Fifth Annual Scientific Research Meeting

U.S. DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE - SOUTHEAST REGION

GREAT SMOKY MOUNTAINS NATIONAL PARK

GATLINBURG, TENNESSEE

JUNE 21-23, 1979

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Great Smoky Mountains National Park
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WELCOME

Merrill D. Beal, Superintendent
Great Smoky Mountains National Park

It is a distinct pleasure and genuine privilege for me to welcome you to Great Smoky Mountains National Park on the occasion of the Fifth Annual Uplands Areas Research meeting. Actually, it is a little incongruous, because I am a new arrival, having reported for duty about six months ago, and many of you have been carrying out scientific investigations here for a long time.

However, I do share your interest and enthusiasm concerning the natural resources of this park and region, and personally claim acquaintance with some of them based on a previous tour of duty here from 1969 to 1972. I am pleased to be back here, and gratified by your presence here today.

This meeting is a learning and sharing occasion and I know we will benefit from the exchange. Let me briefly outline some of the concerns that park managers have that relate to scientific research.

First, we welcome new knowledge and continuing investigations, but must encourage the development of increased professional objectivity. Emphasis must be placed upon identifying alternatives and consequences rather than upon advocacy of specific courses of action or "prescriptions."

Humility is required of all of us. Today science has better methods, equipment and knowledge than ever before, but we must also remember that the "best" of the past has at times led us astray. Our society and the conservation community have at times:

1. Favored prey species to the detriment (even extirpation or extinction) of predators.
2. Favored introduced or exotic species at the expense of native life forms.
3. Favored visitors and their activities at the price of resource degradation.
4. Utilized persistent pesticides in attempts to save threatened resources, and ended up with a "cure" worse than the threat.

Now it is perhaps timely to suggest that we must guard against being so zealous in preservation of resources that we lose sight of the park visitor's needs. The loss of our constituency of park users could ultimately result in the loss of the parks.

Balance and perspective are needed in all our programs. Balance that is consistent with our legal (and sometimes conflicting) mandates, and balance which observes dual objectives of preservation and use in the National Park System.

We must recognize that scientists can often wait as long as necessary for all the data to come in, and to develop "final" or definitive answers, but policy makers and managers must sometimes make decisions quickly with only fragmentary information.

Conversely, managers must recognize the need to change policy, regulation or direction as more information from scientific research efforts becomes available.

Working together, we can accomplish the goal of improved resource protection through proper assimilation and implementation of research findings. I hope we have a very successful meeting!

EDITOR'S NOTE

This publication contains abstracts that are reports of ongoing studies. They are not a part of the scientific literature and should not be reprinted nor quoted without prior consultation with the investigators.

SUMMARY OF TOPIC SESSION

Trout Populations and the Assessment of their Environment

Many biologists specializing in brook trout research participated in the two trout topic sessions held during the Fifth Annual Scientific Research Meeting at Great Smoky Mountains National Park, June 21 - 23, 1979. These sessions served as a forum for discussing and exchanging information on the biology, research progress, management, and status of self-supporting brook trout populations within the streams of the Southern Appalachians.

The sessions were arranged and moderated by Gary Larson, Research Coordinator, Uplands Field Research Laboratory, Great Smoky Mountains National Park. Notable participants included Thomas Harshbarger, Southeastern Forest Experiment Station, U.S. Forest Service; R. Don Estes, B.L. Ridley, and Eric L. Morgan, Cooperative Fishery Unit, Tennessee Technological University; Garland B. Pardue, Cooperative Fishery Unit, Virginia Polytechnic Institute and State University; Robert P. Smith, U.S. Fish and Wildlife Service; Jerry Elwood, Oak Ridge National Laboratory; Richard Strange, University of Tennessee; Gerry West, Western North Carolina University; and Willis King, U.S. Fish and Wildlife Service.

The discussions ranged from trout embryos to habitat and population studies. Current research ideas and techniques were exchanged. Production ecology was debated at length and several different views of how to conduct such field research were expressed. The brook trout rehabilitation program in Great Smoky Mountains National Park was also discussed and several participants contributed views on fish removal and restoration techniques. Future research needs and interests regarding trout populations in the Southeast concluded the discussions.

The following abstracts serve to recount the highlights of the sessions.

PROJECT: Spacial Interaction Between Wild Brook Trout, Mottled Sculpin, Blacknose, and Rosyside Dace

INVESTIGATORS: Gerard A. Gray and Garland B. Pardue, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

When adult and juvenile wild brook trout (Salvelinus fontinalis) were permitted to compete with mottled sculpin (Cottus bairdi), blacknose dace (Rhinichthys atralus) and rosyside dace (Clinostomus funduloides) for social dominance and food in a laboratory stream aquarium, adult and juvenile brook trout successfully fed and defended territories. Results from experiments utilizing adult trout, juvenile and adult trout, and nongame species along with juvenile and adult trout indicated that following an initial adjustment period a social hierarchy developed with associated spacial segregation. The largest trout dominated and defended the preferred territory, becoming particularly aggressive during feeding. A dominant-subdominant relationship also existed between the smaller adult and juvenile trout. All trout aggressively defended territories by nipping and chasing intruding nongame fish.

Nongame fish appeared to have little negative affect on brook trout spacial activity. Rather, the presence of nongame fish seemed to buffer the effectiveness of the dominant trout's aggressive tendencies, allowing the subdominant trout to enter the preferred habitat more freely.

PROJECT: Summary of Three Summers of Electrofishing above Obstructions In Small Headwater Streams, Great Smoky Mountains National Park

INVESTIGATOR: Stephen E. Moore, Tennessee Technological University Cookeville, Tennessee

The feasibility of eradicating rainbow trout (Salmo gairdneri) and brown trout (Salmo trutta) by electrofishing from sympatric populations with brook trout (Salvelinus fontinalis) above natural obstructions in six small headwater streams was studied. All rainbow and brown trout captured were removed from each study area. Of the 240 marked rainbow trout released below obstructions at the beginning of each study area, none were recaptured above these obstructions. Unmarked rainbow trout are believed to have invaded two study areas by passing upstream over obstructions after the completion of sampling in 1976 and 1977.

All brook trout captured were measured for total length, weighed, fin clipped and returned to the area from which they were captured. Movements of marked brook trout were determined approximately one and two years after they were initially marked and released. Age structure was determined from the recapture of known age fish. The native char populations have increased in number and weight in four of the six study areas after substantial reductions in the rainbow trout populations. The brook trout population remained stable in one creek and brook trout were never found in one creek.

All natural obstructions meeting certain criteria and their terminal plunge pools within each study area were measured. Data gathered included the vertical height, percent slope, length of slope, substrate type and the length and depths of the plunge pool.

PROJECT: Age, Growth and Comparison of 28 Southeastern United States and other Selected Brook Trout Populations

INVESTIGATORS: Richard Konopacky and R. Don Estes
Tennessee Technological University, Cookeville, Tennessee

Otoliths were used to age and estimate annual growth increments for 1,152 brook trout. Fish were collected by electrofishing from 32 sites in eight states and the Great Smoky Mountains National Park.

Age III and younger fish constituted 98% of the total with age II fish the oldest observed in 11 samples. One half (13) of the age IV or older fish were taken in the Park samples. Year-class ratios and longevity were not related.

Average annual growth was greatest during the first year in all samples. The position of the population within the brook trout distribution range could not be used as a criteria for predicting growth potential. The differences in length between samples at age I tended to presist in later years. Average annual growth increments became increasingly similar after age I and were not significantly ($P \geq .05$) different after age III (13 samples).

Twelve streams, including 4 with age IVand /or V fish, would not have contributed to a 6-inch minimum sport fishery. Size limites were not considered an effective means of managing these fisheries. YOY fish and their habitat were suggested as primary areas of ensuing management emphasis.

PROJECT: The Occurrence and Characteristics of Cellulase and Chitinase Activity in Brook (Salvelinus fontinalis), Brown (Salmo trutta), and Rainbow (S. gairdneri) Trout Gastrointestinal Tracts

INVESTIGATORS: Tom M. Abbott and John Cairns, Jr.
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Cellulose and chitin, the major structural components of plants and invertebrates, respectively, are very abundant materials in aquatic ecosystems. Trout food habit studies have shown that cellulose and chitin are retained in the stomach after more digestible components (e.g. protein) have been processed. Previously, cellulase and chitinase enzymes were unreported from salmonoids. We hypothesized that cellulose and chitin retention in the gastrointestinal tract allows trout to increase the assimilation efficiency by utilizing these major components of the total food intake. Therefore, breakdown products of cellulose and chitin, D-glucose, and N-acetyl-D-glucosamine, respectively, may be available energy sources for trout.

Cellulase and chitinase activities were measured by viscosimetry (endocellulase) and colorimetry (N-acetyl-D-glucosamine). Absolute activity values for these enzymes were not the objective of this research. Cellulase and chitinase activities appeared positively correlated with the quantity of cellulose and chitin in the gastrointestinal tract. Enzyme levels were maximal in the stomach region, followed by lesser activity in the intestines. Cellulase and chitinase in Salvelinus fontinalis, Salmo trutta, and S. gairdneri appeared to be from exogenous sources, probably bacterial in origin.

PROJECT: Physical Factors Influencing Trout Biomass in High Gradient, Oligotrophic Streams in the Southern Appalachians

INVESTIGATOR: Thomas J. Harshbarger, Southeastern Forest Experiment Station, U.S.D.A. Forest Service

A four-year study was conducted in five small trout streams in Western North Carolina. The relationship of 44 variables, 18 providing cover and 26 associated with water type and flow, to standing crop biomass of wild brook trout (Salvelinus fontinalis), rainbow trout (Salmo gairdneri) and brown trout (Salmo trutta) was determined in stream sections.

In a preliminary analysis, cover variables were consistently better predictors of trout biomass for all year classes of fish than were those associated with water type or current velocity. Biomass of brook trout and brown trout seems less predictable than that of rainbow trout. Standing crops of juveniles of all species and old, large brown trout were most predictable.

Cover variables important to brook trout were rock area, overstream cover and numbers of pockets of turbulent water; those important to brown trout were rock area, overstream cover, numbers of rocks and area in brush and debris. For rainbow trout, important variables were all of those physically affording cover including turbulent water. Rock cover and numbers of rocks seem to be important predictors of brook and brown trout biomass for older year classes of fish. Water types and current parameters of interest in predicting standing crops of trout were current velocity and the surface area of pools, riffles and flats for brooks; depth, current velocity and surface area of pools, riffles and flats for browns; and depth and the surface area of flats, runs and pools for rainbows. Pool and current parameters seem important to standing biomass of all ages of brook and brown trout but not rainbow trout, except for juveniles of the latter species.

Preliminary results suggest that standing crop biomass of brook and brown trout seems to be related to specific parameters of the physical environment while the biomass of rainbow trout is not. This tendency, and the fact that many Southern Appalachian streams are inherently low producers of fish food, may partially explain how rainbow trout are able to displace brook trout in the wild. Rainbow trout are in the best physical position to utilize cover and water conditions associated with the major food-producing and food-carrying portions of the stream. Because brook trout utilize adjacent areas for cover and shelter, their ability to obtain an adequate supply of food would seemingly be limited in the presence of rainbow trout.

PROJECT: The Impacts of Stocking Hatchery Reared Trout on the Native Brook Trout Populations of Two Streams in Central Virginia

INVESTIGATOR: Arthur L. LaRoche, III
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

A two year study to determine the impacts of stocking hatchery reared trout on populations of native brook trout, was conducted on the North and South Forks of the Tye River in Nelson County, Virginia. Areas investigated included: changes in population structures related to the stocking of hatchery trout; harvest of native brook trout during periods of heavy fishing pressure; competition for food among native brook trout and hatchery trout; and changes in native brook trout growth rates, conditions factors, and length-weight relationships in stocked and unstocked areas of the two streams.

Population estimates of native brook trout during 1977 and 1978 revealed no significant population changes between stocked areas and unstocked areas of both streams. There were, however, highly significant shifts in population densities in all areas of both streams on a seasonal basis; probably the result of severe summer droughts in 1977 and 1978, and heavy winter ice in 1977-78. Native brook trout standing crop estimates dropped 85.0 to 93.1% in both streams in a period of 15 months. A considerable percentage of this reduction in numbers was the result of little or no reproduction during the fall 1977, resulting in essentially no age 0 trout in 1978.

Creel surveys indicated that native brook trout contributed little to the harvest of trout during periods of extremely heavy fishing pressure. Catch per unit effort (number per hour) figures for native brook trout were considerably higher in unstocked areas than in stocked areas of both streams during times of heavy fishing pressure. Creel surveys also indicated that hatchery trout contributed heavily to the catch for only a short time, with dramatic decreases in fishing pressure shortly after stocking.

Food habits analyses on trout from both streams indicated that hatchery trout and native brook trout were primarily opportunistic feeders; taking advantage of the most abundant taxon present in the benthos and drift. Hatchery trout and native brook trout generally fed in spearate spatial areas. Hatchery trout appeared to be primarily benthic feeders; however, they fed little on food items of nutritive value, often consuming great quantities of wood, hemlock, needles, rocks, and insect exuviae. In contrast, native brook trout preyed on drift organisms in warmer months, shifting to benthic feeding during colder months.

Analyses of growth rates of native brook trout indicated that growth rates varied from year to year, depending on standing crop and environmental conditions. During the study, native trout generally grew faster in the long term stocked area of the North Fork. Trout from stocked areas of the two streams were slightly heavier as adults and in better condition than trout in upstream unstocked areas.

PROJECT: Southeastern Brook Trout - The Importance of First Order Tributaries and the Life History in a Southwestern Virginia Stream

INVESTIGATOR: Wayne A. Sadowski, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Two-way fish weirs were placed on six tributaties and two main-stream locations on Guys Run to determine movements of brook trout into tributaries and within the mainstream. Brook trout populations from the Guys Run drainage were also investigated to determine population densities, age structure, survival rates, growth rates and condition factors.

Brook trout appeared to utilize interrupted tributaries for spawning but no quantitative estimate could be obtained. The brook trout population studied also possessed some degree of stability; very little movement was recorded at the weirs. No brook trout were found older than four years old (III+) and the majority were 2 years old (I+) or less. First year growth of brook trout was average while growth thereafter was above average when compared to other streams in eastern North America.

A drought during the summer and fall of 1977 adversely affected the brook trout populations studied. Condition factors for brook trout during 1977-1978 indicated trout were in poor condition. Highly significant differences were found in condition factors for both young-of-the-year and adult brook trout between August 1976 and August 1977. Highly significant differences were also observed in both the length and weight of young-of-the-year brook trout between August 1976 and August 1977. Furthermore, survival of brook trout was poor during 1977-1978. Overwinter survival of both adult and young-of-the-year brook trout was much higher during 1976-1977 than 1977-1978.

PROJECT: The Quantitative Importance and Factors Affecting Brook Trout Recruitment in Interrupted Tributaries

INVESTIGATOR: Gerard A. Gray, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

A two year study to determine the importance of interrupted tributaries in the ecology of native brook trout was conducted on two interrupted tributaries, Beckney Hollow and Three Dwarf Run, flowing into Guys Run, a second order stream in Rockbridge County, Virginia. The objectives were: 1) obtain baseline data on movement into and out of interrupted tributaries and spawning activities in interrupted and permanent streams, 2) determine the quantitative importance of recruitment from interrupted tributaries to a mainstream population of brook trout, and 3) analyze factors affecting survival of brook trout eggs and larvae in interrupted and permanent streams.

Movement in interrupted tributaries was monitored with fish weirs. Two peaks in upstream movement occurred although numbers were small. Age II fish moved into the interrupted tributaries in 1977 while age I fish moved into the tributaries in January 1979. No age 0 and few age I or older brook trout moved out of the interrupted tributaries during the study. Flows were the single most important factor affecting movement into interrupted tributaries.

Age II was the dominant spawning age class in Guys Run. Few age I fish mature and few fish survive to age III. Most brook trout in Guys Run spawn only once during their lifetime. Environmental catastrophes that affect spawning significantly affect these populations. A drought in the summer of 1977 left brook trout in poor condition for the fall spawning season. Perhaps as a result, few fish spawned and the resulting year class was small. In 1978, spawning conditions were apparently good in the mainstream and a strong year class resulted. Low flows impeded movement of spawners into and within the interrupted tributaries during the fall of 1978 and few fish spawned.

The results of this study do not support the hypothesis that interrupted tributaries are important to mainstream recruitment of brook trout since only two fish were recruited to the mainstream from the interrupted tributaries during the study. Interrupted tributaries support small resident populations which may be supplemented on a variable basis by mainstream trout.

Survival of eggs and larvae was high in Guys Run and the interrupted tributaries. No differences in egg and larval survival between Guys Run and the interrupted tributaries could be inferred from statistical analysis.

PROJECT: Population Responses of Brook Trout Concurrent with Reductions in Numbers of Exotic Trout from Areas of Six Streams in the Great Smoky Mountains National Park

INVESTIGATORS: Stephen E. Moore and B.L. Ridley
Tennessee Technological University
Cookeville, Tennessee

Gary Larson, Uplands Field Research Laboratory
National Park Service

Native brook trout have declined in abundance and distribution in the Great Smoky Mountains National Park since about 1900. These decreases are attributed to logging and poaching prior to the establishment of the Park in 1936 and to immigration by rainbow trout and brown trout into allopatric brook trout waters. Attempts at rehabilitating several brook trout populations are discussed in this paper.

Exotic rainbow trout and brown trout populations were reduced in abundance and total weight by electrofishing in six headwater streams in which the exotics were sympatric with native brook trout. Each study area was upstream from a natural obstruction -- waterfall or cascade. Exotics were removed each summer from 1976 to 1978. Captured brook trout were marked and returned to the streams. Brook trout populations have responded to the removal of the exotics by increasing in abundance and total weight. Expected concomitant declines in total weight and abundance of exotic trout were dramatic in some cases but were not as apparent in others. Thus far the exotics could not be completely removed from the streams by the two-man (one shocker) team. Additional field work is scheduled for this summer.

Natural obstructions were measured and their effectiveness evaluated for preventing upstream passage by exotic trout. In some cases, cascades may be more effective barriers than similar sized waterfalls.

PROJECT: Population Structure of Allopatric and Sympatric Rainbow Trout and Brook Trout in Selected Streams in the Great Smoky Mountains National Park

INVESTIGATORS: Jeff Sweeney and B.L. Ridley
Tennessee Technological University
Cookeville, Tennessee

Gary Larson, Uplands Field Research Laboratory
National Park Service

Between 1900 and 1977 the stream miles inhabited by allopatric native brook trout in the Great Smoky Mountains National Park shrank from 425 to 125. A considerable amount of this mileage was lost during the logging era from 1903 to about 1936. Since then, however, continued losses have been attributed to invading populations of rainbow trout -- an exotic.

The objective of this study is to evaluate the invasion characteristics and processes of the rainbow and to determine how the rainbow, in sympatry, affect the brook trout populations. Presently, five of ten study streams have been sampled with back-pack electrofishing units. Preliminary analyses reveal that structural differences do exist in actively invading rainbow populations between sympatric and allopatric stream sections. It appears that large rainbow trout, ofter 200+ mm in total length, may lead the invasions. Very few small fish of either species are found in the sympatric sections relative to allopatric sections. All rainbow captured have been preserved and will be analyzed for age, sex, and prespawning fecundity. The general invasion strategies by the rainbow will be discussed.

SUMMARY OF TOPIC SESSION

Impacts of European Wild Boar in Great Smoky Mountains National Park

Susan P. Bratton, Research Botanist of Uplands Field Research Laboratory, opened the session by describing the history of the exotic European wild boar and its expansion in Great Smoky Mountains National Park. The park's wild boar impact studies were discussed, beginning with the first studies conducted by the University of Tennessee under the direction of Dr. Michael R. Pelton. Bratton's subsequent vegetation impact studies were also discussed.

Research Wildlife Biologist Francis J. Singer, Uplands Field Research Laboratory, described his current work on the population dynamics of the hogs and summarized his views on the damage caused by the hogs in the park. Past studies have documented the reduction of plant cover and invertebrates and alteration of plant species ratios. Additional ongoing studies include investigations of potential impacts of wild boar rooting on soil properties, the forest floor, small mammals, and erosion.

The majority of the topic session focused on the tendency of ecosystem components to eventually reach a level of stability with the wild boar. Garrett A. Smathers, Senior Scientist, National Park Service, described the great increase in exotic plant species in Hawaii after feral pig rooting. A.E. Ammons, North Carolina Wildlife Resources Commission, expressed the opinion that much of the mesic forest types, flowers such as spring beauty (Claytonia virginiania), high wild boar densities, and severe impacts do not occur in the mountains of North Carolina adjacent to the park.

Current wild boar research in Great Smoky Mountains National Park is described in the following abstracts.

PROJECT: A Comparison Among Feral Pigs and European Wild Boar Populations

INVESTIGATOR: Francis J. Singer, Uplands Field Research Laboratory
National Park Service

A variety of intergradations between feral domestic pigs (Sus scrofa) and introduced European wild boar (Sus scrofa) presently inhabit three national parks, three national seashores, and three national monuments administered by the Southeast Region of the National Park Service (NPS). This paper integrates information from European wild boar in Great Smoky Mountains National Park (GRSM) and feral pigs on Cumberland Island National Seashore with published information on both types; it draws tentative conclusions concerning movements, home ranges, group dynamics, and reproductive biology in order to better understand wild pig populations on the various NPS units.

In the harsher climates of northern and eastern Europe, wild boar rutted in the late fall and produced young only in early spring; additional August births occurred in milder parts of Germany. In contrast, European wild boar and feral pigs produced piglets in any month in the southeastern United States, although fall births were rare. Fall/winter production was often equal to or greater than spring/summer production, except during winter following a mast failure, when reproduction in GRSM was almost nonexistent. Wild boar usually conceived at 18 - 20 months of age in Eurasia and at an average of 16.8 months in GRSM, while feral pigs regularly conceived at 6 - 12 months. In a "typical" year, 75 - 100 + percent of females of wild boar bred and produced 302 - 537 piglets per 100 females. Average fetuses per female ranged from 4.4 - 5.6 in European wild boar populations, and 5.4 - 5.8 in feral pigs. Females may produce two surviving litters per year in all wild swine populations except for wild boar in harsher ranges of northern Europe and Asia. Wild boar were distinctly migratory in mountainous areas, while feral pigs are apparently never migratory. Published densities of wild boar ranged from 0.3 - 60 wild boar per km^2; the highest numbers occurred in flood plain and lakeshore habitat in Asia, Saupark, Germany, and high elevations in GRSM. Feral pig densities are generally higher, 3.9 - 79 pigs per km^2, but this could be due to their occupation of productive coastal marsh, maritime forest, and rain forest habitats. Group size of feral pigs, $\bar{x} = 2.2 - 2.7$ per group, is much smaller than European wild boar, $\bar{x} = 4 - 6$ per group.

PROJECT: Studies of Rooting Impacts of European Wild Boar on High Elevation Forest Floor in Great Smoky Mountains National Park : A Status Report

INVESTIGATORS: Francis J. Singer, Uplands Field Research Laboratory
National Park Service

Edward Clebsch, University of Tennessee
Knoxville, Tennessee

The food habits of introduced European wild boar (Sus scrofa) were studied in Great Smoky Mountains National Park during 1977 and 1978. The possible effects of European wild boar rooting on subterranean foods, mainly plant tubers and soil invertebrates, were investigated at the high elevations in 1978. Ongoing studies include assessment of the impact of rooting upon soil properties, soil nutrients, soil erosion, and fauna of the forest floor.

The diet of European wild boar in the high elevations consisted of 55 percent herbaceous plant material, 40 percent roots, 3 percent fruit, and < 2 percent vertebrates and invertebrates. Spring beauty corms (Claytonia virginica) were the most important food item and averaged 33 percent volume, followed by leaves and stems of wood nettle (Laportea canadensis), chickweed (Stellaria pubera), violets (Viola spp.), serviceberries (Amelanchier laevis), and blueberries (Vaccinium spp.). Principal animal foods were fly larvae (Diptera), ground beetles (Carabidae), land snails (Polygridae), and salamanders (Plethodontidae). Spring beauty corms were reduced 80 percent in areas rooted 6+ years and soil invertebrates were reduced 80 percent. Trout lily tubers (Erythronium americanum) are little eaten by wild boars and were not reduced significantly in the rooted habitat.

Studies of possible effects of rooting on the forest floor were initiated in late 1978. Preliminary data suggests that leaf litter is turned into the A_1 soil horizon, and the humic layer is reduced on heavily rooted sites. Ongoing 1979 studies are focused on any difference in litter nutrient levels, soil nutrients, small mammal numbers, salamander numbers, soil loss, and nutrient leaching between rooted and unrooted forested watersheds. Preliminary findings from these studies are reported.

PROJECT: Ecology and Management of European Wild Boar in Great Smoky Mountains National Park

INVESTIGATORS: Francis J. Singer, Uplands Field Research Laboratory
National Park Service

Stuart Coleman, Great Smoky Mountains National Park

European wild boar (Sus scrofa) invaded Great Smoky Mountains National Park in the late 1940's from introduction sites outside of the Park. From 1959 to 1977 the National Park Service live-trapped and released to the adjacent states or destroyed 1,187 wild boar. In late 1976 a more intensive backcountry reduction program and a research program were initiated. The National Park Service control program did not stem the invasion of the remaining unoccupied quarter of the Park by a handful of wild boar in 1979.

Annual population change was 32+ percent and +6 percent during two successive years when mast was abundant and -35 percent when mast failed. Blood condition parameters and fat reserves were reduced during winter of 1978-79 following the mast failure; sows with piglets were particularly stressed. Wild boar were greatly reduced in the Park in three management units, 1976-79. Dispersal back into these units was primarily by males and to a lesser extent by yearling females. Movements and activity of radio-collared wild boar were positively correlated to trapping success. Wild boar moved least in winter when mast was abundant. Capture success then was 49 - 64 man-hours per wild boar captured. Wild boar movements per hour were two times greater during summer, and only 8.2 man-hours were required per wild boar capture. During winter following a mast failure, wild boar movements increased 5.2 times and again capture success increased (15 man-hours per capture). In 1977, only 60, and in 1978, 42 wild boar were removed from an estimated high elevation population of 700 - 1,000. More effective control techniques are needed before any population reduction can be achieved. Presently, control activities are conducted in special protection areas and on any wild boar invading the remaining unoccupied quarter of the park.

PROJECT: Rooting Impacts of the European Wild Boar on the Vegetation of Great Smoky Mountains National Park During a Year of Mast Failure

INVESTIGATORS: Susan P. Bratton, Francis Singer, Mark Harmon and Peter White, Uplands Field Research Laboratory National Park Service

The European wild boar (Sus scrofa), an exotic species, entered Great Smoky Mountains National Park (GRSM) sometime during the 1940's and became established in the western end of the GRSM by the mid-1950's. During the summers of 1977 and 1978, .1 ha survey vegetation plots were established in four areas of the Great Smoky Mountains, including Abrams Creek, Gregory Ridge, Ledbetter Ridge, and Cades Cove, and information on wild boar rooting impact was obtained. During the fall of 1978 and the winter, spring, and summer of 1979, the plots were resurveyed for wild boar rooting and other indications of wild boar utilization. Data show that although wild boar utilization is widespread throughout the western part of GRSM, only a few of the plant communities represented in the sample were intensively rooted. Wild boar utilization was found in 29 of 40 vegetation plots taken in Cades Cove but only those in wet meadow areas and on flood plains showed soil distrubance of over 20 percent of the total area. Intensive rooting was noted in recently burned areas showing strong herbaceous regeneration and around old homesites. During the winter of 1979 very little oak mast was available and oak forest showed almost no rooting disturbance, although some had been noted in the summers of 1977 and 1978. High elevation northern hardwoods and gray beech stands, however, were intensively utilized during the fall and winter and were rooted again the following spring. Winter food habits and impacts on key root forages are presented.

SUMMARY OF TOPIC SESSION

Natural Disturbance in Plant Communities in Great Smoky Mountains National Park

After the first presentation, by Peter White, Uplands Field Research Laboratory, on patterns of natural disturbance, the role of disturbance in the maintenance of populations of endangered plant species was discussed. Some species were thought to be disturbance dependent, although many of the rare plants in Great Smoky Mountains National Park are known to be found in mature forest communities. Several participants mentioned the importance of fire and landslides, the latter particularly at higher elevations, in conjunction with unusual plant occurrences.

Larry Barden, University of North Carolina at Charlotte, presented data on the role of single tree windfalls in the regeneration and the structure of mature cove forests. Discussion centered on the distribution of hemlock and tulip tree and the possible eventual shifts in species distributions.

Mark Harmon, University of Tennessee, spoke on the fire history of the western end of the park. Questions were posed concerning the past importance of human interference, including both Indian and settler burning. Indian impacts may ofter be underestimated.

Nat Kuykendall, Denver Service Center, National Park Service, spoke on succession after pine bark bettle kills in xeric forests. Discussion centered on the recurrence of bettle outbreaks and effects both on fire regime and forest composition. The pine bark bettle is a natural insect pest, while the balsam woolly aphid is, like chestnut blight, an introduced organism.

Christopher Eagar, University of Tennessee, described the effect of the balsam woolly aphid on spruce-fir communities. Discussions centered on the importance of dead firs to fire management at the higher elevations. Spruce-fir stands, which occur on the wet and cool upper mountain slopes, may not be naturally prone to fire. However, logging slash did result in some extensive fires at the upper elevations; presumably, the dead wood resulting from balsam woolly aphid infestation could also result in higher fire danger in these stands.

Susan P. Bratton, Research Botanist, Uplands Field Research Laboratory, served as moderator for the session. Abstracts given during the meeting are presented on the following pages.

PROJECT: Impacts of Deer and Cattle on the Vegetation of Cades Cove

INVESTIGATORS: Susan P. Bratton, Uplands Field Research Laboratory
National Park Service

The impact of a concentrated (0.92 ha/deer) herd of white-tailed deer (Odocoileus virginianus) on the vegetation in Cades Cove is discussed. Utilization by livestock had a greater impact on the woodlots in the Cove than utilization by deer and reduced species number and stem counts in all strata sampled. Deer utilization reduced total species number and favored conifers in the 3-cm-dbh and smaller stem size classes. Reduction in species number was important among deciduous species that were not considered preferred food. The intensive impacts of deer do not appear to extend more than 1 km from Cades Cove.

PROJECT: Impacts of an Agricultural Area within a Natural Area

INVESTIGATORS: Susan P. Bratton, Raymond C. Mathews, Jr., and
Peter S. White, Uplands Field Research Laboratory
National Park Service

Agricultural management in Cades Cove, an historic district in Great Smoky Mountains National Park, has affected natural resources both within the district and in the adjoining natural areas. Aquatic impacts from haying and cattle grazing included increases in water temperatures, turbidity, nutrient loading, and bacterial counts and decreases in benthic macroinvertebrate density and diversity, and fish biomass. Wildlife populations, including groundhogs, wild turkeys, and white-tailed deer, have increased in the open fields and around the periphery of the historic district. Intensive deer foraging has removed deciduous seedlings and saplings from woodlots, lowering species diversity and favoring coniferous reproduction. Cades Cove has a number of limestone habitats unique in the park, and both deer browse and cattle grazing may have disturbed populations of rare plant species. Effects of water quality are detectable at a campground 15 stream km from the agricultural area, and effects of deer foraging extend about 1 km beyond the open fields.

Since "historic landscape" preservation is presently a goal of the park, managing for open vistas in Cades Cove will require some sort of continuing disturbance. Conversion of cattle pastures to hayfields would reduce aquatic impacts, but the deer herd might increase due to reduced competition for forage. Retarded old field succession would increase populations of native plant species but requires mowing by park staff or contracts. It is probably not possible to eliminate all impacts on natural resources as long as the Cove remains open.

PROJECT: Phytogeography of the Balsam Mountains and Pisgah Ridge, Southern Appalachian Mountains

INVESTIGATORS: J. Dan Pittillo, Western Carolina University
Cullowhee, North Carolina

Garrett A. Smathers
National Park Service

The Balsam Mountains occupy a central position in the southern Appalachians and have had a long and complex history, yielding a diverse composition of vegetation covering the varied types of soils, in turn derived from a long-term weathering of metamorphic rocks and subjected to the vagaries of climate. Review of the geology of the region indicated the acidic rocks were predominately metamorphic gneisses and schists. Soils derived from these rocks vary from Typic Dystrochrepts to Typic Hapludults to Typic Haplumbrepts and include several soil series. The climate varies from the cool, moist low elevational (610 m) average annual temperature of 13.2°C (56°F) and 1165 mm (45.9 in) average annual precipitation to the still cooler and more moist high elevational temperature average of 5.4°C (41.7°F) and 2195 mm (86.4 in) of precipitation.

Vegetational composition was studied with 27 10 x 10 m plot releves taken at 92.5 m elevational intervals. Of these, 9 were classified as mesic oak, 5 as xeric oak, 5 as spruce-fir, 3 as cove hardwood, 2 as boulder field, and 1 each as floodplain, cove hemlock, or successional sites. Additional information on grass balds, heath balds, successional communities, and beech gap forests was obtained from research reports. Summaries of the results indicated floodplain woodlands of the French Broad River quickly give way to the extensive oak forests of mountain slopes. These oak forests vary from the mesic type surrounding coves, north slopes, and high elevation ridges to the xeric type of the exposed south-facing ridges. Cove hardwoods occupy the moist, deep-soiled valley floors, sometimes grading into either cove hemlocks or boulder fields in the upper valleys. Highest elevations are dominated by spruce-fir forests with heath balds fringing rock outcrops or high elevation exposed, shallow-soiled ridges. High elevation gaps are often occupied by beech gap forests. Grass balds are scattered inexplicably throughout the spruce-fir forest. Successional communities occupy many areas where disturbance has been a factor, as in the burned-over Graveyard Fields.

Few correlations of physical elements and vegetation were noted. Generally the spruce-fir forests occur over the Burton and Porter soil series of the Haplumbrepts. There was a tendency for mica gneiss to underlie the Chandler soil series. It appears more fruitful to point out that the diversity of physical factors parallels but does not correlate with the diversity of vegetation. Thus the diversity of vegetation noted along a transect of the Balsams is further amplified by the diversity of climate, geology, and soils supporting these interlocking plant communities

PROJECT: Structure and Dynamics of the Plant Communities in a Section of the Obed River Gorge, Cumberland County, Tennessee

INVESTIGATORS: Paul A. Schmalzer and H.R. DeSelm
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C. Ross Hinkle
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Oak Ridge, Tennessee

The vegetation of the Obed River Gorge was sampled between Adams Bridge and Potters Ford within the Obed Wild and Scenic River boundaries. Fifty-eight 0.04 hectare circular plots were used to record canopy and sapling vegetation and to estimate environmental parameters. Agglomerative cluster analysis was used to establish six community types. The types distinguished were chestnut oak-white oak, white oak, tulip tree, beech-tulip, tree-white oak, beech-red maple-sugar maple, and river birch types. Canonical ordination analysis and discriminant analysis of the vegetation data suggested that the types were arrayed along a moisture axis. Discriminant analysis using selected environmental parameters indicated that slope position was most important in separating the communities. Reciprocal averaging ordination was used to examine associations of the canopy and sapling layer species; soil moisture as influenced by topographic position appears to be most important factor influencing these distributions. Diameter distribution curves were constructed in order to clarify successional status of the communities. The river birch and tulip tree communities appear to be successional; the chestnut oak-white oak and white oak communities appear to be relatively stable in overall composition, and the composition of the beech community types may be changing a moderate amount following past disturbance.

PROJECT: Bibliographic and Herbarium Computerization at Great Smoky Mountains National Park

INVESTIGATOR: Peter S. White, Uplands Field Research Laboratory
National Park Service

The biotic richness and rugged wilderness environment of Great Smoky Mountains National Park have long attracted the attention of natural scientists. This has resulted in a variety of information -- from published papers and formal research reports to unpublished theses, field notes, and correspondence. Another kind of information that has accumulated consists of raw data: plant, animal, and geologic collections, documents concerning human history, and baseline data for monitoring efforts. A project funded by the Great Smoky Mountains Natural History Association and carried out under the direction of Uplands Laboratory is described. Bibliographic work has been carried out for vegetation, pteridophytes, and fishes of the park and its vicinity. Computerization of herbarium records has begun. Preliminary results suggesting the usefulness of the system are described.

PROJECT: Mapping Major Forest Covers in Great Smoky Mountains National Park with Computer Processed LANDSAT Imagery

INVESTIGATORS: Mark E. Harmon, University of Tennessee
Knoxville, Tennessee

Jerry S. Olson, Environmental Sciences Division,
Oak Ridge National Laboratory, Oak Ridge, Tennessee

A combination of LANDSAT imagery and computer processing offers potential as a valuable resources management tool providing rapid, yet detailed landscape inventories on a regional level. The original satellite data of a October 1972 scene of the Clingmans Dome quadrangle was grouped into 14 units using cluster analysis and mapped. The overall correspondence between the Frank Miller vegetation map and environmental variables recorded at 207 field stations was noted. Preliminary results indicate the original 14 groups can be further aggregated into 3 units which represent 1) pure deciduous forest, 2) conifer-deciduous forest mixtures, and 3) pure coniferous forest. Individual forest types were not revealed by the imagery alone, although a combination of site variables (e.g., elevation and topographic position) and satellite imagery separated forest types successfully.

PROJECT: Replacement Stands Following Infestations of the Southern Pine Bettle in the Great Smoky Mountains

INVESTIGATORS: Nat Kuykendall, Denver Service Center
National Park Service

Edward Buckner, University of Tennessee
Knoxville, Tennessee

Stand composition and eleven site factors were sampled in 49 stands in the Great Smoky Mountains in which the pine overstory had been killed by the southern pine beetle. Replacement community types were determined using cluster analysis of relative densities for 21 common species. Absolute densities for total stems, total pine, total oak, and eight individual species in the overstory, understory, and reproduction strata were related to selected site and vegetation variables by correlation and stepwise multiple regression.

Infestations greatly reduced the importance of pine in all replacement stands, converting most pine dominated stands to mixed pine-hardwood. Pine reproduction was minimal in all cases. All stands appeared to be in early stages of recovery, and canopy closure was very low.

Six replacement types were derived. The red maple-dogwood type occupied low elevation, lower slope, old field sites. The red maple-sourwood type occurred on mid elevation broad ridgetops and protected upper slopes. The blackgum-mixed pine type occurred on mid elevation, mid to upper slope, exposed sites. The mixed pine-scarlet oak and the Virginia pine-blackgum types occupied exposed ridgetops and upper slopes at mid to low elevations. The table mountain pine-pitch pine type occupied high elevation kills on steep, exposed, upper slope positions.

Important environmental factors influencing replacement stand composition and dynamics appeared to be elevation, incident solar radiation, topographic position, and soil nutrient availability.

Future composition of replacement types was projected based on present composition and site conditions. The red maple-dogwood type will succeed to stands dominated by mixed hardwoods and white pine. In the red maple-sourwood type, the blackgum-mixed pine type, and the Virginia pine-blackgum type, chestnut oak will eventually dominate with scarlet oak and scattered pines in the canopy. The mixed pine-scarlet oak type will succeed to stands dominated by scarlet oak with residual pines as associates. Canopy closure will remain very open in the table mountain pine-pitch pine type due to the suppression of regeneration by dense mountain laurel, and the overstory will consist of widely spaced scarlet oaks and residual pines.

PROJECT: Community Composition, Species Diversity, Forest Structure and Dynamics as Affected by Soil and Site Factors and Selective Logging in Savage Gulf, Tennessee

INVESTIGATOR: Michael Sherman, University of Tennessee
Knoxville, Tennessee

Savage Gulf, a narrow gorge in the western Cumberland Plateau in Grundy County, Tennessee, supports one of the largest areas of virgin forest in the eastern United States. Also present is an adjacent secondary forest selectively logged in the past. The vegetation of these two areas was sampled during the summer of 1977. One hundred sixty-six .05 ha circular plots were placed in both secondary and virgin areas within four slope positions. Soil and site characteristics were measured.

Eight virgin community types and six secondary types were determined using an agglomerative clustering technique utilizing the importance values of 30 canopy species. Distribution of community types in both areas was best related to slope aspect and position.

Soils of the upper gorge were sandy, strongly acid and contained a deep mor type organic layer. Upper slope soils in the central area which were derived from sandstone were typically shallow, sandy and acidic. Lower slope soils which were derived from sandstone colluvium and limestone residuum, were deeper, slightly acid, contained less stone and sand than upper slope soils and had higher percentages of silt and clay.

Significant changes in the vegetation occurred in response to selective cutting. On the north-facing slope sapling density was significantly greater in the secondary area, representing a surge of reproduction which followed cutting. Overstory density and basal area were significantly greater in the virgin area. Sapling and overstory species richness and diversity were lower in the secondary area, due primarily to dominance of reproductive and canopy layers by sugar maple. Sapling densities of hemlock, yellow birch and shagbark hickory were significantly lower in the virgin area.

On the south-facing slope, sapling density was significantly greater in the secondary area; subsapling and overstory density were slightly greater in the virgin area. Basal area was significantly lower in the secondary area. Sapling and overstory diversity and richness were greater in the secondary area due primarily to the replacement of chestnut oak by a variety of successional shade intolerant taxa. Chestnut oak, mockernut hickory and hemlock densities were significantly lower in the overstory of the secondary area which was dominated by white ash, black locust, white oak and tulip poplar.

Communities of the virgin area were relatively stable; overstory dominants were reproducing in the understory layers. Secondary communities appear to be transitional to community types similar to those of the virgin area at corresponding slope positions.

PROJECT: Tree Replacement in Small Canopy Gaps of a Tsuga Canadensis Forest in the Great Smoky Mountains National Park

INVESTIGATOR: Lawrence S. Barden, University of North Carolina at Charlotte, Charlotte, North Carolina

Tree species replacement was studied in 95 canopy gaps created by the fall of single trees in an undisturbed, old-growth forest in Great Smoky Mountains National Park, Tennessee. When large trees (dbh > 70 cm) of the very shade tolerant species, Tsuga canadensis, die and fall, they are usually replaced by less tolerant species such as Betula alleghaniensis, Liriodendron tulipifera, and Magnolia fraseri. Species diversity of the replacement trees, measured by the index, $1/\Sigma p_i^2$, was 5.77 compared to a diversity of 1.66 for the fallen trees. The results suggest that minor endogenous disturbances such as death and fall of single canopy trees can maintain early and mid-successional species in an old-growth forest.

PROJECT: The Distribution and Dynamics of Forest Fuels in the Low Elevation Forests of Great Smoky Mountains National Park

INVESTIGATOR: Mark E. Harmon, Uplands Field Research Laboratory
National Park Service

In fall 1977 a study was initiated to examine forest fuel accumulations after 40 years of the fire suppression in Great Smoky Mountains National Park. Variations in fuel biomass, decay rates, and production were examined along gradients of elevation, topography, aspect disturbance, and community structure. Leaf litter production ranged between 350 - 450 grams per meter for mature stands and did not increase significantly in stands with basal areas larger than 10 meter^2 (hectare^{-1}). Major differences between stands in 01 and 02 horizons of the soil were correlated with forest cover, elevation, and time since last fire. Leaf decay rates were found to correlate with elevation and litter quality. Major differences in downed wood biomass were related to major canopy disturbances (e.g., fire, blowdown, insect damage, and chestnut blight), the time since disturbance, and the woody species killed. Hardwood and oak wood were found to decay faster than wood of pine or hemlock. Fires were found to remove 70 - 90 percent 01 and 25 - 90 percent 02, depending upon season and moisture content. Repeated man-set fires on upland sites during the prepark era reduced forest fuels to 1/2 - 1/8 the present levels. At present, most forest floors have reached a "steady-state" value; further fuel accumulation will probably only occur in conifer forests above 3,000 feet and within severely disturbed stands.

PROJECT: Fire History and Ecology of Western Great Smoky Mountains National Park

INVESTIGATOR: Mark E. Harmon, Uplands Field Research Laboratory
National Park Service

Examination of fire scarred trees from 21 ridges indicates a mean frequency of fire once every 16 years between 1860 and 1940. After 1940, an active fire suppression policy has allowed only two ridges to burn in 38 years. Although forest fuels have accumulated since approximately 1940, most low elevation stands have reached "steady-state" levels. However, further accumulation can be expected in high elevation pine forests and beneath severely distrubed canopies. Frequent man-set fires during the prepark era reduced upland forest fuel biomass between 1/2 to 1/8 the present levels. Tree mortality during fires was found to be a function of species, diameter, and fire severity. For any given diameter and fire severity, thin barked species were found to be twice as susceptible to fire as thick barked pines, oaks, and xeric hardwoods. Increment coring revealed that mesic hardwoods and suppressed pines will survive cool ground fires after 30 - 40 years of growth. A combination of xeric site and frequent man-set fire reduced the importance of thin barked mesic species on upland sites, although complete fire suppression since 1940 has reversed this trend. A combination of fire history, fuels, species growth rates, and age-specific fire mortality indicates upland sites prior to 1940 consisted of very open stands of large, widely spaced trees, with very little tree reproduction.

PROJECT: Biomass and Nutrient Composition of the Hannah Branch Watershed in Great Smoky Mountains National Park

INVESTIGATORS: D. A. Weinstein and Mark E. Harmon
University of Tennessee, Knoxville, Tennessee

Biomass and nutrient budgets of the Hannah Branch watershed above-ground woody vegetation were quantified as a tool for analyzing the effects of natural disturbances and human management practices on essential forest processes. 42% of the watershed area is covered by a mixed hardwood vegetation type, 26% by cove forests, 16% by a yellow pine type, and 16% by a chestnut oak type. Average biomass in cove forests, containing 220 mtons/ha, far exceeded average weights in other vegetation types. Coves also had the largest stand to stand variation in weight. The mixed hardwood type contributed the greatest amount to total watershed biomass due to its wide distribution. The same relationships held for phosphorus content on both the stand means and the total watershed basis. Pine bark beetle reduced biomass in pine stands by two thirds. Cool fires reduced biomass from 1 to 12%, and hot fires from 50 to 95%. A detailed forest simulator is being used to investigate the synergistic effects of the complex of variables which determine the effects of fire on stand composition, nutrient regimes, and stream water chemistry.

PROJECT: Type Specimens of Fungi from the Great Smoky Mountains National Park

INVESTIGATOR: James A. Liebman, University of Tennessee
Knoxville, Tennessee

The Great Smoky Mountains National Park (GSMNP) supports a rich mycoflora. This diversity is documented by species lists kept over a fifty year period of L.R. Hesler, mycologist at the University of Tennessee, and by the recent publication of a revision of this list under the title Checklist of Fungi of the Great Smoky Mountains National Park. The present study is an attempt to discover all species with holotypes from the GSMNP. Out of about 2400 species of fungi reported from the park, there are over 100 species with types from the park. Forty percent of these types are from Cades Cove. The project has yielded several products: 1) straightened up the card catalogue to the fungus herbarium of the University of Tennessee; 2) added some 200 new species records to the park list; 3) started towards production of a GSMNP exsiccatae; 4) improved the mycofloristic records for the park; 5) shed light on the use of floristic diversity as an alternative to defining rare and endangered status in fungi. The Rare and Endangered Species Act implies that the presence of rare and endangered species may be grounds for preserving a piece of land in a natural state. With fungi, the question of what is rare and/or endangered is difficult or impossible to answer for several reasons: the thallus of a fungus is below the substrate; fruit bodies, which are ephemeral, are presently the main basis for taxonomic and floristic work; both taxonomy and floristics are poorly known for many taxa. A taxon cannot be described as rare and/or endangered if it cannot be defined taxonomically and floristically. If one point of preserving rare species and habitats is to maintain diversity of life on earth, then perhaps definitive records of floristic deversity for an area can be used to preserve that area, as an alternative to defining rare and endangered status, especially for problematic groups such as the fungi. Hence, the continuing mycofloristic records for the GSMNP are particularly valuable.

PROJECT: Floristics, Rare Plants, Limestone Flora, and Additions to the Flora of Great Smoky Mountains National Park

INVESTIGATOR: Peter S. White, Uplands Field Research Laboratory
National Park Service

Botanical research in Great Smoky Mountains National Park has added 82 species to the list of vascular plants known from the park. Fifteen of these species are plants listed as rare, endangered, threatened, or of special concern by the States of Tennessee and North Carolina, thus increasing our total of listed plants to 120, roughly 10 percent of the native flora. The limestone areas and their floras are unique in the park, and work in these areas has resulted in about 30 additions to the park flora.

PROJECT: After Preservation: Managerial Issues Concerning Rare Plants in Great Smoky Mountains National Park

INVESTIGATORS: Susan P. Bratton and Peter S. White
Uplands Field Research Laboratory
National Park Service

Conservation of rare species is often though of primarily as a battle to protect the lands on which they occur. Great Smoky Mountains National Park was originally protected for its landscape and old growth forest as well as for its botanical diversity. Although it has been a legislated preserve for over 40 years and supports over 100 plants of state or national concern, human interference still threatens rare plant populations. Direct impacts include construction of roads and other developments, campsites and trails, legal and illegal collecting, and trampling by visitors. Indirect anthropogenic impacts include air pollution, introduction of exotic species, and disruption of ecosystem structure, especially in the case of overgrazing by ungulate populations. Changes in developed areas both inside and outside the preserve may influence plant populations through modifications in drainage, substrate stability, or herbivore utilization. Important issues for the preserve manager include: At what genetic level should one manage? Should management be ecosystem/process oriented or species oriented? Is "natural" extinction permissible? How should natural disturbances like fire be managed in relation to rare species? Should aesthetically appealing or historic plant communities be maintained?

PROJECT: Management of Spruce-Fir Forests

INVESTIGATOR: Paul Richard Saunders, Clemson University
Clemson, South Carolina

During the past five years research has been conducted on the effects of various disturbances on our Southern Appalachian spruce-fir forests. These studies have examined the effects of the balsam woolly aphid, the Mt. LeConte Lodge, the network of hiking trails, the overnight campsites and shelters, and various types of logging on these forests. Although there are seven disjunct spruce-fir areas within this region (Great Smoky Mountains, Plott Balsam Mountains, Balsam Mountains of North Carolina, Black Mountains, Grandfather Mountain, Roan Mountain, and Balsam Mountains of Virginia), all face similar managment problems, primarily from heavy recreation use. Poor resource management practices of the past have resulted in the loss of over one-half of the original spruce-fir forests in the Southern Applachians.

Based on this previous research, several guidelines can be offered for the management of spruce-fir areas. These guidelines are directed primarily towards problems of recreation managements, and focus on such issues as exotic plant and animal species, restricting the size of disturbances, and returning disturbed areas to the native vegetation. These guidelines include (1) prohibit the introduction of exotic plant and animal species, (2) keep recreation disturbances as small as possible, (3) increase the quality and quantity of trail maintenance, (4) reinforce horse trails or eliminate horse use, (5) prohibit campfires at all back-country sites, (6) reduce the size requirements for campsites or shelters or other structures in order to lessen the threat of windthrows, (7) prevent fires in logged spruce-fir stands, (8) use of draft animals and selection cutting rather than heavy machinery and clear cutting in logging operations, (9) prevent the logging of aphid infested stands, and (10) develop a forest regeneration program such as seeding and/or planting on older burned or logged sites and on severely disturbed recreation sites.

These guidelines are by no means complete, because much research remains to be done. Neither have these guidelines been implemented under rigorous test procedures. However, careful analysis of research results and current management practices indicate that these may be useful tools in the management of our remaining spruce-fir stands.

PROJECT: Great Smoky Mountains Preliminary Study for Biosphere Reserve Pollutant Monitoring

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A preliminary sampling program was initiated in the Great Smoky Mountains National Park. This national park of 209,000 hectares was selected to be a part of the Southern Appalachian Biosphere Reserve cluster. It serves as a permanent reservoir of genetic material and a site where natural ecosystems can be sampled, studied, and preserved.

An interest in the state of the environment as indicated in the framework of the Man and Biosphere Program (MAB) necessitates the need for assaying and documentating the environmental quality in these preserves. As such, a monitoring program was initiated. This initial program, a mutual effort by the U.S. Environmental Protection Agency and the U.S. National Park Service, had two objectives. The first objective was to determine the levels of trace elements and organic contaminants in physical and biological media. The second objective, following data analysis and evaluation, was to design an effective and cost efficient pollutant monitoring system.

Physical and biological media sampled included air, water, soils, litter, and various species. Analytical results of these samples showed a variety of elemental contamination. The concentration of lead in litter at four sampling sites was of particular importance. The concentration ranged from 246 to 469 parts per million. This data, similar to that reported by other researchers, showed that lead levels increase with altitude.

A field sampling error of plus or minus 10 percent at the 95 percent confidence level was desired. The number of samples required to satisfy this condition, for a permanent monitoring system, based upon the sample/element combination, was determined.

Environmental monitoring, as signified by the U.S. Environmental Protection Agency, is the systematic collection of physical, chemical, biological, and related data pertaining to environmental quality, pollution sources, and other factors that influence or are influenced by environmental quality. Environmental quality data are essential for determining the exposure of critical populations at risk. Such data are obtained by establishing monitoring systems to identify and measure pollutants and their concentrations in air, water, vegetation, soil, and food. The identification and measurement of pollutants in preserved areas, such as the biosphere reserves, may permit the monitoring of subtle deleterious processes which may be masked in areas of high impact. In identifying and measuring the exposure of receptor communities to chemical or physical agents, monitoring data provide the basis for quantitating the contributions of environmental pathways for each chemical or physical form of the pollutant.

PROJECT: Air Quality in the Great Smoky Mountains and Shenandoah National Parks and Related Studies on Impacts to Vegetation

INVESTIGATORS: N. Thomas Stephens, John M. Skelly, Lance W. Kress, Barbara Lubkert, and T. Frederick Albee
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Ambient air quality, visibility, and other related parameters have been the subject of a study in the Great Smoky Mountain and Shenandoah National Parks. These studies have been conducted utilizing a specially instrumented twin engine aircraft to which several recent additions have been made. A description of these additions, and data representative of the most recent monitoring flights were discussed, and related to examples of ozone damage symptoms to Pinus strobus (Eastern White Pine) in the park were presented.

Recent equipment additions to the aircraft include an integrating nephelometer for visibility, a dew point hygrometer, and a teflon filter system for aerosol composition and gravimetric analyses.

Ambient air quality data to date indicate a substantial difference in ozone concentration on the south side of the park which is not as subject to anthropogenic influences as the north side. Ozone concentration differences on the order of 20 to 30 ppb are common. High values of ozone concentration recorded have been on the order of 90 to 100 ppb. Sulfur dioxide concentration values of on the order of 2 to 20 ppb have been recorded, with the higher values occurring in late fall. No extremely poor visibilities have been recorded to date, however the monitoring equipment has only been recently installed. Visibility ranges of 10 to 100 miles have been recorded. Aerosol samples are being collected to analyze for mass concentration and composition. To date, particles collected have shown a high sulfate concentration.

Results of the June, 1979 survey of Pinus strobus at the Northwest section of the Great Smoky Mountains indicated the presence of photochemical oxidant injury including tip burn indicative of high oxidant exposure during the previous 10 to 14 days.

Similar studies are being conducted in the Shenandoah National Park, and data were discussed based on the early phase of these studies.

PROJECT: Physical and Chemical Characteristics of Streams in Great Smoky Mountains National Park

INVESTIGATORS: David Silsbee, Gary Larson, and Raymond C. Mathews, Jr.
Uplands Field Research Laboratory, National Park Service

Most of the Great Smoky Mountains National Park (GRSM) is underlain by insoluable sandstones, although there are also limestone areas, areas of highly acidic rocks (Anakeesta), and several other less dramatic formations. A one-year study was begun in the fall of 1977 to assess the water quality of streams in the Park with possible relation to these factors as well as elevation and forest type.

Water samples were taken from streams in all areas of GRSM and analyzed for pH, conductivity, alkalinity, hardness, turbidity, nitrate concentration, fecal coliform, fecal streptococcus, and total coliform bacteria. Temperature and flow measurements were also made. Each station was sampled quarterly to look at seasonal variation, and two stations were sampled daily to assess shorter term variability. Results were correlated to vegetation, geology, past and present human disturbance, and elevation of watersheds, as well as season and weather conditions. Only the more generally significant findings are presented here.

Nitrate concentrations were found to be controlled almost exclusively by elevation and past logging history. Watersheds which had been logged prior to establishment of the Park showed much lower nitrate concentrations than those never exposed to extensive logging. High elevation streams had much higher concentrations than those at low elevations. Concentrations ranged from near zero in low elevation logged areas to over 5 mg NO_3 /1 in high elevation unlogged areas.

Other chemical parameters were affected primarily by geology and elevation. Conductivity was generally below 20 μmhos/cm^3, alkalinity and hardness below 10 mg/1 (as $CaCO_3$) and other parameters at similarly low levels except where influenced by limestone or other carbonate-containing rocks. Water was much more acidic in high elevation streams, decreasing at a rate of approximately 0.3 pH units per 1,000 ft. elevation. Concentrations of most mineral constitutents reversed at both high and low elevations; lowest values were found at middle elevations.

Bacterial counts, though high in some heavily used areas, seemed to be affected primarily by water temperature. The highest counts were found in summer and at low elevations.

PROJECT: Satellite Remote Monitoring Project: A Status Report

INVESTIGATORS: Raymond E. Burge, Coastal Field Research Laboratory
National Park Service

Raymond C. Mathews, Jr., Gary Larson, and David Silsbee
Uplands Field Research Laboratory, National Park Service

Raymond Herrmann, Air and Water Resources Division
National Park Service

Since June 1977 four automated convertible data collection platforms have been in use in the Great Smoky Mountains National Park. These units, provided to the National Park Service by the U.S. Geological Survey EROS Program, have been undergoing field test for data validation, operational practicality, and support requirements, while at the same time producing data that have been extremely helpful to the research program of the park.

Of the four platforms, two are implemented with water quality sensors which monitor temperature, conductivity, pH, oxidation reduction potential, and dissolved oxygen. The remaining two platforms are implemented with meteorological sensors which monitor cumulative precipitation, wind speed, wind direction, temperature, barometric pressure, and relative humidity.

Three of the platforms, two water quality and one weather unit, were initially deployed in the Cades Cove area on Abrams Creek, providing a comprehensive survey of the water quality relative to responses caused by weather phenomena, cattle impacts, and stream flow regimes. The remaining weather unit was located at the Uplands Field Research Laboratory in the Twin Creeks area, where data generated by this system have allowed researchers to look at pH depression trends in Scratch Britches Creek in response to acid precipitation.

The potential of these platforms to provide both management and theoretically orientated information to NPS scientists is continuing to be investigated. Presently the platforms have been relocated to other areas of the park where data generated will be utilized to assess changes in water quality of watersheds having different forest growth dynamics, and to correlate weather trends with air quality data.

PROJECT: Heavy Metals in the Sediments of Fontana Lake

INVESTIGATORS: A.R. Abernathy, Environmental Systems Engineering
Clemson University, Clemson, South Carolina

Gary Larson and Raymond C. Mathews, Jr.
Uplands Field Research Laboratory, National Park Service

Several Great Smoky Mountains National Park streams which empty into Fontana Lake may be contaminated with heavy metals leached from Anakeesta formation. The objective of this study was to determine if heavy metals are deposited in the sediment of the lake from these streams. Heavy metal analyses of the sediment included iron, copper, zinc, magnesium, manganese, aluminum, and mercury. Sediment samples were collected in the shallows near the mouth of each main stream entering the reservoir as well as in the deepest portions of the reservoir.

Samples from the major river stations were greater in concentration of each metal than stations on small streams except for mercury, which was the same. The main lake sediments were higher in concentration in all metals than were samples from small streams, and similar in concentration with samples from the main river. Mercury was highest in concentration in main lake samples. Copper was high in concentration in two small stream samples, these streams receiving drainage from an abandoned copper mine. Based upon the literature, the sediments of the lake seem high in concentrations of heavy metals in comparison to lake sediments from unpolluted areas. Possible sources of these metals are discussed.

PROJECT: Human-Bear Interactions in the Great Smoky Mountains National Park

INVESTIGATOR: Jane Tate Eagar, University of Tennessee
Knoxville, Tennessee

An ethological investigation of interactions between panhandler black bears (Ursus americanus) and park visitors was conducted in the Great Smoky Mountains National Park from 1976 through 1978. This report focuses only on one aspect of the overall study - ursid aggression. There were 301 panhandling sessions recorded on 33 different bears. Because of the occasional presence of more than one bear at a panhandling site, there were 392 total data observations. Seven types of aggressive acts were classified: 1) low moan vocalization, 2) blow vocalization, 3) dispersal running, 4) bipedal swat, 5) quadripedal swat, 6) charge, and 7) snap-bite. For analysis each type was assigned a numeric value reflecting its apparent severity; these were summed to obtain a level of aggression for the session.

Of 392 observations, 172 (43.9%) involved at least one aggressive act, and a total of 624 aggressive acts were recorded. Calculating aggression indices (mean number of aggressive acts per session) for all bears showed that there was much individual difference in the amount of agonistic behavior exhibited; some bears were simply more aggressive than others. Generally males had higher indices than females and those bears panhandling on a regular basis (Group I Panhandlers) had lower indices than those doing so less often (Group II Panhandlers). Furthermore, the time latency from the beginning of the session until the performance of an aggressive act was significantly greater for Group I (15.8 minutes) than for Group II (9.7 minutes) (Mann Whitney U test, $p < 0.05$).

The frequency of occurrence of each of the seven types of aggression and all 20 classes of apparent precipitating factors was tabulated. Precipitators of aggression were either single factors (e.g., handfeeding, crowding, photographing, harassing, petting, etc.) or a combination of such factors. The blow vocalization (frequency = 257) and charge (frequency = 234) were the most common aggressive acts, accounting for 78.7%. Crowding by visitors was the most frequent precipitating factor, being at least partially responsible for 63.9% of all aggression. Construction of a two-way table of precipitating factors by types of aggression illustrated that certain factors were more likely to lead to a specific type of agonistic behavior. A Chi-Square test was significant at $p=0.0001$.

Only 5.9% of all recorded aggression resulted in actual physical contact, and 78.4% of all contact aggression was caused by crowding, petting, or a combination thereof.

A multiple regression analysis was employed to ascertain whether certain elements of the setting within which the human-bear interaction occurred had an effect upon the likelihood of performance of aggression. Independent setting variables included date, time duration of session, temperature, weather condition, maximum distance from cover, number of visitors, number of feeding incidents, and sex and age of the bear. The level of aggression was the dependent variable. Results indicated that the duration of the session and the number of feeding incidents were the best predictors of aggression.

These data substantiated the hypothesis that there was an approach-avoidance conflict inherent in panhandling for black bears. The low incidence of contact aggression attested to their remarkable restraint in dealing with visitors. Yet even bears who panhandled regularly and had learned what was "expected" of them in their encounters with people, often exhibited agonistic behavior when the situation became sufficiently anxiety-laden.

PROJECT: Tubers, Waders, and Swimmers in the Great Smoky Mountains National Park

INVESTIGATORS: Gary L. Larson, Uplands Field Research Laboratory
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Little research has been done concerning recreational use of the park's aquatic resources. During the summer of 1978, a preliminary study was initiated to investigate some of the dynamics of tubing, swimming, and wading in various park streams. Systematic observation and park use estimates were used to determine: 1) sites and frequency of use, 2) number of users, 3) time-of-day use patterns, 4) potential for ecological impacts and user conflicts, and 5) future research needs.

Results indicate that tubing was most common at Deep Creek, where an estimated 25,000 tubers participated during 1978. Swimming and wading were most common at the Townsend Wye site. All three activities occurred most often betwen the hours of 1400 and 1600 and during the months of July and August. Most serious impacts consisted of streambank erosion (much due to on-lookers), and alteration of the stream characteristics when forming dams and race-way chutes for tubing. The three recreational activities often occurred in different portions of the streams, indicating that user conflicts may not be a concern. But no data was collected from users concerning preferences and possible use conflicts. Most of the aquatic activity was by day users, not campers.

The baseline data collected serves as a basis for future studies concerning ecological impacts, and behavioral research of these users for management purposes.

PROJECT: Human Visitation, Undocumentated Caves, and Fall Usage by Bats in Caves of the Great Smoky Mountains National Park

INVESTIGATORS: Ben Nottingham, Uplands Field Research Laboratory
National Park Service

Alan Rabinowitz, University of Tennessee
Knoxville, Tennessee

From September 6 to October 25, 1978, activity monitorings were conducted to determine fall bat usage at eight cave entrances in the Great Smoky Mountains National Park. Visual counts of bat flights indicated that activity may vary depending on cave location and date of observation. For most caves, activity was generally light and in some cases non-existent. Special emphasis was placed upon Blowhole Cave which exhibited high levels of flight activity. This activity may be indicative of swarming behavior. Fall activity did not serve as an indicator of winter cave usage by bats. Previous literature notes that bats involved in fall swarming at a cave entrance do not usually occupy that cave during winter.

A survey of undocumented caves in the park was conducted by interviewing park employees, local residents, and spelunkers. One undocumented cave was located and mapped.

Human visitation data (1965-1978) was collected for all park caves through interviews, grotto newsletters, and park files. Gregory Cave displayed the highest use due to its usage as a study area by the Tremont Environmental Education Center. Bull and Blowhole Caves showed the next highest visitation but were significantly below that of Gregory Cave. All other caves received relatively little visitation.

Visitor use caused some adverse impacts on the cave environments. Trash, spent carbide, speleothem breakage, and campfire evidence were reported in half of the caves. These could affect the caves' asethetic and water qualities. Disturbances to hibernating bat colonies has likely resulted since winter visitation was recorded.

PROJECT: Preliminary Report of the Effects of Microhabitat Structure on Centipede Distribution

INVESTIGATOR: Gerald Summers, University of Illinois
Urbana, Illinois

Preliminary results of a study of centipede distribution in forest-floor litter in the Great Smoky Mountains National Park are presented. Approximately 130 specimens representing 13 species were collected with a modified litter-sampling device from 5 sites along an elevational gradient. Structural features were measured at four sites. Scolopendromorph centipedes show a significant relationship to tree dispersal (a measure of basal area) while a significant proportion of the variation in lithobiomorph centipede distribution is explained by shrub size. Additionally, weak correlations were found between Scolopocryptops nigridius McNeill 1887 and shrub size and Nampabius carolinensis Chamberlin 1913 and canopy cover, but no other specific correlations were found.

PROJECT: Activity Patterns of Woodchucks in Cades Cove, Great Smoky Mountains National Park

INVESTIGATOR: Cathy A. Taylor, University of Tennessee
Knoxville, Tennessee

Twice weekly between 7 July 1977 and 11 July 1978, observations were made of woodchucks (Marmota monax) in Cades Cove, Great Smoky Mountains National Park to assess behavioral responses to the environment. Cades Cove is located near the southeastern extremity of the woodchucks' range. Mean activity observed per hour changed throughout the year in response to changing densities of nonhibernating woodchucks and changing activity levels per individual. Mean activity of woodchucks in Cades Cove differed from more northern populations due to a longer growing season and a shorter period of hibernation. Frequency distributions of various behaviors changed with season and time of day in response to reproductive condition, environmental conditions, and social interactions. Foraging was predominant during all seasons, though it occurred less frequently than in northern populations. Alert positions occurred more frequently in summer and fall than during winter and spring. Resting, alert, traveling, and social behaviors were more prevalent during the morning while foraging was the dominant behavior during the afternoon. Daily activity patterns changed throughout the year with a unimodal distribution occurring in spring and fall and a bimodal distribution occurring in late spring and summer. The bimodal pattern was not found to occur in response to temperature as suggested by earlier researchers, but rather was thought to be a result of individual activity levels. Cloud cover, temperature, and precipitation were found to affect activity over a yearly period, though differences were found in the seasonal effects of those variables. Though not significant over a year, relative humidity influenced behavior during certain seasons.

PROJECT: Some Population Trends of the Cades Cove Deer Herd

INVESTIGATOR: Michael J. Kiningham, University of Tennessee
Knoxville, Tennessee

Roadside counts of the Cades Cove deer herd have been conducted 3 times a week (at dawn, dusk, and night) since July 1978 to determine the current status of the herd. Pellet counts and deer drives both supplemented and complemented the roadside counts. Results indicated that a high density of deer occurs within the Cove. The highest density, 1.82 ha/deer, was obtained from the roadside counts made during April 1978. Density estimates derived from night counts of fields only show that there were more deer utilizing the fields during the summer of 1978 and the spring of 1978 prior to a die-off that occurred in 1971. Reduced numbers of cattle in the Cove may explain why a die-off did not occur in 1978. Because a high population of deer exists in the Cove, the threat of a die-off persists. The potential for habitat destruction also remains unchanged, at best.

A historical area surrounded by a natural area creates a challenge for resource managers. An appropriate balance needs to be established between cultural and wildlife concerns. Such a balance does not currently exist and as a result both concerns might ultimately suffer.

PROJECT: Aspects of the Reproductive Biology of Black Bears in the Great Smoky Mountains National Park and Cherokee National Forest

INVESTIGATOR: John H. Eiler, University of Tennessee
Knoxville, Tennessee

Research is being conducted on the reproductive biology of black bears (Ursus americanus) in the northwestern section of the Great Smoky Mountains National Park and the adjacent Cherokee National Forest. Female black bears trapped during summers are radiocollared and checked for signs of estrus or lactation. Vaginal smears and the pH and electrical resistance of the vaginal tract are recorded as possible indications of estrus. Sightings of family groups are recorded to compare litter sizes from different years. Winter dens of radiocollared females are located to determine number of cubs produced. The dens of 20 radiocollared females were located during the winter of 1978-79. Six individuals denned on the ground; the remaining 14 denned in tree dens. The reproductive condition for 15 females in winter dens was determined. Five females produced cubs. Litters of 2 and 3 cubs were observed. Five females were observed with yearlings in the den. Litters of 1, 2, and 3 yearlings were observed. Five females were found without cubs or yearlings in the dens.

PROJECT: The Systematic Status and Distribution of Jones' Middle-toothed Snail, a Species Proposed for Endangered Status

INVESTIGATOR: Fred G. Thompson, Florida State Museum
University of Florida, Gainesville, Florida

The land snail Mesodon jonesianus was proposed for endangered species status because 1) it was thought to be restricted to Newfound Gap, Great Smoky Mountains National Park, 2) it was thought to be rare, and 3) possible impact by humans and wild hogs may be having adverse impacts upon its extant populations.

Field studies conducted in 1978 showed that a) jonesianus has a much wider distribution than previously thought on Newfound Gap Ridge, Thomas Ridge, and adjacent areas, b) it is generally common throughout its range, c) the snail is cryptozoic in dryer red oak-hemlock-beech forests, d) no significant impact by humans or hogs is occurring, although hog impact may occur in the future if hog populations continue to expand in the park, and e) jonesianus is subspecifically related to two other land snails within the park.

PROJECT: Status of the Endangered Indiana Bat, Myotis sodalis, in the Great Smoky Mountains National Park

INVESTIGATORS: Alan Rabinowitz, University of Tennessee
Knoxville, Tennessee

Ben Nottingham, Uplands Field Research Laboratory
National Park Service

From January 13 through March 31 single visits were made to the nine known caves within the park. Individual bats or small clusters were tallied with hand counters. Large clusters were estimated by measuring and counting a portion of the cluster and then extrapolating over the cluster surface area. Temperature and humidity measurements were taken in all caves.

Only two of the park caves, Blowhole Cave and Bull Cave, were found to contain Indiana bats. The estimated population size in Blowhole Cave of 12,000-15,000 Indiana bats makes this cave the largest known hibernaculum for this species in Tennessee and it is cited as one of the ten largest known hibernaculum in the United States. Furthermore, since the estimated colony size showed no change in numbers from a 1974 census carried out by Tuttle and Humphrey, it appears that the population has remained stable during the last five years. The fact that no bands were noted on these bats suggests that this colony may represent a breeding unit separate from the formerly large Kentucky populations which have decreased 73% in the last 15 years. Several hundred Indiana bats were also discovered in Bull Cave. The cold, wet, hazardous conditions of this cave made exact counts on the bats impractical. Park restrictions regarding winter entry into this cave have caused this population to remain undiscovered until this time.

The structural complexity and temperature ranges found within these two caves provide the necessary cool, stable habitat for the Indiana bat during the winter months. The small size of most of the clusters observed (50-100 bats), as well as the availability of unoccupied sites within the range of optimal hibernating temperatures, indicate that with proper protection from human disturbance these caves might contain larger numbers of Indiana bats in the future. This is particularly true for Blowhole Cave. Proper protection of these caves is crucial at a time when so many other Indiana bat colonies have disappeared or are declining.

PROJECT: Experimental Verification of Interspecific Competition in Terrestrial Salamanders

INVESTIGATOR: Nelson G. Hairston, University of North Carolina
Chapel Hill, North Carolina

Experimental removal of Plethodon jordani from plots in the Great Smoky Mountains resulted in a statistically significant increase in the abundance of P. glutinosus. Removal of P. glutinosus from other plots resulted in a significant increase in the proportion of the youngest age classes. These results conform to expectations of strong competition, based on the fact that the two species overlap by only 200-400 feet vertically. In the Balsam Mountains, where wide altitudinal overlap led to the expectation of no significant competition, the same experiments gave similar results, but later in the experiment and less dramatic than in the Great Smoky mountains. Both sets of experiments permitted the direct calculation of coefficients of competition and carrying capacities. The ratios of the latter were always greater than the former, as is required in ecological theory for coexisting species.

PROJECT: The Evolution of Ecological Differences Under Competition

INVESTIGATOR: Nelson G. Hairston, University of North Carolina
Chapel Hill, North Carolina

Transferring Plethodon jordani between areas of intense and weak competition with P. glutinosus showed that both species have evolved in ways that decrease competition in the Balsam Mountains, because neither has an appreciable effect on the opposite species from the Great Smoky Mountains. This result conforms to recently elaborated evolutionary-ecological theory. In the Great Smoky Mountains, by contrast, both species have evolved competitive mechanisms sufficiently potent to keep them almost completely separated altitudinally. Both have a stronger effect on the opposite species from the Balsam Mountains than the local Balsam populations have on each other. This result is not well explained by current theories of evolutionary ecology.

PROJECT: Reoccupation by Beaver and the Otter Niche in Great Smoky Mountains National Park

INVESTIGATORS: David LaBrode, Lorrie Sprague, and Francis J. Singer
Uplands Field Research Laboratory, National Park Service

Beaver (Castor canadensis) were extirpated from Great Smoky Mountains National Park (GRSM) by the time of its creation in 1934, and otter (Lutra lutra) were extirpated soon afterward. In recent years beaver have been extending their ranges in all five adjacent states, and in 1968 they reentered the park at Eagle Creek. Information on beaver range, habitat, and food habits is presented, along with the potential otter niche.

Beaver presently occupy six drainages in the park and are invading at an average rate of 4.0 km of stream per year. Beaver are largely confined to the lower 2 - 5 km of slower moving water near the park boundary, although foraging extends as far as 14 km into the park.

Gradient is high in the park streams and few beaver dams are built. Twenty-one species of trees and shrubs were fed upon in the five streams studied. A value index based upon relative abundance and degree of utilization indicated flowering dogwood (Cornus florida) was by far the most important species. Yellow poplar (Liriodendron tulipfera), black birch (Betula lenta), yellow birch (Betula lutea), oaks (Quercus spp.), sycamore (Plantanus occidentalis), ironwood (Carpinus caroliniana), beech (Fagus grandifolia), witch hazel (Hamamelis virginiana), hemlock (Tsuga canadensis), and alder (Alnus serrulata) all had a value index over 50. We predicted that the best otter habitat would also be in the pools and slower moving water near the park boundary and consequently would be a somewhat limited range. Fish population changes have been considerable since the 1930's as exotic brown trout (Salmo trutta) and rainbow trout (Salmo gairdneri) progressively invade the park.

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