generalist like the European wild hog. I feel there is much room for improvement in these techniques in the park.

4) In terms of continued research, there are significant conflicts between collection of biological data and any concomitant, extensive control efforts. There are enough natural environmental variables working on the population without confounding them with human-induced variables. Consequently, trade-offs and/or compromises should be carefully considered before initiating future field research.

5) Finally, the best management strategies are derived from biological data collected on a systematic, organized, and long-term basis. Only through long term studies can sound and reasonable judgments be made.

Veterinary Perspectives on Control of European Wild Hogs

Jim Jensen, College of Veterinary Medicine, University of Tennessee

I would like to discuss two categories of control today: infectious diseases and chemical control. However, I want to say that I agree with Mike Pelton (see page 25) that neither of these is likely to play a major part in control of hogs in Great Smoky Mountains National Park.

Any disease that could be considered for introduction in the park should have the following characteristics. First of all, it should be swine specific. It should be highly contagious through direct contact and have low natural resistance. It should not be vector borne, to prevent spread to domestics surrounding the park. It should result in fatality or sterility. Optimally, it would also have a carrier state to cause the disease to continue after the initial outbreak.

Some diseases which are unacceptable are hog cholera, African swine fever, and teschen. These are viral and swine specific; however, they are foreign diseases, and the U.S.D.A. will prevent our getting them into the country. Pseudorabies is a viral disease that can be very dangerous but has a multi-species effect. We would not want to introduce a disease that could affect our deer, bears, etc. Leptospirosis, erysipelas, and salmonellosis are bacterial diseases not specific for swine species.

Swine-specific diseases which might be considered include SMEDI, a viral disease causing still birth, mummification, embryonic death, and infertility, and TGE--a viral disease primarily of young swine. Brucella suis, which may be the best potential disease for control of swine, has a devastating effect on reproduction. It also has a carrier state to prolong infection. While it is fairly specific for swine, it has been known to produce titers in other animals as well as mild infection in some. Moreover, it could affect people who might eat the meat from infected animals, and I suppose we deceive ourselves if we think there is no hunting in the park. Bordatella bronchiseptica causes atrophic rhinitis but is not high on the list of potential agents because it is not highly contagious and requires crowding for spread. It can also cause pneumonia-like diseases in canids. I would like to reiterate that I am not a proponent of any of these because there are too many inherent problems. The views of farmers and wildlife agents on the introduction of disease into the mobile population in the park must also be considered.

Chemicals have been shown to be ineffective in controlling wild animal species in the past. Dicoumarol, a widely used rat bait, causes hemorrhagic problems and often delayed death. A positive point is that it seldom has secondary toxicity and, therefore, would not present problems for carrion eaters. Cadmium, although it might affect other species including humans, has severe effects on reproduction--from testicular atrophy to acute necrosis of the testes. It concentrates in testicular tissue, and sterility can come about within 24 hours of consumption. Furthermore, it affects pregnant females more than non-pregnant ones, resulting in abortions. Estrogens and estrogenic plants could also help in hog control. They affect sperm counts if given in proper dosages and cause male libido to decrease. There is contraception in females. Secondary effects include tumors in adults and offspring, abnormalities in offspring, bone marrow suppression and death from anemia, and thromboembolic episodes resulting in vascular clotting and causing death. Progesterones decrease vaginal pheromone production and may prevent estrous females from attracting males in the breeding season. Corticosteroids, although an unlikely choice, can have a feedback effect on the pituitary gland and stop its stimulation of the sex organs. Gossypol, a product of cottonseed meal, is the best choice for controlling the hog population in the park. It is known to cause sterility in laboratory animals and is being investigated as a human male infertility drug in Oriental nations. It reduces spermatogenesis and results in infertility. Higher doses also cause congestive heart failure and death. Swine are more susceptible to this product than many other mammal species. Another positive point is that it is relatively inexpensive.

One interesting point about chemical controls is that if we could find the right one to use, we could sterilize the adult population and hopefully not interfere with the social structure of the species. Dominant males, if they could be sterilized, would still attempt to breed and exclude other subordinant, possibly fertile, males.

As a veterinarian, I urge you to consider the humane--or inhumane--aspects of these diseases and chemical agents in evaluating their potential for controlling the European wild hog population. We must also consider what the U.S.D.A., state wildlife agencies, and local farmers would say about such practices. Administering and monitoring a project of this nature would be difficult and expensive. Evaluation of the effectiveness of a disease or chemical control would be essential. We might, however, consider using them following a mast failure or when the population is suffering otherwise, but only as an adjunct to hunting and trapping efforts.

Modeling Hog Populations

Boyd Dearden, Department of Forestry, Wildlife, and Fisheries, The University of Tennessee

Program ONEPOP (Gross et al. 1973, Roelle 1977) integrates three processes which determine population size: reproduction, natural mortality, and harvest. This program has been modified to fit the biological and life history properties peculiar to the mountain lion and renamed LIONPOP (Sheriff 1978). LIONPOP is currently being modified for these properties of the wild hog and will be renamed HOGPOP.

LIONPOP has several features that would be especially important in modeling wild hog populations. Recruitment of young animals can be scheduled so that reproduction can occur throughout the year by any proportion of the female population. Another feature, the immigration-emigration routine, is helpful when modeling a small group of animals with a limited amount of movement to and from the area of interest.

There are three basic components of LIONPOP. The input component is used to place the required input data into the memory of the computer for processing by the population simulator. The population simulator consists of a series of mathematical statements that represent the processes of birth, natural death, harvest, and movement of the animals from and into the population. The population manipulator calculates the number of births, animals immigrating or emigrating, and deaths (both by natural means and by harvest) for each year of a simulation of a population, up to a maximum of 100 years. The output component is used to print computed results from the simulation trail.

For the purpose of this workshop, a discussion of the population parameters needed for the operation of LIONPOP (HOGPOP) seems appropriate. The following basic parameters are necessary for utilizing the program: 1) maximum age to which a male or female will live, 2) the number of males and females in each age class divided into mortality periods into which they were born at the start of the simulation, and 3) crude natural mortality rates for males and females for each age class or subgroup for each mortality period.

We also need information about births into the population: 1) the proportion of all young that are males, 2) the minimum ratio of sexually mature males to females considered necessary to maintain a viable population at the time of breeding, 3) the proportion of all sexually mature females giving birth for each mortality period, 4) the minimum ages that males and females become sexually mature, and 5) the maximum ages that males and females are still sexually mature.

There are three main options for finding the number of births in the population. The first is density-dependent reproduction which requires the following parameters: 1) time or times when population density is calculated for use in the calculation density-dependent reproduction; 2) the number of groups that females are divided into for defining the density-dependent rates for each age group and the age classes that are included in each age group; 3) the intercept and slope of the conception (pregnancy) rate for each age group; 4) the intercept and slope of the ovulation rate for each age group; 5) the maximum conception (pregnancy) rate for each age group; 6) the maximum ovulation rate for each age group; and 7) population size of males and females if breeding for a mortality period was prior to the start of the first year of the simulation. The second main option is reproductive crop, the number of young produced in each mortality period. The last option is using reproductive rate, the number of young per 100 sexually mature females.

Parameters on the harvest of the population are also necessary. While the National Park Service may not be interested in the part of this subroutine that deals with trophy animals, some other aspects are applicable. Information needed includes: 1) minimum age classes of males and females considered to be trophy animals, 2) maximum age classes of males and females considered to be trophy animals, 3) minimum age when trophy males can be distinguished from non-trophy males, 4) age-specific harvest rate component for males and females of each age class. These age-specific harvest rates are probably most important to NPS. They are based on a relative scale, usually representing the effort a hunter puts into hunting a certain age class.

Again, this model allows flexibility in finding the harvest rate for the population. There are four primary options: 1) A constant rate can be used for all years and would require knowing the probability that either a male or female is harvested from the population. 2) A variable harvest rate can be used; this would require the probability that a male or a female is harvested from the population for each year that the option is used. 3) A set number of animals can be harvested from the population each year. 4) The desired density at the end of the harvest period can be determined, and the model will indicate how many animals must be removed to attain that density.

Currently, LIONPOP (HOGPOP) is being adapted to run on the main frame computer in batch mode at the University of Tennessee. Once this is completed, an interactive version will be developed. We would also like to develop a version for the IBM/PC. Once the model is running in the interactive mode, the next step will be to validate it by using real population parameters from data collected by the Tennessee Wildlife Resources Agency. After the model mimics as closely as possible the real population from TWRA, biologists from other areas will be contacted to simulate other populations of wild hogs for which they have data.

Effectiveness of Hunting Methods for European Wild Hogs in the Tellico Unit, Cherokee Wildlife Management Area, Tennessee

Richard H. Conley, Tennessee Wildlife Resources Agency

Several types of managed hunts have been conducted on the Tellico Unit of the Cherokee Wildlife Management Area. Basically two methods are permitted: still hunting and dog hunting. Still hunting is defined as stalking hogs on foot or waiting for them at certain locations called stands. Dog hunting is driving hogs with dogs, with hunters in pursuit or waiting at stands and taking the animal as it is chased or bayed. In general, still hunting is used by individual hunters while dog hunting is employed by organized groups of hunters.

The objective of this presentation is to evaluate the effectiveness of hunting European wild hogs by different still-hunting methods and dog hunting.

The 78,500-acre (123 square miles) Tellico Unit is located in the southern Appalachian Mountains, Monroe County, Tennessee. The management area is part of the Cherokee National Forest, and management is a cooperative project between the U.S. Forest Service and the Tennessee Wildlife Resources Agency. Harvestable populations of big game on the area include white-tailed deer, black bear, European wild hog, and wild turkey.

Hunting data were compiled from "managed" big game hunts conducted on Tellico area from 1949 through 1972; however, hog and bear hunting was prohibited in 1970 and 1971. Managed hunting is "any form of hunting during which controls more rigid than those imposed by general hunting laws are exercised over the hunter on his method of taking various species of wild game" (Mosby 1952). All hunters were required to have a special permit and to check through one of three checking stations before hunting and upon leaving the area following completion of the hunt. In 1966, however, the regulation requiring hunters to "check out" upon completion of their hunt was discontinued. Hunters making a kill were still required to check their animal through one of the checking stations for examination and tagging.

All hunts were conducted in October and November. They were two days in length and the number of hunts varied from year to year.

The still hunts were subdivided into four types: Individual Still Hunt, Party Still Hunt, Wilderness Hunt, and Bear and Wild Hog Still Hunt. In the first three listed, deer, bears, and hogs were legal game; one of each species of either sex was the bag limit. (Either sex deer hunting was not legal, however, until 1953.) The use of dogs was prohibited in all Still Hunts.

The most popular was the Individual Still Hunt. This was a quota hunt with a maximum of 1400 hunters; each hunter applied individually. A drawing determined successful hunters. This hunt began in 1949 and continued through 1972.

The second type of still hunt was the Party Still Hunt. It was applied for by parties, which consisted of a minimum of 60 hunters and a maximum of

100; a drawing determined the parties chosen. An eight-party quota was the limit, and each party was assigned a compartment in which to hunt. The objective of this type of hunt was to have a party of men hunting together by driving. Drive hunting is conducted by hunters dividing into two groups; one groups places themselves at likely stands while the other attempts to drive the game past the standers by walking through a given area towards the standers. This hunt began in 1962 and continued through 1972.

The third type of still hunt was the Wilderness Hunt. This was conducted in the northern section of the Tellico area (61.5 square miles) and camping in the area was required. There was no hunter quota. The purpose of this hunt was to harvest game in areas which received very little hunting pressure. It was held for three days and was always the last hunt of the season. This hunt began in 1963 but was discontinued after 1969 because of litter problems caused by hunters and hunter-safety considerations.

The fourth type of still hunt was the Bear and Wild Hog Still Hunt. One of each species of either sex was the bag limit. This was a non-quota hunt. It was first held in 1951 and 1955 through 1963, after which it was again discontinued because of a lack of hunter interest.

The only dog hunt conducted was the Party Bear and Wild Hog Hunt. It was applied for in parties, which consisted of a minimum of 40 hunters to a maximum of 100; a drawing determined the parties chosen. One bear and wild hog of either sex was the bag limit. A four-party quota was the limit, and each party was assigned a compartment in which to hunt. Most of the parties hired guides and dog handlers. The objective of this hunt was to have a party of men hunting together with dogs. Hunters were placed on stands where bears or hogs were likely to pass when fleeing from dogs. However, dogs often bring an animal to bay, making it necessary for a hunter nearby or one of the dog handlers to reach the animal and make the kill before it escapes, injures, or kills the dogs.

Of the four types of still hunts, the Bear and Wild Hog Still Hunt ranked as the most successful. The percent hunter success was the highest and the hunter success ratio and the hunters per square mile were also the highest (Table 3). However, this type of hunt was only held for ten years and was discontinued after 1963 because of lack of hunter interest. This lack of interest was somewhat difficult to explain in view of these excellent statistics. Some of the older employees of TWRA believed that many of the hunters who had participated on this hunt thought their chances of bagging a hog or bear were better on the dog hunt and subsequently participated mostly in the dog hunt.

The Individual Deer, Bear, Wild Hog Still Hunt had the second highest percent hunting success, second highest hunter-success ratio, and highest number of hunters per square mile (Table 3). The data from this hunt indicate that ample hunting opportunity could be provided without over-exploitation of the hog population.

Table 3. Summary of hunting pressure on European wild hog, still and dog hunts, Tellico Unit, Cherokee Wildlife Management Area, Tennessee, 1949 through 1979.[a]

Type of Hunt	Years Held	No. Hunters	Hogs Killed	% Hunter Success	Hunter-Success Ratio	Number Hunters/ Sq. Mile	Total No. Hunting Days
STILL HUNTS							
Individual Deer, Bear, Wild Hog	1949-1969, 1972	46,742	862	1.8	1:54.23	18.09	166
Party Deer, Bear Wild Hog	1962-1969, 1972	5,436	77	1.4	1:70.59	4.91	18
Bear, Wild Hog	1951, 1955-1963	2,178	79	3.6	1:27.57	1.96	20
Wilderness Deer, Bear, Wild Hog[b]	1963-1968, 1972	11,132	128	1.1	1:87.00	12.92	21
DOG HUNT							
Party Bear, Wild Hog	1949-1969, 1972	17,469	794	4.5	1:22.00	6.76	180

[a]Hog hunting was prohibited in 1970 and 1971.

[b]Confined to the northern portion of the Tellico Unit (61.5 square miles).

The Party Still Hunt ranked third in percent hunting success, third in hunter-success ratio, and had the second lowest number of hunters per square mile (Table 3).

The Wilderness Hunt had the lowest percent hunter success and hunter-success ratio and ranked second in terms of most hunters per square mile (Table 3). This hunt was always the last hunt of the season and was held in an area considered to be remote and most challenging in terms of hunter access and varied terrain. These factors may account for the poor kill statistics for this method.

Three elements appear to be common to the Bear, Wild Hog Still Hunt and the Party Dog Hunt: organization, experience, and driving. Both types of hunters planned their hunt in advance; they knew how and where to place hunters on stands, the habits of the hog, the terrain, and how to drive with men and dogs. These characteristics may account for their similar success.

Hunting hogs with dogs does appear to be more efficient than still hunting. However, there are many people-related problems with this type of hunting, such as attitudes of the dog hunters and controlling dogs to hunt wild hogs.

Still hunting hogs did not appear to be as effective as hunting with dogs. However, experienced, highly-organized still hunters or a large number of hunters in a given area may predispose a hog population to high mortality by hunters.

Sustained Yield Management Studies on Wild Hogs in Florida

Robert C. Belden and William B. Frankenberger, Florida Game and Fresh Water Fish Commission

Wild hog research by the Florida Game and Fresh Water Fish Commission is not so much concerned with the control of hogs as it is with sustained yield management. The wild hog is viewed by many Florida hunters as a desirable big game animal. It occurs on most state wildlife management areas and is harvested in numbers comparable to the white-tailed deer.

The major difficulty encountered by the Commission in its attempt to manage wild hogs has been the inability to maintain hog populations in the face of heavy hunting. Re-stocking is expensive and is fast becoming unfeasible because of restricted sources of wild hogs to trap and restock. Wild hog management strategies that maintain optimum breeding stock are needed in order to terminate expensive re-stocking programs.

The overall objective of the Commission's hog research is to develop hunting regulations that will permit sustained yield management of wild hogs on public hunting areas. The research being done can be divided into three more-or-less interrelated segments involving four study areas: 1) hog reproduction, 2) harvest strategies, and 3) dispersal and survival of stocked hogs.

From September 1977 to April 1979, the hog population on the Brunswick Pulp and Paper Company area in Levy County was studied primarily to look at reproductive parameters. During this period, 121 hogs were captured, sexed, aged, weighed and measured, blood and fecal samples taken, tagged in both ears, and released at the capture site. Thirteen sows were laparotomized. During the operation, number and size of ovarian structures and the number and size of any fetuses were determined. Seven of these sows were fitted with radio-transmitter collars and released at their capture sites and several were freeze-branded. Freeze-branding was tested as a permanent marking technique that would be more observable than present tagging techniques, but proved to be unsuccessful. Litter size was determined by: 1) number of fetuses, 2) size of trapped litters, 3) field observations of pigs per sow, and 4) number of functional (swollen) teats on lactating females. Farrowing peaks were determined by: 1) aging and back-dating fetuses, 2) aging and back-dating trapped pigs, 3) aging and back-dating adult hogs, and 4) field observations of sows with young pigs.

Data obtained on the Brunswick Study Area was used in planning the harvest simulation study on Lykes Brothers Fisheating Creek Wildlife Refuge in Glades County--the second segment of the research. From July 1978 to June 1979, a "pre-treatment" study was conducted on the hog population on the 8000 acre Fisheating Creek Study Area to examine physical condition, reproductive potential, food habits, and parasites and diseases. An attempt was made to collect two males and two females in each of three age classes (adult, subadult, and juvenile) on a monthly basis by using catch dogs or shooting. Ninety-three hogs were collected, weighed, measured, and examined.

For aging purposes the skull and mandibles were cleaned, and after a minimum of six months in 10 percent formalin, the lenses were removed from the eyeballs and weighed. To evaluate physical condition the adrenals and spleens were trimmed of adhering tissue and weighed, the consistency of the marrow fat from the femur was evaluated, internal and back fat were evaluated, and gross weight and external measurements were used to determine a condition index. Reproductive tracts were weighed and measured and notes kept on the presence of ovarian structures. Fetuses were weighed, measured, and aged when possible. Stomach contents were analyzed for food habits information. The blood samples and smears and internal organs were sent to the University of Florida College of Veterinary Medicine for parasite and disease analysis.

The actual harvest simulation study on the Fisheating Creek Study Area began in the summer of 1979. The goal was to attempt to capture every hog on the study area and selectively remove a portion of the population. This was done by intensively trapping the area during a nine-week period in late summer for five years. The strategy was to keep select breeding stock and try to remove the rest of the population. Selection was based on color, condition, body conformation, aggressiveness, etc.

Each hog captured was tagged, aged, weighed and measured, and ectoparasites, blood, and fecal samples were collected. Notes were kept on general condition and reproductive status. Weights and measurements were used to index physical condition. Ectoparasites, blood, and fecal samples were sent to the University of Florida College of Veterinary Medicine for parasite and disease analysis. During 1979, 226 hogs were captured and 28 were released, but the operation was hampered by vandalism. The captures:releases for the following years were: 1980 - 470:82, 1981 - 407:85, 1982 - 343:62, and 1983 - 685:103. The total for the five years was 2,131 captured and 360 released.

The impact of each year's removal was measured by the next year's trapping success, sex and age ratio changes, and other population changes. Also, mast production and water levels were monitored on the area during the study period. Mast was monitored by estimating acorn production of 250 oak trees using the "Whitehead Index" (Whitehead 1969) and subjectively evaluating cabbage palm and palmetto mast. Ultimately, we hope that a model can be developed using this data that will assist in predicting populations and harvests on other areas in Florida.

During the trapping operations of 1979-1981, the hogs removed from the Fisheating Creek Study Area were sent to the J. W. Corbett and Everglades Wildlife Management Areas where they were used in studies to determine dispersal patterns of hogs stocked in different seasons and to compare survival of stocked hogs in dog hunt and still hunt areas.

All of the data from all segments of the research are presently being analyzed and final reports being written. It is hoped that from this analysis we can develop new hunting regulation strategies which will then be tested on public hunting areas under actual hunting conditions.

Hog Control Methods in Hawaii

Reginald H. Barrett, University of California, Berkeley

The following comments are a brief summary of portions of a paper in preparation by myself and Charles P. Stone, Research Scientist, Hawaii Volcanoes National Park (HVNP), with the assistance of Daniel Taylor and Larry Katahira of the park's Resource Management Division. My involvement came about through a seven-month sabbatical spent reviewing the park's pig management program.

While the Polynesian pig has existed in the park area for perhaps hundreds of years, the predominant form now is feral stock resulting from continuing introductions of modern domestic breeds. Park policy is to reduce feral pig populations as rapidly and as completely as possible. Now that feral cattle and feral goats have been nearly eliminated from the park, the feral pig management program is being accelerated.

Prior to 1972 pigs were commonly shot by rangers but few organized control activities existed. Since then a Citizen Hunter Program has provided for selected sport hunters to be deputized and encouraged to hunt in designated pig management units within the park. Daily records of hunter effort and pig kills are kept and summarized monthly. A detailed analysis of all the available records for the past decade revealed that: 1) hunter success was a function of pig density; 2) degree of control was a function of accessibility by road or major trail; and 3) only one pig management unit (around park Headquarters) was successfully cleared of pigs. Over most of the 25 percent of the entire park that is suitable habitat for pigs, populations remain close to carrying capacity (up to 40 pigs per km^2 in the rain forest habitat). At such high densities, up to half of the forest floor is rooted every six months. The Citizen Hunter Program alone is not the solution to controlling feral pigs in HVNP.

In 1980 an accelerated program involving several methods was instituted by the Resource Management Division. Initial fencing trials indicated that, although expensive ($5000/km), a well constructed, woven-wire fence was capable of excluding pigs. Such fencing has been critical in keeping the Headquarters unit pig free following extermination by hunters. Additional fencing is planned for most of the park perimeter and a number of 4-16 km^2 subunits. Fencing is considered essential to separate the park from influence of adjacent lands and to break the overall problem into manageable portions. Maintenance costs for at least the perimeter fences will be high and ongoing in perpetuity.

Initial trials with corral traps were disappointing; therefore, 20 collapsible, box traps with drop doors were constructed in 1983. They are made of aluminum and can be bundled for transport by helicopter. These traps can be set with either a sensitive, treadle trigger or an insensitive, push-rope trigger. The latter allows captures of up to a dozen individuals at once, whereas the former typically captures only the first animal entering the trap. Bait trials have indicated that maggot-producing carrion and papayas are the most attractive baits, but more tests are needed in different habitats and at different seasons. Preliminary trials after a two-week prebaiting period suggest a capture efficiency of about 70 percent per week for the 50-75 percent of the population that is susceptible to baiting.

Special two-person crews of well-trained hunters are now being tested for cost effectiveness in comparison with other methods. It is clear that professional hunters are substantially more efficient than sport hunters, especially with low pig densities. Crews systematically work approximately 125-ha areas with several dogs until catch-per-unit-effort figures indicate pig density is too low for efficient hunting. All pig carcasses are left in the field after sex, age, color, and reproductive information are recorded. There has been no evidence of disease potentially dangerous to humans or other wildlife in these pigs.

In 1983 a new style of snare was tested. Although unsuitable in most other situations, in Hawaii there is no native wildlife at risk. The modified snares are set to garrot a pig, which dies very quickly when hung by the neck. Pigs from 10 to 80 kg have been successfully killed by this method. Since sets do not need to be checked daily, the relative cost effectiveness of snaring may be very good, particularly with low pig densities.

It is likely that ongoing cooperative efforts between management and research to look for the most efficient control system will show that some combination of methods will be optimum. For example, it may be best to start by trapping a dense population, switch to hunting, and finally to snaring. Hunting and trapping (but not snaring) could be accomplished simultaneously by the same crew.

Research efforts are aimed at pilot tests of toxicants as well as bait preference trials, establishment of efficient monitoring schemes for pigs and vegetation, and evaluation of overall control strategies. It is evident that extermination of feral pigs from significant portions of Hawaii Volcanoes National Park is technically feasible, but the cost will be great.

III. MANAGEMENT RECOMMENDATIONS

The management recommendations made in this section of the report resulted from group discussions held at the workshop. Participants were divided into five groups composed of five to seven persons. They were asked to delineate both short-term and long-term alternatives which they felt were most viable for controlling the wild hog populations in GRSM. They were also asked to consider alternatives in terms of cost, manpower, threat to non-target species, other negative ecosystem responses, logistical problems, socio-political ramifications, effectiveness, concurrence with NPS policy, and sex and age specificity. The results of these discussions were then presented to the entire workshop by the designated group leaders.

As would be expected in a forum such as this, some control actions were recommended by all groups and others by only one. However, the fact that a particular group did not suggest a specific alternative should not necessarily be interpreted as their opposing it. Where a group clearly stated their opposition, this is so indicated in summarizing the recommendations. Similarly, when all endorsed an alternative, this is so stated. Positive and negative points about different control actions, which resulted from these discussions, are also incorporated into this report.

Workshop participants expressed concern that personnel in Great Smoky Mountains National Park must establish realistic objectives before initiating any new or expanded control program. Although the park is mandated to remove all wild hogs, the reality of accomplishing this is highly unlikely. There will probably always be a residual population, either in inaccessible areas or around the periphery of the park. However, the concensus of opinion was that the population can be drastically reduced from present levels parkwide and that the species can be totally exterminated from smaller special protection areas. The recommendation was made that the NPS set realistic levels of acceptance of hog damage (reflective of population density). One group recommended defining special protection areas of high resource value and reducing damage to a prescribed percentage (e.g., 10 percent) of the baseline in a specific year (e.g., 1984). Having established this tolerance level, the next step is to make a true commitment--both philosophically and from the standpoint of money and manpower--to achieve the objective. Accomplishing this goal will require utilizing an integrated approach which is comprised of a combination of techniques, developing a means of evaluating management actions, reviewing control techniques on a regular basis, and making changes or refinements when necessary. Management must be flexible, sometimes innovative, to be effective. Likewise, various management actions must be objectively evaluated for effectiveness if the goals of the overall program are to be achieved. Close cooperation between the divisions of Resource Management and Science is essential.

Recommendations of the participants covered nine major areas: 1) increased hunting and trapping, 2) fencing, 3) developing or refining a censusing technique, 4) investigating alternative baits, 5) researching the use of chemical or biological controls, 6) developing a realistic simulation model for the population, 7) improving data collection on animals removed, 8) re-introduction of predators, and 9) improving public relations.

Increased Hunting and Trapping

Participants felt the best alternative for effectively reducing the wild hog population was greatly increased hunting and trapping. This was the principal suggestion made by all five groups although they emphasized that other techniques should be utilized to enhance the success of the control program. One group further stated that trapping should have a low priority in comparison to hunting.

Personnel for hunting/trapping could be composed solely of NPS employees or could incorporate volunteers under the supervision of the NPS. The use of NPS personnel, which was given priority by two groups, could entail employing additional permanent or seasonal persons or establishing a program for using furlough and annual leave employees. Cooperative efforts could utilize the services of citizen volunteer groups (such as that which is presently in existence), interagency personnel (both federal and state), or military personnel on special exercise. One group stated that citizen volunteer groups should be used only in high need situations (e.g., following a poor mast crop) because of potential ramifications (e.g., threat to non-target species, other negative ecosystem responses) and a lack of NPS control.

Several suggestions were made for increasing the effectiveness of the hunting/trapping efforts. Upgrading equipment--guns, nightscopes, traps, etc.--could be quite beneficial but require only moderate expenditures. Greater accessibility to remote areas of the park would not only decrease the manhours required per hog removed but also would allow control in pockets of the population which have not been previously hunted or trapped. One group suggested that the intensity and somewhat restricted locations of present control efforts may even be aiding population growth parkwide. One means of increasing the accessibility would be to allow NPS personnel to utilize existing roads that were closed in recent years with the initiation of the park's being managed as a wilderness area.

To make control efforts more manageable, participants suggested the park be sectioned into watersheds, and efforts concentrated in one watershed at a time. Saturation hunting, perhaps by military or volunteer groups, could increase manpower available and might take the form of a drive hunt utilizing drift fences to channel the animals. Cost effectiveness could further be increased by concentrating efforts in areas thought to have the highest density on a seasonal basis. One group suggested testing different hunting methods with well trained dog packs; however, another group felt that dog hunting should not be allowed in the park. Similarly, one group was in favor of opening the park to closely supervised and regulated fee hunting and another was against this action, stating that this would create an undesirable precedent.

The use of fire was suggested as a possible auxiliary to increase effectiveness of hunting/trapping. Prescribed burns could be used for altering the distribution patterns of hogs. Fire might also be used as a drive technique in conjunction with saturation hunting.

One group suggested negotiating with the Tennessee Wildlife Resources Agency (TWRA) to establish a special category for the corridor bordering the park on the Tennessee side. Opening this area to liberal hunting could be very helpful in dealing with a peripheral population and decreasing immigration.

Participants felt that hunting must be allowed in the North Carolina section of the park, some further stating that the NPS has no responsibility for trapping hogs to be relocated within the states. If state agencies want the animals for stocking in wildlife management areas, they should be responsible for bearing the cost of doing so. Moreover, questions were raised about the self-defeating aspects of relocating these animals because of perpetuating present problems, maintaining the possibility of immigration into the park, and even about the moral responsibility of introducing this exotic species into areas where it does not presently exist.

The cost of equipment and manpower for an increased hunting/trapping program by NPS employees is likely to be quite high but so is its effectiveness. Conversely, threat to non-target species and other negative ecosystem responses are likely to be low. Relying upon cooperative efforts would decrease costs but increase threat to non-target species.

Evidence has indicated that these techniques have substantially reduced hog populations in other areas: Hawaii Volcanoes National Park, Hobcaw Plantation in South Carolina, and the Tellico Wildlife Management Area, where hunters were successful in obtaining a moratorium on legal hunts in 1970-71 because they felt population levels were becoming too low. This pressure on the population must be maintained because the high reproductive potential of the species allows rapid recovery within a very short time.

Fencing

All five groups recognized the need for establishing and fencing primary protection zones within the park; however, one group endorsed such practices only if they could not be avoided. It was recommended that before initiating such a project the type of fencing to be used should be researched as to material costs, costs of installation and maintenance, and effectiveness at excluding hogs. The costs and manpower for this operation would be extremely high but so would be its effectiveness in controlling hogs and protecting natural resources. One group recommended using less expensive materials, closely monitoring exclosures, and hunting/trapping any animals that might occasionally get inside. Hawaii Volcanoes National Park initiated a fencing program in 1980, using 32" fence. Installation costs were $5000 per km, but park officials feel that its contribution to control efforts warrants the cost.

While the size of these exclosures would vary necessarily with the particular area to be protected, the recommended size was between 4-16 km^2. After areas are fenced, it is mandatory to remove all hogs and to closely monitor the area thereafter. Traps might also be built into the fences at intervals to catch animals attempting to enter.

Participants recommended that vegetation changes be monitored within the exclosures after removal of hogs. This could be similar to research presently being conducted by Uplands Laboratory personnel to study recovery rates and species diversity (see White, page 26). Any changes in animal populations (e.g., small mammals, salamanders) within the fenced areas should also be closely monitored. While the impact of fencing on non-target species and its potential for other negative ecosystem responses were generally felt to be rather low, some concern was voiced about the effects of fencing upon movements and behavior of large mammals such as white-tailed deer and black bears. These potential effects should be studied as well.

The use of portable drift fences was suggested to channel hogs into trap sites along known migration routes. This could also enhance the effectiveness of drive or saturation hunts because the animals could be concentrated into a smaller area. The type of fence used in this regard should be researched, but it was mentioned that in Europe a single strand of wire with cloth strips attached at intervals was successful in guiding the movements of hogs.

Although not viewed as a top priority and not to be considered in the short-term, one group suggested that portions of or the entire boundary of the park eventually be fenced. Doing so would require legislative change and be extremely costly, but it would be most effective at preventing future immigration from surrounding areas (not only of hogs but also of other exotic species that might present similar problems in the future) and would aid efforts to reduce the population within park boundaries. Another group suggested that areas outside the present range of the hog or those from which hogs have been removed be enclosed with fencing. They also suggested fencing large segments of the park along the major roads (US 129 AND 441) to separate the park from areas where hogs are being relocated.

Censusing the Population

Participants felt that the development of a censusing technique was essential for evaluating management practices. The terrain of the Smokies and the nature of the wild hog probably preclude the use of more traditional wildlife censusing tecnhiques; therefore, monitoring hog impacts by measuring rooting damage is likely to be the most realistic method of assessing relative population changes. The project initiated in 1983 by Uplands Laboratory (see Eagar, page 24) should be continued, making adjustments and refinements in the methodology when they are deemed necessary. The benefits of the project extend beyond locating population centers for hunting/trapping purposes. Changes in the rooting index could be plotted against the cost of control actions for a specified time frame to obtain a regression line useful in evaluating cost effectiveness of the management program. Hunter success is a function of hog density; as the population decreases, more effort (and money) must be expended for each hog removed. Therefore, use of this rooting index to cost regression could be helpful in determining future budget requests.

The use of non-traditional surveillance techniques was also recommended in this regard. Aerial surveys utilizing aircraft with experienced observers could be used to locate hogs, especially after snowfall when the animals would be more visible. The use of infrared photography was also suggested since the animals' thin coats would allow their body heat to be detected when contrasted to a cold background. These aerial techniques would allow for only crude estimates of population or changes in density, but they could be effective in locating areas of animal concentration for hunting or trapping.

Alternative Baits

Three groups recommended that alternative baits should be systematically investigated. A more effective bait could greatly enhance trapping success. While no definite experimental design was recommended, it was suggested that this research would likely necessitate direct observation and quantitative measurement of the attractiveness of the alternatives. It was also suggested that chemical and/or biological attractants be included in this study. If an attractant could be found and concentrated, this would further facilitate trapping efforts by negating the necessity of carrying large amounts of baits into the backcountry. The practicality of investigating such attractants was substantiated by recent research in Germany. European wild hogs have traditionally been used to hunt truffles in Europe. Scientists have now found that one of the ingredients in truffles is a substance also present in the saliva of male hogs searching for a mate. This undoubtedly has potential for attracting estrous females into traps and could have a definite impact on reproduction within the population.

The ultimate objective of this research would be the development of a species-specific bait. Although the likelihood of discovering such a substance for a generalist like the wild hog is very low and the cost quite high, it could facilitate the use of chemical or biological controls without endangering native species.

Chemical or Biological Controls

Three groups recommended that research into chemical or biological controls be investigated as a long-term possibility for reducing the wild hog population in conjunction with hunting/trapping. Conversely, one group felt that such research would not be worthwhile because these practices would not be acceptable to other agencies and because the high number of visitors to the Smokies could make the possibility of transfer to other areas a reality, thus creating monumental problems. The use of gossypol as a sterility agent was felt to be the most promising of such agents and research was recommended. One group suggested sterilizing all hogs relocated outside the park. Other suggestions were made for investigating: 1) repellents for use in protection of critical areas; 2) species-specific toxicants for use in closely monitored test situations; 3) nutrient inhibitors, especially for pregnant females; and 4) genetics engineering as an avenue to affect reproduction.

Simulation Modeling

The development of a simulation model for the wild hog population in the GRSM was recommended as a valuable management tool. Two possibilities suggested were adapting the model developed by Dr. Reginald Barrett for Hawaii Volcanoes National Park or the ONEPOP model presently being rewritten by Dr. Boyd Dearden for wild hog populations on wildlife management areas in Tennessee. Use of modeling would allow the NPS to better understand population dynamics, evaluate implications of management actions, and determine the number of animals to be removed annually to maintain an acceptable population level. Another potential use of simulation modeling would be the assessment of possible competitive interaction between the hog and native species.

Data Collection on Trapped/Shot Animals

Participants expressed the need for improving data collection on animals being trapped or shot. The effort required to do this would be minimal and the information gained about population dynamics most valuable. Sex, age, reproductive condition, and age-specific natality and mortality rates are essential parameters for simulation modeling as well as for understanding the growth rates of any wildlife population. One group recommended that if the moratorium on direct reduction remained in effect in North Carolina, it would be necessary to sacrifice some of the animals trapped there to obtain these basic biological data.

Furthermore, data that have been collected in recent years should be analyzed to help clarify the status of the population and local exploitation rates. Researchers in Florida measured the impact of the hogs removed each year by trapping success and sex-age ratio changes the following year (see Belden and Frankenberger, page 39). Despite a myriad of other unknown variables, even general analyses of these data might lend insight into the structure and relative changes of the population within the park.

On a broader scope, two groups suggested using captured animals as experimental subjects for long-term research. Animals in traps could provide an immediate laboratory for well designed, carefully administered, and closely monitored experiments on sterilants and toxicants. Because of possible ramifications, however, this project would have to follow very strict guidelines. Less controversial, but of no less potential merit, was the recommendation for long-term enclosure or lead studies on the behavior of the wild hog. Ethological research on the species is quite limited and might provide insight into new means of control.

Re-introduction of Predators

Re-introduction of predators (especially the cougar, Felis concolor) was suggested by three groups as an adjunct to other control programs. Although their effectiveness at controlling the hog population was felt to be fairly low, these participants stated that any ecologically non-detrimental element should be given serious consideration. Another group, while stressing that they were not opposed to re-introduction, rejected this as an alternative.

They avowed that the small number of animals involved in any re-introduction program would have a negligible effect on the hog population.

Public Relations

A strong public relations program is an important adjunct to any control technique. Elimination of the wild hog from GRSM has been historically, and shall likely continue to be a controversial, sometimes volatile, issue. Therefore, public education is essential to assuage these socio-political ramifications.

An annual meeting should be held to increase communications among all involved agencies--National Park Service, U.S. Forest Service, state wildlife agencies, etc. This would provide a forum for discussing management actions and techniques, evaluating alternatives, exploring practical or philosophical differences, and planning policies for the future.

Three suggestions were made for educating visitors to the Smokies about the wild hog control program. 1) Fencing could be used as an interpretative tool by placing informative signs on exclosures and comparing rooted and non-rooted areas. In past research, exclosures have been placed in areas of low visibility so as not to detract from the aesthetics of the park. An opposing viewpoint was suggested at the workshop--place some fences in areas frequented by visitors and use signs to explain their necessity in controlling this exotic species and protecting the natural ecosystem. 2) Mobile exhibits could be moved to different areas along roadsides where rooting damage occurs to further illustrate the negative impacts of the hog. 3) Body mounts of the wild hog could be placed at visitor centers accompanied by a brief written explanation of the effects of the hog in the Smokies. There is, however, potential danger in placing exclosures in highly visible, easily accessible areas. The fences would be subject to vandalism, which has been a problem in the past. Within a short time a few people could destroy what had cost thousands of dollars and manhours to construct. Moreover, there is the possibility that the NPS may appear to some public factions (e.g., hunters) as if they have solved the hog problem by erecting a few fences. This might create difficulties in gaining support for control actions in the future.

Another suggestion was made for the disposition of the meat from animals removed to local people. A program for doing this would probably require coordination with the appropriate state or federal agencies; nonetheless, it could be effective in silencing opposition to NPS control on the basis that it is a waste of meat, one of the principal objections of some North Carolina hunting groups.

Three research projects were recommended, the results of which might be useful for public relations purposes. 1) A comprehensive literature search should be conducted on the impacts of hogs on other game species worldwide. Subsequently, it might be desirable to perform actual research in the park. If hunters could be made to realize that hogs are impacting other game species they might be less likely to condemn NPS control actions. At the very least, hunters of those other game species would probably become more vocal in opposing hog hunters' demands for relocation and in supporting NPS policies.

2) Reliable and accurate data on the transplant cost per hog--both materials and manpower--could be used to persuade hunters that direct reduction is a much more cost-effective means of controlling the park population. TWRA has data which show that very few of these tagged, relocated animals are killed by hunters. The present relocation program is very time consuming, monopolizes traps which could be used in additional control efforts, is very costly, and is basically ineffective at providing additional hogs to be harvested in wildlife management areas. Again, it was reiterated that the respective states of Tennessee and North Carolina should be responsible for bearing the costs of any relocations that do take place. 3) Tree regeneration-reproduction studies should be initiated on National Forest lands to determine impacts of hog activities on commercially valuable trees. If results indicated that hogs are adversely affecting these species, more people might not only support NPS control actions but also question the policy of relocating there.

SUMMARY OF MANAGEMENT RECOMMENDATIONS

Workshop participants were briefed on many aspects of wild hogs in GRSM: history of control efforts; socio-political ramifications and management constraints; past and present research on biology, ecology, and impacts of the species; and potential alternatives for improving control actions. They were also informed of research and management programs in other areas. Being cognizant of all these issues, participants made the following management recommendations:

Prerequisites to Control Program

1. Establish realistic objectives.

2. Make a true commitment to achieve these objectives.

3. Utilize an integrated approach involving different control techniques and objectively evaluate their effectiveness on a periodic basis.

Specific Management Recommendations

1. Increase hunting and trapping.

   Recognizing that traditional techniques are likely to be the most effective means of control, it was recommended that these operations be improved by:

   1.1 Increasing personnel through additional NPS employees, interagency personnel, or citizen volunteer groups.

   1.2 Upgrading equipment.

   1.3 Allowing greater accessibility to remote areas.

   1.4 Concentrating efforts in one section of the park at a time.

   1.5 Investigating use of well trained dog packs.

   1.6 Negotiating special hunting regulations for corridor bordering the park.

   1.7 Rescinding the moratorium on hunting in the North Carolina section of the park.

2. Establish and fence primary protection zones within the park.

   Noting the importance of protecting areas of high resource value, it was suggested that this be accomplished by:

   2.1 Fencing areas of manageable size, perhaps 4-16 km^2.

2.2 Removing all hogs within the exclosure and closely monitoring it thereafter.

2.3 Monitoring changes in vegetation and animal populations within the exclosure.

2.4 Investigating use of portable drift fences to channel hogs into traps.

2.5 Exploring possibility of fencing large sections of the park boundary to prevent further immigration.

3. Develop censusing technique to monitor relative population changes.

Being aware that assessing changes in population levels is essential for evaluating control actions, it was recommended that this be done by:

3.1 Establishing an index to hog rooting damage reflective of relative population density.

3.2 Utilizing non-traditional surveillance techniques (e.g., aircraft, infrared photography).

4. Investigate alternative baits to enhance trapping success.

Recognizing the importance of attracting hogs to traps, it was suggested that a variety of substances be investigated, including chemical and biological attractants, the ultimate (if unlikely) goal being the development of a species-specific bait.

5. Realizing potential dangers to non-target species as well as possible legal ramifications, it was nonetheless suggested that certain agents might be useful--Gossypol (a chemosterilant), species-specific toxicants, repellents, and nutrient inhibitors.

6. Develop a simulation model.

Noting the importance of computers as a managment tool, it was recommended that an existing simulation model be adapted for wild hogs in GRSM to aid in understanding population dynamics and in evaluating control actions.

7. Improve data collection on hogs removed.

Recognizing the necessity for data on population parameters, it was recommended that basic biological information be recorded on sex, age, reproductive condition, and age-specific natality and mortality.

8. Re-introduce predators.

Being cognizant that their effectiveness in controlling the hog population would be fairly low, it was suggested that re-introduction of predators (especially the cougar) be given serious consideration.

9. Establish a strong public relations program.

Being mindful that elimination of the wild hog from GRSM has historically been a controversial and volatile issue, it was recommended that a public relations program be initiated which would include:

9.1 Holding an annual meeting of all involved agencies.

9.2 Educating visitors to the park about the hog control program and its necessity.

9.3 Initiating research projects, the results of which might be useful in delineating the effects of hogs on other game species, their impacts on tree regeneration, and the transplant cost per hog relocated.

IV. ANALYSIS OF CONTROL DATA FOR WILD HOGS IN GRSM

One of the recommendations made by workshop participants was that data on wild hogs removed from GRSM be analyzed to determine if information contained therein could be utilized for better understanding population dynamics or evaluating the effectiveness of control actions. The final section of this report focuses on that task. However, there are many problems inherent in doing so.

1. The nature of the data set precludes making definitive conclusions. Those persons responsible for control activities were directed to remove as many hogs as possible given management constraints, rather limited access, and limited resources. The information they recorded was meant simply as a record of their efforts and was not intended for stringent statistical analysis.

2. The data analyzed represent only animals shot, trapped, or otherwise removed from the park populations. Lack of information on unsuccessful control efforts does not allow comparisons between activities that were fruitful and those that were not. Nor was there information on the effort expended (e.g., manhours, amount of time the trap was set) for successful removal. This prevented calculating capture success rate for different locations.

3. Individual case records were sometimes incomplete, thereby being deleted from analyses relating to those missing variables.

4. Some variables (e.g., elevation, watershed, and vegetation type) were not included in the original records but were added to the data set based upon locations which were sometimes not specific or based upon recall of where the operation took place.

Recognizing the inherent problems, the records of hog control actions in GRSM were summarized for the past five years. Inferences--either statistical or biological--are kept to a minimum. However, the value of this analysis is that it may lend insight into improving data collection in the future, thereby providing a sound basis for evaluating different control techniques and the impact of composite efforts on the total population.

Several persons assisted in this phase of the project. Personnel from the Resource Management Division not only supplied the records upon which this summary is based but also provided more specific information on location of operations. Peter White, Christopher Eagar, Mark MacKenzie, and John Sandsteadt from Uplands Field Research Laboratory assisted in various aspects of the analyses and in providing additions to the data set; all their efforts are deeply appreciated. Dick Conley, Tennessee Wildlife Resources Agency, graciously supplied data for extrapolating age of hogs from weight.

METHODS

Records of control actions for wild hogs in GRSM from 1979 to 1983 were summarized according to sex-age class, time of year, location, and method of removal. The following variables were used in the analysis.

1. Date.

2. Location.

3. Removal method - This included nine separate categories:

   a. trapped/relocated - hog relocated to wildlife management area within respective state where captured;

   b. trapped/shot - hog shot after being trapped;

   c. trapped/overdose - hog given lethal dose of drug after being trapped;

   d. trapped/died - hog died in trap without any other management action;

   e. trapped/research - hog was transferred to research facility (e.g., University of Tennessee College of Veterinary Medicine, Southeastern Cooperative Wildlife Disease Study);

   f. trapped/other - hog was trapped but was subsequently stolen, killed by bear, etc.;

   g. shot - hog shot while free-ranging;

   h. shot/research - hog shot while free-ranging and then transferred to research facility;

   i. other - hog killed by vehicle, found dead of unknown cause, etc.

   For some analyses these categories were combined to represent two groups--animals effectively removed from the population either by killing, other form of death, or use for research purposes (items b through i) and those relocated (item a). In other analyses, all trapping operations regardless of disposition of the animal were compared to all hunting.

4. Sex.

5. Weight.

6. State - North Carolina or Tennessee, where control action occurred.

7. Elevation - Elevation of site of control action to nearest 100 feet as determined by using topographic maps. These were grouped into 1000 foot classes: 1 - <2000, 2 - 2000-2900, 3 - 3000-3900, 4 - 4000-4900, and 5 - >5000.

8. Vegetation type - The predominant vegetation type(s) at the site of the control action. Categories were: grass; successional hardwood; cove hardwood; northern hardwood; oak, formerly chestnut; yellow pine and hardwood; spruce; or any combination thereof.

9. Watershed - Any of the 28 standardly classified watersheds within the park, where the control action took place.

10. Age - Three main categories, extrapolated from weight: juvenile - <26 lbs, subadult 26-80 lbs, adult >80 lbs.

Initial summaries entailed computing simple frequency tabulations for each variable by year and for the entire data set. Next, a variety of combinations of these variables was used to construct contingency tables for chi-square analysis. The validity of this statistic was, however, often suspect because of the sparcity of cells and the tables could be used only to detect patterns in the data. Three-way tables, controlling for sex, were computed to ascertain whether differences could be detected between data for males and females.

RESULTS AND DISCUSSION

Temporal Analyses and Sex-Age Distribution

Over the five-year period from 1979 through 1983, a total of 1500 wild hogs were removed from GRSM. The general trend was for the number of animals removed to increase each year (Table 4), with the greatest increase (68 percent) over the previous year's effort coming in 1981. The largest number of hogs removed in one year was 520 in 1983. Overall, the greatest number of hogs were removed in the summer months, peaking in June with 261 animals (Seasons were divided as follows: spring-March, April, May; summer-June, July, August; autumn-September, October, November; winter-December, January, February). Autumn had the lowest frequencies, with only 27 hogs being removed in October over the entire five-year period. In 1979 and 1980 more hogs were taken from January through March; in 1982 the number peaked in February.

The low number of hogs removed during autumn is somewhat anomalous. At that time they should be concentrated in low-elevation areas near mast-producing trees (Tipton and Otto 1979, Scott and Pelton 1975, Conley et al. 1972), and, as will be discussed later, it is within such elevational ranges that control actions have been concentrated in recent years. The most pragmatic explanation may be related to available manpower for control efforts. Not only are more seasonal personnel generally employed during late spring and summer, but the citizens volunteer group is also more active during that time. In fact if the data for 1983 (when volunteers were involved in 273 trapping operations) are deleted from the monthly totals, a more nearly even distribution results. That relatively large numbers of animals are taken in winter is likely related to their reduced daily movements (Singer et al. 1979), poorer physical condition, and greater visibility against snow-covered terrain.

The overall sex ratio of hogs removed was 52.9 percent female:47.1 percent male (Table 5). This ratio remained fairly consistent throughout the years. Only in 1979 did the number of males exceed that of females. Examining the results in terms of age categories showed that 26.7 percent were juveniles, 31.1 percent were subadults, and 42.2 percent were adults (Table 6). The percentage of juveniles was very low in 1979 (3.3 percent) but afterward remained fairly consistent (between 25-35 percent). The proportion of subadults was 38.4 percent in 1979, declined in intermediate years, and peaked in 1983 at 41.9 percent. The trend for percentage of adults shows a general decline over the years. However, utilizing the combined sex-age classes, chi-square tests showed there was no significant difference for animals removed either overall or in any individual year (Table 7).

Tabulating the number of female versus male hogs removed by month and year showed that for the five-year period, males outnumber females during colder months (October through February) (Table 8). More females were removed from March through September, with the greatest discrepancy by sex being in July. While these numbers can be used to elucidate the trend, the overall difference was not significant (chi square = 17.0, df = 11, p = .108) nor was that pattern present during each individual year. Table 9 examines the number of hogs removed for the five-years in terms of sex-age class by month. Total

Table 4. Total number of wild hogs removed from GRSM by month and year, 1979-1983.

Month	Year					Total
	1979	1980	1981	1982	1983	
January	40	17	23	17	25	122
February	57	25	9	76	27	194
March	21	30	14	52	62	179
April	2	3	26	20	34	85
May	5	10	36	43	41	135
June	6	15	51	54	135	261
July	5	15	32	20	136	208
August	12	5	14	18	34	83
September	1	14	6	25	14	60
October	1	10	3	12	1	27
November	7	4	-	30	1	42
December	3	7	46	38	10	104
TOTAL	160	155	260	405	520	1500

Table 5. Number of female and male hogs removed from GRSM by year, 1979-1983.

Year	Sex: Female N(%)	Sex: Male N(%)	Total
1979	72 (47.1)	81 (52.9)	153
1980	83 (53.9)	71 (46.1)	154
1981	137 (54.8)	113 (45.2)	250
1982	207 (52.8)	185 (47.2)	392
1983	273 (53.5)	237 (46.5)	510
TOTAL	772 (52.9)	687 (47.1)	1459

Table 6. Number of juvenile, subadult, and adult hogs removed from GRSM by year, 1979-1983.

Year	Age Class Juvenile N(%)	Subadult N(%)	Adult (N%)	Total
1979	5 (3.3)	58 (38.4)	88 (58.3)	151
1980	37 (25.0)	28 (18.9)	83 (56.1)	148
1981	85 (34.6)	59 (24.0)	102 (41.4)	246
1982	132 (33.2)	92 (23.1)	174 (43.7)	398
1983	130 (25.2)	216 (41.9)	169 (32.8)	515
TOTAL	389 (26.7)	453 (31.1)	616 (42.2)	1458

Table 7. Frequency of different sex-age classes of hogs removed from GRSM, 1979-1983.

Year	Sex-Age Class						Total		Probability
	Juvenile		Subadult		Adult				(based on chi square)
	Female	Male	Female	Male	Female	Male	Female	Male	
1979	2	3	28	30	41	46	71	79	0.94
1980	19	18	14	14	46	37	79	69	0.85
1981	41	37	29	28	64	38	134	103	0.24
1982	61	69	55	35	91	81	207	185	0.12
1983	68	62	107	105	98	68	273	235	0.24
Subtotal	191	189	233	212	340	270	764	671	0.22
TOTAL ANIMALS	380		445		610		1435		

Table 8. Frequency of female and male hogs removed each month for each year, GRSM, 1979-1983.

Month	1979		1980		1981		1982		1983		Total	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
January	22	18	9	8	6	16	9	8	12	12	58	62
February	17	37	12	13	6	3	37	35	15	12	87	100
March	14	7	17	13	5	9	23	28	31	31	90	88
April	0	1	1	2	16	6	7	13	21	13	45	35
May	3	2	6	4	24	8	24	17	16	24	73	55
June	4	1	11	4	28	23	31	23	73	61	147	112
July	3	2	9	6	18	14	14	6	80	53	124	81
August	6	5	3	2	7	7	11	6	17	16	44	36
September	0	0	7	7	4	2	13	9	5	7	29	25
October	0	1	4	6	2	1	5	6	1	0	12	14
November	2	5	1	3	-	-	17	13	0	1	20	22
December	1	2	3	3	21	24	16	21	2	7	43	57
TOTALS	72	81	83	71	137	113	207	185	273	237	772	687

Table 9. Frequency of wild hogs removed each month by sex-age class, GRSM, 1979-1983.

	Month												
Sex-Age Class	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Juvenile													
Female	4	36	34	20	26	32	30	2	2	1	1	3	191
Male	7	29	45	15	25	33	21	6	2	0	1	5	189
Subadult													
Female	23	15	18	8	11	49	50	29	15	3	8	4	233
Male	18	17	10	3	17	56	43	17	8	1	9	13	212
Adult													
Female	29	36	34	17	36	64	44	13	12	8	11	36	340
Male	27	52	31	17	13	22	17	13	15	13	12	38	270
Total													
Female	56	87	86	45	73	145	124	44	29	12	20	43	764
Male	52	98	86	35	55	111	81	36	25	14	22	56	671

frequencies for juveniles were nearly equal (191 females, 189 males) with more juveniles being removed from February through July. For the five-year period, slightly more subadult females than males were removed, and the difference was even greater for adult animals.

The significance of differential removal of various sex-age classes can only be ascertained in terms of how accurately that mimics the structure of the population as a whole. Otherwise definitive statements cannot be made about varying vulnerability to hunting/trapping or possible implications of control actions on population density or growth. Information on sex-age structure of the population in GRSM is minimal. Singer and Ackerman (1981) reported a slight bias toward males in their study of 550 animals collected from 1976 to 1980 (298 male:262 female); however, they found that habitat type and harvest history greatly influenced sex-age ratios. They attributed the changing ratios to the occupation of prime habitat by females and to the greater mobility of males as well as a greater likelihood of males entering habitats vacated by intensive harvesting of resident animals. The present analysis of data from 1978-1983 showed a different sex ratio, with more females being removed (687 males:772 female). Without more accurate data on population dynamics, inferences about the different ratios of males and females cannot be made.

The fact that more juveniles were removed from February through July is consistent with the generally accepted farrowing range (Singer and Ackerman 1981, Conley et al. 1972). While births do occur throughout the year in the Smokies, they are less frequent from August to November. The fact that such a distinct seasonal bias was not evident for subadults was likely the result of their rapid development as well as the weight range (26-79 lbs) used for determining this age class. Of the animals removed, 42 percent were adults, 31 percent subadults, and 26 percent juveniles. Unfortunately, lack of knowledge about the age structure of the total population precludes making conclusions about this age ratio or whether a certain category may be more susceptible to control actions.

There are problems inherent in using the weight-to-age regression, and summaries based on age class should be viewed accordingly. Because of individual variation and changing food supply, weights of hogs are not precise indicators of age. The animals removed from the park were not aged by dentition (Conley et al. 1972, Henson 1975), and establishing categories based on weight was the only viable alternative. Furthermore, the classes were based on data from another - albeit adjacent - population of hogs at Tellico Wildlife Management Area. Examining the data set in terms of weights recorded for hogs revealed a pronounced tendency to place animals in five-pound categories (i.e., 5 lbs, 10 lbs, 15 lbs, etc.) with few animals being recorded in intervening weights (i.e., 7 lbs, 13 lbs, etc.). This could be indicative of weights being rounded off in that manner or of weights simply being estimated, in which case all summaries involving age class would be extremely suspect. Hopefully, using only three broad age categories alleviates some of the potential bias introduced by all these factors.

Locational Analyses

The locational aspects of hogs removed from GRSM were considered in the following ways: specific site, state (Tennessee or North Carolina), elevation class, watershed, and vegetation type. Elevation and vegetation type were added to the records maintained by the Resource Management Division and were based on site information provided by personnel involved in control actions.

Specific site. There were 135 different locations recorded as the site of hunting/trapped operations. However, 20 sites accounted for 965 (64.3 percent) hogs; in fact, the top 10 sites accounted for 640 (42.7 percent) animals (Table 10). Most locations showed relatively equal numbers of males and females; however, a few sites exhibited a preponderance of one sex. More females were removed from Tremont and Ollie Cove while the number of males was higher in Greenbrier.

The fact that so few of the locations accounted for most of the hogs removed is more likely related to control efforts being concentrated at these sites than to population densities being higher there. Most are fairly accessible, which was undoubtedly a factor in their selection. Singer and Ackerman (1981) speculated that males are more mobile and, hence, more likely to re-invade areas from which resident animals have been removed. Assuming that their supposition is correct and given that more females than males have been removed, re-invasion of areas where control efforts have been concentrated is likely. In addition, some species respond to harvesting of the population by increased reproduction. Specific information on response of wild hogs in this respect is not available; nonetheless, the possibility exists that the level of control practiced in recent years may be enhancing reproduction and range expansion.

State. Of the 1500 hogs removed, 60.8 percent (912) were from Tennessee and 39.2 percent (588) from North Carolina (Table 11). Only in 1983 were more animals taken from North Carolina. Overall, there was no significant difference in number of males and females from each state (chi square = 0.06, df = 1, p = 0.81). The percentages for sex by state were very closely related to the overall percentages removed from each state (North Carolina - 39.5 percent of all females, 39.6 percent of all males; Tennessee - 60.5 percent of all females, 60.4 percent of all males). In assessing these figures for individual years, only in 1980 was there a significant deviation from expected values; at that time more males and fewer females were removed from North Carolina (chi square = 4.22, df = 1, p = 0.04). However, the overall age categories did show a significant difference by state (chi square = 40.25, df = 2, p = 0.0001) with more subadults being removed from North Carolina and more adults from Tennessee. This trend was also followed in significant deviations for the years 1980, 1982, and 1983.

The effects of the moratorium on killing hogs in North Carolina were certainly reflected by the overall percentages of animals removed from each state. Likewise the increased efforts due to the activities of the citizen volunteer group in 1982 and 1983 are evident in the tremendous increase in animals taken from North Carolina. While there was no significant difference in sex by state, there were significantly more younger animals removed from

Table 10. Ranking of top 20 specific sites by number of hogs removed, GRSM, 1979-1983.

		Number Removed			
Rank	Site	Female	Male	Sex Unknown	Total
1	Tremont	74	57	2	133
2	Greenbrier	28	61	5	94
3	Ollie Cove	54	30	-	84
4	Sugarlands	41	41	1	83
5	Hazel Creek	42	39	-	81
6	Pilkey Creek	31	23	6	60
7.5	Cades Cove	28	29	1	58
7.5	Old 288	24	33	1	58
9	Metcalf Bottoms	23	14	1	38
10	Twentymile	21	15	-	36
11	Forge Creek	17	14	1	32
12	Couches Creek	21	10	-	31
13	Calhoun Branch	16	12	-	28
14	Parsons Branch Road	11	13	2	26
15	Fontana Dam	7	18	-	25
16	Old Sugarlands	11	11	-	22
17	Little River	10	10	1	21
18	Big Island	11	8	-	19
19.5	Crib Gap	10	8	-	18
19.5	Derrick Knob	10	8	-	18
	TOTAL	490	454	21	965

Table 11. Number of wild hogs removed from TN and NC by year, GRSM, 1979-1983.

Year	State NC N(%)	State TN N(%)	Total
1979	49 (30.6)	111 (69.4)	160
1980	38 (24.5)	117 (75.5)	155
1981	37 (14.2)	223 (85.8)	260
1982	135 (33.3)	270 (66.7)	405
1983	329 (63.3)	191 (36.7)	520
TOTAL	588 (39.2)	912 (60.8)	1500

North Carolina and adults from Tennessee. Many factors could be responsible for this including, dispersal of younger animals, previous intensity of control efforts, and type of control action. Intuitively it would seem - all other factors being equal - that the moratorium on killing hogs in North Carolina would have resulted in more animals reaching adulthood. Perhaps as the adult population increased, thereby occupying more of the prime and/or remote areas, subadults were forced to disperse into more accessible areas where the majority of trapping efforts took place.

Elevation. Over 95 percent of the hogs were removed from elevations below 3000 feet and 71 percent below 2000 feet (Table 12). This trend was evident for each year but was especially pronounced in 1981-1983. Most control actions in higher elevations occurred in 1979-1980. The numbers of various sex-age classes removed from different elevations showed no significant deviations from expected values (Table 13); however, most of the animals taken from higher elevations were adults, with females of all age classes outnumbering males 39 to 18.

That such a large proportion of hogs were removed at lower elevations is undoubtedly more a reflection of management practices than of differential density of animals. The concentration of control actions at lower elevations likely results from greater accessibility, and as will be discussed later under Control Techniques, the types of equipment used and amount of effort required at higher elevations. However, these findings do question earlier reports of the distinct seasonal migration of wild hogs (see Coleman, page 18) (Tipton and Otto 1979, Scott and Pelton 1975). While some animals may migrate to high elevation beech forests, the fact so many hogs were taken at lower elevations indicates that this is not true for the entire population. The number of hogs removed from high elevations from 1979-1983 represents a very limited sample; however, they were primarily adult females. From the standpoint of management practices, it could be most useful to ascertain if this preliminary assessment is true. Social dynamics of the population in the Smokies are not well documented but could prove valuable to a successful control program.

Watershed. Eight watersheds accounted for 80.6 percent of the hogs removed from GRSM during 1979-1983 (Table 14). Of these, Hazel Creek, Little River, and West Prong-Little Pigeon comprised the largest percentages overall. Examining these data by individual years showed that in 1979 the largest number of hogs were taken from Hazel Creek (18.2 percent); in 1980 from West Prong-Little Pigeon (15.0 percent); in 1981 from Little River (27.3 percent); in 1982 from Middle Prong-Little River (19.1 percent); and in 1983 from Forney Creek (24.3 percent). In 1983, 124 animals were removed from Forney Creek compared to only 15 in the previous four years. There were no animals taken from five watersheds, and seven others accounted for fewer than five hogs. Because of sparcity of cells, no statistical significance could be derived from an examination of the sex-age classes by watershed; however, a few trends are worth mentioning. More males of all age classes were removed from the Middle Prong-Little Pigeon watershed while more females of all age classes were taken from Hazel Creek (Table 15). Considering only adults, the largest disparity in numbers of each sex taken occurred in Hazel Creek, Forney Creek, and Middle Prong-Little River. (More females were removed in each case.) Over the five-

Table 12. Number of hogs removed from different elevation classes, GRSM, 1979-1983.

Elevation Class	Year 1979	1980	1981	1982	1983	Total
<2000	59	46	121	267	434	927
2000-2900	55	41	78	92	55	321
3000-3900	1	0	2	2	0	5
4000-4900	15	21	1	0	1	38
>5000	1	8	0	6	1	16
TOTAL	131	116	202	367	491	1307

Table 13. Number of hogs of different sex-age classes removed from elevation classes, GRSM, 1979-1983.

Sex-Age Class	Elevation Class* 1	2	3	4	5	Total
Juvenile						
Female	113	48	0	2	1	164
Male	135	42	0	1	0	178
Subadult						
Female	151	46	1	1	5	204
Male	151	45	0	0	0	196
Adult						
Female	192	73	2	21	6	294
Male	145	62	1	13	3	224
TOTAL						
Female	456	167	3	24	12	662
Male	431	149	1	14	3	598

*Elevation classes: 1=<2000, 2=2000-2900, 3=3000-3900, 4=4000-4900, 5=>5000

Table 14. Number of hogs removed from different watersheds by year, GRSM, 1979-1983.

Watershed	Year					Total
	1979	1980	1981	1982	1983	
Cosby	-	2	-	-	-	2
Indian Camp	3	-	-	-	-	3
Webb	3	3	1	17	-	24
Middle Prong - Little Pigeon	5	4	41	15	32	97
Roaring Fork	8	4	2	6	19	39
West Prong - Little Pigeon	15	22	30	45	59	171
Little River	8	17	70	54	24	173
Middle Prong - Little River	6	7	38	76	29	156
West Prong - Little River	2	1	12	23	-	38
Hesse	1	-	-	-	-	1
Abrams	24	20	20	27	26	117
Parsons	19	5	8	2	1	35
Twentymile	5	9	5	50	54	123
Eagle Creek	1	7	-	1	-	9
Hazel Creek	29	20	18	39	101	207
Forney Creek	9	4	10	2	124	149
Noland Creek	9	3	-	6	2	20
Deep Creek	-	8	-	1	1	10
Cooper Creek	-	-	1	-	-	1
Oconaluftee	8	9	-	33	38	88
Straight Fork	2	-	-	-	-	2
Cataloochee	-	2	-	-	-	2
Big Creek	2	-	-	-	-	2
TOTAL	159	147	256	397	510	1469

Table 15. Number of hogs of different sex-age classes removed from each watershed, GRSM, 1979-1983.

Watershed	Juvenile		Subadult		Adult		Total	
	Female	Male	Female	Male	Female	Male	Female	Male
Cosby	0	0	0	0	0	2	0	2
Indian Camp	0	0	0	0	0	3	0	3
Webb	5	3	2	0	5	7	12	10
Middle Prong - Little Pigeon	4	15	9	13	16	22	29	50
Roaring Fork	7	4	9	2	7	7	23	13
West Prong - Little Pigeon	24	20	28	29	31	36	83	85
Little River	23	16	30	21	42	38	95	75
Middle Prong - Little River	30	28	20	13	38	22	88	63
West Prong - Little River	9	6	4	5	8	3	21	14
Hesse	0	0	1	0	0	0	1	0
Abrams	10	11	12	12	41	29	63	52
Parsons	0	0	6	7	10	9	16	16
Twentymile	13	28	17	24	23	17	53	69
Eagle Creek	0	0	1	0	5	2	6	2
Hazel Creek	39	31	31	23	49	27	119	81
Forney Creek	13	15	35	36	30	12	78	63
Noland Creek	0	0	8	3	3	5	11	8
Deep Creek	0	0	1	4	2	3	3	7
Cooper Creek	0	0	0	0	1	0	1	0
Oconaluftee	12	11	14	15	21	14	47	40
Straight Fork	0	0	0	0	1	1	1	1
Cataloochee	0	0	0	0	2	0	2	0
Big Creek	0	0	0	0	0	2	0	2
TOTAL	189	188	228	207	335	261	752	656

year period, more juveniles were removed from Hazel Creek, more subadults from Forney Creek, and more adults from Little River. The watersheds from which the largest number of animals were removed each year were examined in terms of frequencies of hogs from different sex-age classes removed the following year to determine if patterns of re-invasion existed; none was evident.

As with other parameters investigated, the predominance of a few watersheds is an artifact of locations being subjected to control actions as well as where hogs exist. Only the Cataloochee area is considered free of hogs at the present time. Some watersheds (e.g., West Prong-Little Pigeon, Little River, Abrams, and Hazel Creek) were trapped and/or hunted each year, with relatively consistent numbers of hogs being removed. Nonetheless, without records of unsuccessful control actions, it is not possible to state that hog densities are higher in those areas. A parkwide index to hog damage (reflective of relative population density) is desperately needed in this regard (see Eagar, page 24). Singer and Ackerman (1981) stated that more mobile males were likely to re-invade areas from which residents were removed. No evidence of this could be found, suggesting that the resident populations in even the more heavily trapped/hunted watersheds have not been truly impacted by control efforts. With so many remote, inaccessible areas being relatively untouched by management practices, it is impossible to discern the effects that present control actions may be having on the population parkwide.

Vegetation type. Of all categories used, three accounted for 75.0 percent of hogs removed: successional hardwood (379), cove hardwood/grass (254), and successional hardwood/grass (119) (Table 16). Few animals were taken from northern hardwood or northern hardwood/grass types but most of these were adults (34 adults, 2 subadults, and 4 juveniles) (Table 17). More juveniles and adults were found in successional hardwood, and more subadults in cove hardwood/grass. No other patterns emerged either from year of control action or sex-age class.

The vegetation types certainly correspond to the elevation classes from which most animals were removed. From a management perspective, this information might be useful if a particular age class were selected as control targets. For example, Singer et al. (1979) reported restricted movements by females with offspring. Since most juveniles and adults were found in successional hardwood, control efforts might be concentrated there during peaks of the farrowing range. Similarly, dispersing subadults are more likely to be found in cove hardwood/grass. While the probability is fairly high of finding hogs in those vegetation types just discussed, little can be said about probabilities in other types which have not been as intensively hunted/trapped.

Control Technique and Disposition

Removal of hogs was considered in two separate ways: the control technique (hunting versus trapping), and the disposition of the animal (killed or relocated). Hogs that were trapped and subsequently sent to research facilities were classified as "killed" since they were effectively removed from the wild population.

Table 16. Number of hogs removed by year from different vegetation types, GRSM, 1979-1983.

Vegetation Type[1]	Year 1979	1980	1981	1982	1983	Total
CH	20	1	11	9	1	42
CH, GR, OC, PH	-	-	2	-	10	12
GR	1	7	-	29	26	63
GR, CH	27	17	70	74	66	254
GR, NH	15	14	-	1	-	30
GR, OC	2	-	2	16	-	20
GR, OC, CH	-	1	-	-	13	14
GR, OC, PH, SH	-	1	-	4	5	10
GR, PH	-	-	-	-	16	16
GR, SH	26	20	7	53	27	133
NH	-	8	1	4	-	13
OC	-	-	1	4	4	9
OC, CH, PH	-	2	1	-	-	3
SH	22	43	104	134	76	379
SH, CH	1	-	-	-	-	1
SH, OC	1	-	-	-	1	2
SP	-	-	-	-	1	1
TOTAL	115	114	199	328	246	1002

[1]CH = Cove Hardwood; GR = Grass; OC = Oak, formerly Chestnut; PH = Yellow Pine, Hardwood; NH = Northern Hardwood; SH = Successional Hardwood; SP = Spruce.

Table 17. Number of hogs of different sex-age classes removed from different vegetation types, GRSM, 1979-1983.

Vegetation Type[1]	Sex-Age Class: Juvenile Female	Juvenile Male	Subadult Female	Subadult Male	Adult Female	Adult Male	Total Female	Total Male
CH	0	0	6	8	11	13	17	21
CH, GR, OC, PH	5	0	2	1	3	1	10	2
GR	10	5	9	9	20	10	39	24
GR, CH	24	28	44	40	61	53	129	121
GR, NH	0	0	3	0	16	10	19	10
GR, OC	8	6	0	1	2	2	10	9
GR, OC, CH	1	0	2	3	5	3	8	6
GR, OC, PH, SH	2	0	2	2	3	1	7	3
GR, PH	1	0	8	2	4	1	13	3
GR, SH	14	22	21	16	25	27	60	65
NH	3	1	2	0	5	2	10	3
OC	0	0	3	2	6	2	9	4
OC, CH, PH	0	0	0	1	1	1	1	2
SH	55	68	39	42	81	70	175	180
SH, CH	0	0	0	0	0	1	0	1
SH, OC	0	0	0	0	0	2	0	2
SP	0	0	0	0	0	1	0	1

[1]CH = Cove Hardwood; GR = Grass; OC = Oak, formerly Chestnut; PH = Yellow Pine, Hardwood; NH = Northern Hardwood; SH = Successional Hardwood; SP = Spruce.

From 1979-1983, 1079 (73.5 percent) hogs were trapped and 389 (26.5 percent) were shot free-ranging (Table 18). The largest disparity in control techniques occurred in 1983 when 90.2 percent of the animals removed were trapped. Trapping operations exceeded hunting each year, but there was more parity between the two in 1980 and 1981. Trapping was responsible for most hogs removed below 3000 feet, where control efforts have been concentrated (Table 19). While few animals were taken from higher elevations (>3000 feet), hunting took precedence over trapping there. Assessing control techniques by watershed revealed that in only six did hunting surpass trapping (Roaring Fork, Indian Camp, Abrams, Eagle Creek, Cooper Creek, and Straight Fork); however, the total number of animals shot in these watersheds was fairly low (97) (Table 20). Of all vegetation types only in northern hardwood and northern hardwood/grass types did hunting exceed trapping (Table 21). More animals of all sex-age classes were trapped than shot although the percentage of adults shot was higher than any other age class (Table 22).

The more effective method of removing hogs is shooting (see Coleman, page 18). Yet the technique utilized most often was trapping. Despite the fact that many of these animals were subsequently killed in the trap, manpower and money were expended in an initial trapping operation. Certainly there are locations of high human use where trapping must be used (e.g., campgrounds, picnic areas, near roadsides); nonetheless, if the proportion of hunting relative to trapping was increased, the control program might be more successful. This is especially true when population levels are high. Socio-political considerations are definitely a factor in choice of control technique; however, the ultimate goal of the management program must be kept in mind as well. For every variable considered in this analysis, trapping predominated as the technique used.

For the five-year period, 828 (55.2 percent) hogs were relocated and 672 (44.8 percent) were effectively removed from the population (Table 23). From 1979 through 1981, fewer animals were relocated; however, the tremendous increase in relocations during 1983 drastically altered the total picture. In terms of elevation class, the majority of hogs (74.0 percent) removed from lower elevations were relocated compared to only one of 60 animals taken above 3000 feet (Table 24). The only pattern to emerge from the analysis of vegetation type was that all animals taken from northern hardwood and northern hardwood/grass were killed (Table 25). More watersheds had a greater number of hogs killed than relocated; nonetheless the frequencies of animals relocated were much higher in a few watersheds which accounts for relocation exceeding removals (Table 26). The number of animals relocated is higher for all sex-age classes except adult males (Table 27). Overall, 90 more females were relocated, with adults being primarily responsible for the difference.

The principle indication of the relocated animals exceeding those killed is that the NPS is perpetuating the problems of this exotic species. Re-invasion from the adjoining wildlife management areas has been documented (GRSM 1978) and will undoubtedly continue to occur. As population levels grow in these adjacent areas, migration back into the park may even increase. Furthermore, relocation of wild hogs, especially into regions where they do not presently exist, has been questioned from a philosophical as well as practical viewpoint. The problem is compounded by the fact that more females (capable of producing large numbers of offspring) are being moved to other areas. Notwithstanding the moratorium on killing hogs in North Carolina or other socio-political ramifications, continuing this management practice is, in essence, only temporarily transferring the problem and is self-defeating.

Table 18. Comparison of number of hogs taken each year by hunting versus trapping operations, GRSM, 1979-1983.

Control Technique	Year 1979	1980	1981	1982	1983	Total
Hunting	40 (25.3)	69 (45.4)	119 (46.7)	111 (28.4)	50 (9.8)	389 (26.5)
Trapping	118 (74.7)	83 (54.6)	136 (53.3)	280 (71.6)	462 (90.2)	1079 (73.5)
TOTAL	158	152	255	391	512	1468

Table 19. Number of hogs taken from different elevation classes by hunting versus trapping operations, GRSM, 1979-1983.

Control Technique	Elevation Class <2000	2000-2900	3000-3900	4000-4900	>5000	Total
Hunting	161	51	4	22	14	252
Trapping	754	266	1	15	1	1037
TOTAL	915	317	5	37	15	1289

Table 20. Number of hogs removed by trapping versus hunting operations for each watershed, GRSM, 1979-1983.

Watershed	Control Technique: Trapping	Control Technique: Hunting	Total
Cosby	2	0	2
Indian Camp	0	3	3
Webb	13	11	24
Middle Prong - Little Pigeon	76	19	95
Roaring Fork	17	22	39
West Prong - Little Pigeon	103	58	161
Little River	103	67	170
Middle Prong - Little River	108	47	155
West Prong - Little River	22	14	36
Hesse	1	0	1
Abrams	54	62	116
Parsons	31	4	35
Twentymile	110	11	121
Eagle Creek	2	7	9
Hazel Creek	178	28	206
Forney Creek	129	18	147
Noland Creek	19	0	19
Deep Creek	10	0	10
Cooper Creek	0	1	1
Oconaluftee	84	0	84
Straight Fork	0	2	2
Cataloochee	1	1	2
Big Creek	2	0	2
TOTAL	1065	375	1440

Table 21. Number of hogs taken from different vegetation types by hunting versus trapping operations, GRSM, 1979-1983.

Vegetation Type[1]	Control Technique		Total
	Hunting	Trapping	
CH	9	33	42
CH, GR, OC, PH	0	12	12
GR	7	56	63
GR, CH	77	172	249
GR, NH	17	13	30
GR, OC	3	17	20
GR, OC, CH	0	14	14
GR, OC, PH, SH	0	10	10
GR, PH	0	16	16
GR, SH	19	113	132
NH	12	0	12
OC	1	8	9
OC, CH, PH	0	3	3
SH	107	262	369
SH, CH	0	1	1
SH, OC	0	2	2
SP	0	1	1
TOTAL	252	733	985

[1]CH = Cove Hardwood; GR = Grass; OC = Oak, formerly Chestnut; PH = Yellow Pine, Hardwood; NH = Northern Hardwood; SH = Successional Hardwood; SP = Spruce.

Table 22. Number of hogs of different sex-age classes removed by hunting versus trapping operations, GRSM, 1979-1983.

Sex-Age Class	Control Technique		Total
	Hunting	Trapping	
Juvenile			
Female	46	143	189
Male	38	149	187
Subadult			
Female	46	182	228
Male	32	174	206
Adult			
Female	112	227	339
Male	89	172	261
Total			
Female	204	552	756
Male	159	495	654

Table 23. Number of hogs removed each year by different control techniques, GRSM, 1979-1983.

Control Technique	1979	1980	1981	1982	1983	Total
	Number Removed From Population					
Shot	38	69	119	111	50	387
Shot/Research	2	-	-	-	-	2
Trapped/Shot	28	22	33	45	56	184
Trapped/Overdose	1	-	6	-	-	7
Trapped/Died	-	-	11	1	-	12
Trapped/Research	9	21	5	-	1	36
Trapped/Other	1	1	-	1	9	12
Other	2	3	5	14	8	32
Subtotal	81	116	179	172	124	672
	Number Relocated					
Trapped	79	39	81	233	396	828
TOTAL	160	155	260	405	520	1500

Table 24. Number of hogs removed by different control techniques from five elevation classes, GRSM, 1979-1983.

Control Technique	Elevation Class <2000	2000-2900	3000-3900	4000-4900	>5000	Total
	Number Removed From Population					
Other	12	4	0	1	1	18
Shot	159	51	4	22	14	250
Shot/Research	2	0	0	0	0	2
Trapped/Died	11	1	0	0	0	12
Trapped/Overdose	5	2	0	0	0	7
Trapped/Other	9	2	0	0	0	11
Trapped/Research	24	8	0	0	0	32
Trapped/Shot	126	33	1	15	0	175
Subtotal	348	101	5	38	15	507
	Number Relocated					
Trapped	579	220	0	0	1	800
TOTAL	927	321	5	38	16	1307

Table 25. Number of hogs removed by different control techniques from various vegetation types, GRSM, 1979-1983.

Vegetation Type[1]	Control Technique		Total
	Removed	Relocated	
CH	21	21	42
CH, GR, OC, PH	2	10	12
GR	10	53	63
GR, CH	134	120	254
GR, NH	30	0	30
GR, OC	5	15	20
GR, OC, CH	1	13	14
GR, OC, PH, SH	2	8	10
GR, PH	0	16	16
GR, SH	45	88	133
NH	13	0	13
OC	5	4	9
OC, CH, PH	3	0	3
SH	228	151	379
SH, CH	1	0	1
SH, OC	0	2	2
SP	0	1	1
TOTAL	500	502	1002

[1]CH = Cove Hardwood; GR = Grass; OC = Oak, formerly Chestnut; PH = Yellow Pine, Hardwood; NH = Northern Hardwood; SH = Successional Hardwood; SP = Spruce.

Table 26. Number of hogs removed by different control techniques from various watersheds, GRSM, 1979-1983.

Watershed	Control Technique: Removed	Control Technique: Relocated	Total
Cosby	1	1	2
Indian Camp	3	0	3
Webb	14	10	24
Middle Prong - Little Pigeon	78	19	97
Roaring Fork	25	14	39
West Prong - Little Pigeon	103	69	172
Little River	103	69	172
Middle Prong - Little River	92	64	156
West Prong - Little River	17	21	38
Hesse	1	0	1
Abrams	82	35	117
Parsons	11	24	35
Twentymile	14	109	123
Eagle Creek	9	0	9
Hazel Creek	53	154	207
Forney Creek	23	126	149
Noland Creek	1	19	20
Deep Creek	0	10	10
Cooper Creek	1	0	1
Oconaluftee	14	74	88
Straight Fork	2	0	2
Cataloochee	2	0	2
Big Creek	0	2	2
TOTAL	649	820	1469

Table 27. Number of hogs removed from population versus number relocated by sex-age class, GRSM, 1979-1983.

Sex-Age Class	Removed	Relocated	Total
Juvenile			
Female	71	120	191
Male	67	122	189
Subadult			
Female	77	156	233
Male	64	148	212
Adult			
Female	159	181	340
Male	173	97	270
Total			
Female	307	457	764
Male	304	367	671

SUMMARY

1) From 1979 to 1983, 1500 wild hogs were removed from GRSM; the greatest number of animals (520) were removed in 1983.

2) More hogs were removed in the summer than in any other season while autumn had the lowest frequency.

3) Of the total number of hogs removed, 52.9 percent were female and 47.1 percent male. In terms of age categories, 26.7 percent were juveniles, 31.1 percent subadults, and 42.2 percent adults.

4) There were 135 different locations of hunting/trapping operations; however, 20 of these accounted for 64.3 percent of hogs removed.

5) Of the 1500 hogs removed, 60.8 percent were from Tennessee and 39.2 percent from North Carolina. Only in 1983 were more taken from North Carolina. There was no significant difference in sexes removed from each state; however, significantly more subadults were removed from North Carolina and more adults from Tennessee.

6) Over 95 percent of the hogs were removed from elevations below 3000 feet. There were no significant differences in sex-age classes by elevation, although most animals taken from higher elevations were adults, with the number of females exceeding males.

7) Eight watersheds accounted for 80.6 percent of the hogs, with Hazel Creek, Little River, and West Prong-Little Pigeon comprising the largest percentages.

8) Of all vegetation types used, 75 percent of the hogs were removed from successional hardwood, cove hardwood/grass, or successional hardwood/grass. Few animals were removed from northern hardwood.

9) Over the five-year period, 73.5 percent of the hogs were trapped compared to 26.5 percent being shot while free-ranging. Only in elevations over 3000 feet did hunting take precedence over trapping.

10) Overall, 55.2 percent of the animals were relocated while 44.8 percent were effectively removed from the population by killing, transfer to research laboratories, etc. The number of animals relocated was higher for all sex-age classes except adult males.

LITERATURE CITED

Ackerman, B. B., M. E. Harmon, and F. J. Singer. 1978. Seasonal food habits of the European wild hog. Part II, Studies of the European Wild Boar in Great Smoky Mountains National Park, A Report for the Superintendent, Gatlinburg, TN.

Barrett, R. H. 1977. Wild pigs of California, In G. W. Wood, ed., Research and Management of Wild Hog Populations: Proceedings of a Symposium. Belle W. Baruch Forest Service Institute of Clemson University, Georgetown, SC. pp. 111-113.

Belden, R. C., and M. R. Pelton. 1975. European wild hog rooting in the mountains of East Tennessee. Proceedings Ann. Conf. SE Assoc. of Game and Fish Comm. 29:665-671.

Bratton, S. P. 1977. Wild hogs in the United States - origin and nomenclature. In G. W. Wood, ed., Research and Management of Wild Hog Populations: Proceedings of a Symposium. Belle W. Baruch Forest Service Institute of Clemson University, Georgetown, SC. pp. 1-4.

Bratton, S. P. 1975. The effect of the European wild boar, *Sus scrofa*, on gray beech forests in Great Smoky Mountains. Ecology 56(6):1356-1366.

Bratton, S. P. 1974a. The effect of European wild boar (*Sus scrofa*), on the high-elevation vernal flora in GRSM. Bull. Torr. Bot. Club 101(4):198-206.

Bratton, S. P. 1974b. An integrated ecological approach to the management of European wild boar (*Sus scrofa*) in GRSM. Management Report No. 3, Uplands Field Research Lab, Great Smoky Mountains National Park, Gatlinburg, TN.

Bratton, S. P., M. E. Harmon, and P. S. White. 1982. Patterns of European wild boar rooting in the Western Great Smoky Mountains. Castanea 47:230-242.

Conley, R. H. 1977. Management and research of the European wild hog in Tennessee. In G. W. Wood, ed., Research and Management of Wild Hog Populations: Proceedings of a Symposium. Belle W. Baruch Forest Service Institute of Clemson University, Georgetown, SC. pp. 67-70.

Conley, R. H., G. Matschke, and V. G. Henry. 1972. Final report for the European wild hog research project W-34, Tennessee Game and Fish Commission. 259pp.

Decker, E. 1978. Exotics. In J. L. Schmidt and D. L. Gilbert, eds., Big Game of North America. Stackpole Books, Harrisburg, PA. pp. 249-256.

Fox, J. R., and M. R. Pelton. 1977. An evaluation of control techniques for the European wild hog in the Great Smoky Mountains National Park. In G. W. Wood, ed., Research and Management of Wild Hog Populations: Proceedings of a Symposium. Belle W. Baruch Forest Service Institute of Clemson University, Georgetown, SC. pp. 53-65.

Great Smoky Mountains National Park, Resource Management and Visitor Protection Division. 1982. European wild boar management plan. Gatlinburg, TN. 20pp.

Great Smoky Mountains National Park, Resource Management and Visitor Protection Division. 1978. European wild boar management, Great Smoky Mountains National Park, 1959-1977. Report for the Superintendent, Gatlinburg, TN.

Gross, J. E., J. E. Roelle, and J. L. Williams. 1973. Progress report, Program ONEPOP and the information processor, systems modeling and communications project. Colorado Coop. Wildl. Res. Unit, Colorado State University, Fort Collins.

Henson, T. M. 1975. Age determination and age structure of the European wild hog (Sus scrofa). M.S. Thesis, University of Tennessee, Knoxville. 58pp.

Howe, T. D., and S. P. Bratton. 1976. Winter rooting activity of the European wild boar in Great Smoky Mountains National Park. Castanea 41:256-264.

Howe, T. D., F. J. Singer, and B. B. Ackerman. 1981. Forage relationships of European wild boar invading northern hardwood forests. J. Wildl. Manage. 45(3):748-754.

Howe, T. D., F. J. Singer, and B. B. Ackerman. 1979. High elevation forage relationships of European wild boar invading Great Smoky Mountains. Report for the Superintendent, GRSM, Gatlinburg, TN.

Huff, M. H. 1977. The effect of the European wild boar (Sus scrofa) on the woody vegetation of gray beech forests in the Great Smoky Mountains. Research/Resources Management Report No. 18, USDI, NPS, SERO, Atlanta. 63pp.

Jones, P. 1959. The European wild boar in North Carolina. Game Div., NC Wildlife Resources Comm., Raleigh. 29pp.

Matschke, G. H. 1965. Predation by European wild hogs on dummy nests of ground dwelling birds. Proceedings Ann. Conf. SE Assoc. Game and Fish Comm. 19:154-156.

Mosby, H. S. 1952. Some results of supervised forest game hunts in Virginia. Eighth Annual Meeting, Northeast Section, Wildlife Society. 8pp.

Ramsey, C. 1968. Texotic line-up. Texas Parks and Wildlife 25:3-7.

Roelle, J. E. 1977. National bison range, big game management modeling. Ph.D. Thesis, Colorado State University, Fort Collins. (unpublished)

Scott, C. D., and M. R. Pelton. 1975. Seasonal food habits of the European wild hog in the Great Smoky Mountains National Park. Proceedings Ann. Conf. SE Assoc. of Game and Fish Comm. 29:585-593.

Sheriff, T. 1978. Program LIONPOP. M. S. Thesis, Colorado State University, Fort Collins. (unpublished)

Singer, F. J. 1981. Wild pig populations in the National Parks. Environ. Manage. 5(3):263-270.

Singer, F. J., and B. B. Ackerman. 1981. Food availability, reproduction, and condition of European wild boar in Great Smoky Mountains National Park. Research/Resources Management Report No. 43, USDI, NPS, SERO, Atlanta. 52pp.

Singer, F. J. and S. Coleman. n.d. Ecology and management of European wild boar in Great Smoky Mountains National Park. 12pp.

Singer, F. J., D. K. Otto, A. R. Tipton, and C. P. Hable. 1979. Home ranges, movements, and habitat use of European wild boar. Report for the Superintendent, Great Smoky Mountains National Park, Gatlinburg, TN.

Singer, F. J., W. T. Swank, and E. E. C. Clebsch. 1982. Some ecosystem responses to European wild boar rooting in a deciduous forest. Research/Resources Management Report No. 54, USDI, NPS, SERO, Atlanta. 31pp.

Tipton, A. R., and K. K. Otto. 1979. Evaluating wild boar movement activity and distribution in Great Smoky Mountains National Park. Final Project Report, Contract CX500061138. Gatlinburg, TN. 87pp.

Whitehead, C. J. 1969. Oak mast yield on wildlife management areas in Tennessee. Tennessee Games and Fish Commission, Nashville, TN. 11pp. (unpublished)

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