

FISHERY MANAGEMENT PLAN
GREAT SMOKY MOUNTAINS NATIONAL PARK
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FISHERY MANAGEMENT PLAN

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I. INTRODUCTION

The National Park Service (NPS) is unique among federal land managing agencies in that it is mandated to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations" (NPS Organic Act, 1916). Throughout the history of NPS, managers have encouraged recreational angling in naturally functioning aquatic ecosystems characterized by wild native and non-native species and natural habitats. In the southeast, the Great Smoky Mountains National Park is recognized for the quality of recreational angling and the diversity of its fish fauna. This Fishery Management Plan provides guidance for future management actions and ensures the preservation of naturally functioning aquatic ecosystems. The plan should be reviewed and updated on a three-to-five-year basis, but changes in funding or priorities during this time period may also dictate the need for revision at other times.

A. Management Policies

One of the guiding philosophies of the National Park System is the protection and preservation of native ecosystems including native species and natural ecosystem processes. The intent of this philosophy is to protect unique areas from anthropogenic influences so that present and future generations can understand and appreciate their natural environment. Unfortunately, the land included in many of the parks was acquired after the landscape and species composition had been changed by European discovery/intervention. In aquatic systems, the result has been the expanding displacement of native species or the disruption of natural ecosystem processes as a result of the introduction of species of exotic fish.

1. Exotic Species

NPS Management Policies (4.11) defines exotic species as:

"...those that occur in a given place as a result of direct or indirect, deliberate or accidental actions by humans (not including deliberate reintroductions).... The exotic species introduced because of such human action would not have evolved with the species native to the place in question and, therefore, would not be a natural component of the ecological system characteristic of that place."

The management of exotic fishes, especially sport fish, is a common problem to the majority of NPS units that have substantial fishery resources. Frequently, the introduction of a non-native species has been initiated to satisfy recreational angling demand and has resulted in the displacement of native fish species. Prime examples of this are brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta) in western parks, which are displacing native cutthroat trout (Oncorhynchus spp.), and the displacement of brook trout by rainbow trout (Oncorhynchus mykiss) and brown trout in Great Smoky Mountains National Park (GRSM). In the

latter case, research has shown that when rainbow trout are removed from streams, the remaining brook trout population responds with increases in number and total weight. These efforts have also demonstrated that rainbow trout can be eradicated by electroshocking from mixed populations upstream of natural barriers.

2. Management of Existing Populations of Exotic Species

NPS Management Policies (4:12) addresses the management of existing populations of exotic species as follows:

"Management of populations of exotic plant and animal species, up to and including eradication, will be undertaken wherever such species threaten park resources or public health and when control is prudent and feasible. Examples of threatening situations include:

posing a public health hazard as determined by the Centers for Disease Control or a hazard to public safety

disrupting the accurate presentation of a historic scene

damaging historic or archeological resources

interfering with natural processes and the perpetuation of natural features or native species (especially those that are endangered, threatened, or otherwise unique)

significantly hampering the management of park or adjacent lands

"High priority will be given to the management of exotic species that have a substantial impact on park resources and that can reasonably be expected to be successfully controlled; lower priority will be given to exotic species that have almost no impact on park resources or that probably cannot be successfully controlled. The decision to initiate a management program will be based on existing, and where necessary newly acquired, scientific information that identifies the exotic status of the species, demonstrates its impact on park resources, and indicates alternative management methods and their probabilities of success. A management plan will be developed and implemented according to established planning procedures and will include provisions for public review and comment, where appropriate. Care will be taken that programs to manage exotics do not result in significant damage to native species, natural ecological communities, natural ecological processes or historic objects."

NPS Natural Resources Management Guideline, NPS-77 (3:45), provides the following interpretation of policy concerning exotic fish species and the protection of native fishes:

"The encroachment of exotic (non-native) fish species into the range of native fish species is a prevalent NPS fisheries management problem. The displacement of native species by exotics is not allowed if such displacement can be prevented by management. Management of populations of exotic species, up to and including eradication, will be undertaken whenever such species threaten park resources or public health and when control is prudent and feasible. Methods to prevent the invasion or reinvasion of exotic fish may include the use of natural barriers, the improvement of existing obstructions to create a barrier, the building of a fish barrier, and, lastly, the use of mechanical or chemical methods.

"Superintendents will give high priority to the management and control of exotic fish species that have substantial impact on native fish and associated aquatic organisms."

The implementation of programs to control exotic species of fish is often difficult because many of these fish species are highly prized by the angling public. However, NPS Management Policies (4:10) concerning restoration efforts states that:

"The National Park Service will strive to restore native species to parks wherever all the following criteria can be met:

Adequate habitat to support the species either exists or can reasonably be restored in the park and, if necessary, on adjacent public lands and waters, and once a natural population level is achieved, it can be self-perpetuating.

The species does not, based on an effective management plan, pose a serious threat to the safety of park visitors, park resources, or persons or property outside park boundaries.

The subspecies used in restoration most nearly approximates the extirpated subspecies or race.

The species disappeared, or was substantially diminished, as a direct or indirect result of human-induced change to the species population or to the ecosystem.

Such programs will be carried out in cooperation with other affected agencies, organizations, and individuals."

These policies are supported by NPS-77 guideline (3:45):

"The decision to strive to restore native fish populations at the expense of exotic fish will be based on valid resource information obtained through research. Information needed includes, but is not limited to:

1. the presence of, or potential for, restoring adequate habitat

2. historic genotype availability
3. the degree of human-induced change resulting in substantially reduced populations of native fish
4. the feasibility of the effort; and
5. a determination that once the population is restored, it will become self-perpetuating."

Research efforts in the Smokies have shown that man's activities, such as logging, fire and exploitive fishing practices from about 1900 to the mid-1930s, decimated over 256 km of the brook trout's original range. Larson and Moore (1985) demonstrated a loss in brook trout range of 94.2 km in 59 streams from 1937 to 1977, due to the encroachment of rainbow trout. Brook trout range continues to decline in some streams, but they have apparently been completely displaced from other streams since the 1972-1977 surveys (Moore, field observations 1990). Other research efforts have shown that rainbow trout can be successfully removed from mixed populations with electrofishing techniques (Moore and Larson 1989; West et al. 1990). This information combined with the data on range loss and historic distribution clearly shows that adequate brook trout range still exists but is currently being inhabited by non-native rainbow trout.

3. Closures to Fishing and Restoration Activities

NPS Management Policies (4.7 and 4.8) provide clear direction for closures to fishing and for restoration activities:

Fisheries Management. Fishing may be restricted in certain waters and at certain times if it is determined such actions are needed

to protect rare, threatened, or endangered plant or animal species in the waters or in adjacent habitat

to meet park objectives for scientific study, interpretation, environmental education, appreciation of fish and other aquatic life, or other public benefits

to provide opportunities for depressed fisheries to recover

to protect spawning grounds of endemic fish species

to maintain natural distributions, densities, age-class distributions, and behavior of fish or of native wildlife species that use fish for food

to protect the natural integrity of aquatic areas within natural zones

"In natural, cultural, and park development zones, fisheries management will seek to preserve or restore natural aquatic habitats and the natural abundance and distribution of native aquatic species, including fish, together with the associated terrestrial habitats and species. In these zones, waters that are naturally barren of fish will not be stocked with any species. Artificial stocking of native fish will be employed in natural zones only to reestablish native species in the historic ranges; stocking of exotic fish species will not be permitted in natural zones. Stocking of native or exotic species will be permitted in cultural zones only where there is a special need associated with the historic events or individual commemorated and where an exotic species, if used, could not spread to natural zones or waters outside the park. Stocking with native species, but not with exotic species, will be permitted in park development zones. Stocking programs for other purposes in these zones will be discontinued or phased out except where there is congressional intent expressed in law or a House or Senate report accompanying legislation."

The management of non-native species for recreational angling has created much discussion in the NPS. NPS policy has been clarified in an effort to address this issue, particularly where there is demand to manage for a non-native sport fish population and no feasible method exists to remove non-native species. NPS-77 states:

"The current policy for fisheries management within natural, cultural, and park development zones emphasizes the restoration and preservation of natural assemblages of native species. However, in some instances, stocking done decades ago, possibly predating the establishment of the park, has introduced species which have become well established and ecologically balanced within their aquatic community. Often these are highly desirable species to the recreational fishing visitor, and there is strong local support for managing them. Designating as special use zones all water bodies where these species occur is usually not practical. Under such circumstances within natural, cultural, and park development zones, management actions that encourage the survival of a fishery for an exotic species, such as limits on catch, may be permitted, but only if both of the following criteria apply, in accordance with the general NPS policy on exotics:

- a. there is no practical means of eliminating the exotic from the natural aquatic habitat; and
- b. the species has a limited impact on native fish and non-fish species and has not greatly altered the natural ecological functioning of the aquatic community.

"If a superintendent declares, for a specific water body, that such management of an exotic species of fish will be permitted in accordance with the above criteria, he/she shall clearly state that intent within the park's Statement for Management, Resource

Management Plan, and other such public documents. Such declaration will not override consideration for and perpetuation of other native species within the park, in accord with NPS Management Policies and in compliance with the National Environmental Policy Act and other pertinent legislation. The policy will not preclude using future technologies to eliminate the exotic species in favor of truly native populations.

"The emphasis in NPS sport fishery management will be to maintain a naturally functioning aquatic ecosystem, protect and perpetuate native aquatic species and natural habitats, and allow recreational fishing activities only when ecosystem impacts are minimal.

"Beyond ecosystem concerns, management emphasis will be based upon the recreational fishing experience and preservation of the opportunity for fishermen to enjoy the natural aquatic environment, not on fish harvest."

4. Recreational Angling

Recreational angling is a consumptive use activity that has been allowed in national park units since Yellowstone was established. Approximately one-third of all NPS units support substantial recreational fishery activities; this sport is widely accepted as one of the ways visitors enjoy national parks. Management policies for fishery resources were intended to provide common objectives for natural, cultural and development zones in parks. However, differences in interpretation led to some confusion about the intent of these policies. To alleviate this problem, NPS-77, in part, was drafted to clarify fishery management policies and management requirements on issues such as "...exotic species, stocking, commercial harvest, traditional use, fisheries restoration versus enhancement, and maintenance of genetic integrity."

NPS Management Policies (8:4) states that:

"Recreational fishing will be allowed in parks where it is authorized by federal law or where it is not specifically prohibited and does not interfere with the functions of natural aquatic ecosystems or riparian zones. Where fishing is allowed, it will be conducted in accordance with applicable federal laws and treaty rights and state laws and regulations. However, the National Park Service may restrict fishing activities whenever necessary to achieve management objectives outlined in a park's resource management plan."

Interpreting the above, NPS 77 (3:32) states:

"Recreational fishing has been permitted in national parks since the establishment of Yellowstone in 1872. The NPS Organic Act, since its inception, has been interpreted to mean that recreational fishing shall be permitted as a means of providing for the enjoyment of parks. Recreational fishing in national parks is authorized by

36 CFR 2.3. Congress has declared (Redwoods Act and General Authorities Act) that all NPS units are parts of a national system and there is to be no derogation of that system unless specifically authorized by Congress.

"However, the activity of recreational fishing is generally resource consumptive and, if not closely regulated, is inconsistent with resource preservation philosophies. Park managers should recognize that once the harvest of fish resources is permitted, some degree of alteration of the aquatic ecosystem will occur."

NPS Management Policies (4:8) states:

"In natural, cultural, and park development zones, fisheries management will seek to preserve or restore natural aquatic habitats and the natural abundance and distribution of native aquatic species, including fish, together with the associated terrestrial habitats and species."

NPS-77 (3:33) interprets this statement as follows:

"This policy is taken to mean that superintendents will strive to preserve or restore the natural behavior, diversity, and ecological integrity of fish populations in fulfilling their fishery management responsibilities. Managers should give strong consideration to protection of nonfish aquatic species under this policy. Naturally fish-free waters should not be considered 'barren.' Their assemblages of aquatic insects, amphibians, and plankton can be significantly altered by the introduction of fish.

"When harvest is permitted, the superintendent will determine a permissible harvest level based upon the species, its biological characteristics, and reproductive potential; but, in no case, will harvest be allowed to reduce the reproductive potential of the population or to radically alter its natural (unfished) age structure. The fisheries management goal will not be to maximize sustainable harvest but to determine an optimum harvest level based upon biological balance and integrity as well as the quality of the fishing experience. In evaluating permissible harvest, superintendents should recognize the potential for adversely impacting other park fish and wildlife. Consideration should also be given to ecological impacts on associated aquatic and terrestrial organisms that prey upon or utilize native fish, and to the effects of fishing activity on other resources, such as trampling of vegetation, compaction of soil, and disturbance of sensitive wildlife."

Amplifying the NPS Organic Act of 1916, The Act of April 29, 1942, establishing GRSM, identified certain prohibitions concerning wildlife and stated that the Secretary of the Interior "shall make and publish rules and regulations for the management and care of the park and for the protection of the property therein." The act specifically required that

provisions be made for "the preservation from injury or spoilation of all timber, mineral deposits, natural curiosities or wonderful objects, and for the protection of animals and birds in the park from capture or destruction, and to prevent their being frightened or driven from the park; and that rules and regulations be made governing the taking of fish."

Current sport fishing activities in GRSM focus on rainbow trout, brown trout, smallmouth bass and rock bass. Regulations prohibit the possession of brook trout. However, when genetics issues involving a determination of the existence of native strains are resolved and/or loss of the historic range for this species has been rectified, fishing for this species may again be allowed. Fishery management practices will not attempt to enhance the size or density of the sport fishery since enhancement activities aimed at producing larger sport fish (predators) will most likely have negative impacts on non-game fish populations and further reduce the range of native brook trout. The opportunity to fish in a natural setting for the number and size of fish that are naturally produced in the streams will be emphasized. This management approach, as currently implemented, is not known to interfere with natural ecosystem processes in non-game fish populations and is consistent with NPS policies. The approach does not, however, address the need to arrest distribution losses occurring in native brook trout populations. Strategies being implemented to address this issue are discussed in III-C, Brook Trout Preservation, page 21.

B. History of Fish Management in Great Smoky Mountains National Park

Prior to establishment of the park in 1934, approximately 80 percent of the area was intensively logged. Approximately 40 percent of native brook trout range was lost because of this commercial activity and exploitive fishing practices. Because of the demand for recreational angling, logging companies and well-meaning individuals began to stock rainbow trout into streams that eventually became part of the park. It was believed at the time that this species could withstand extant environmental conditions and that as reforestation occurred, native brook trout would eventually reclaim lost range. This practice was also continued by the park after its establishment but was reduced in the 1950s and finally eliminated by 1975. The only recorded stocking of brown trout in the park occurred in 1965 in the Oconaluftee River. However, this species presently occurs in all but two watersheds, having immigrated to the park from stocking programs in perimeter waters, or having been unofficially stocked by anglers who prefer brown trout over rainbow trout and brook trout. Rainbow and brown trout are widely accepted and preferred by many anglers, some of whom believe these species to be "native" because they have been in the park for over 60 years. These species continue to expand their range upstream and displace native brook trout.

During the stocking era, an effort was also made to restore brook trout populations in many streams. Unfortunately, efforts to produce brook trout in hatcheries from local brood stock failed. Managers then resorted

to using "northern" hatchery strains of brook trout with over 800,000 being stocked throughout the park. However, many local anglers and some biologists were concerned that the two fish were different subspecies of brook trout. Efforts to resolve this issue in the 1970s met with mixed results. Initially, Bussard and Nielsen (1976) stated that brook trout from the park were genetically different from northern brook trout. Another study by Harris et al. (1978) stated that there were no genetic differences between the two strains. However, Stoneking et al. (1981) found fault with the findings of Harris et al. (1978) and stated that brook trout in GRSM appeared to be a subspecies of Salvelinus fontinalis.

The discovery and evaluation of historic stocking records have led park biologists to reevaluate the question of brook trout genetics in GRSM. To date, the data show that a few streams have never been stocked or that "northern" strains have hybridized with southern "strains" where they were stocked into streams having native populations. According to geneticists currently evaluating this issue, the two strains are significantly different from each other. These results tend to complicate the restoration issue because, by policy, only native genetic forms should be restored.

Brook trout distributional surveys in the 1970s documented significant range loss compared with USFWS surveys conducted in the mid-1950s. The reduction was attributed to encroachment by rainbow trout. This documented range loss led to the closure of brook trout fishing in 1975 since it was believed that angling exploitation was contributing to the problem. The closure and brook trout restoration programs initiated since then have met with resistance because some anglers believe the closure decision was an attempt to slowly phase out recreational angling in the park because the species was not listed as federally threatened or endangered. Other anglers, and certain special interest groups, view brook trout restoration efforts in small headwater streams as the first step toward eliminating rainbow and brown trout from the park.

Early workers, primarily employees of the U.S. Fish and Wildlife Service (USFWS), gathered baseline data from the 1930s to the 1970s that have been invaluable in determining changes in distribution of sport fish, and to a lesser extent, non-game species. The activities of management biologists up to the 1970s were concentrated in the following areas: (1) stocking; (2) game fish population surveys; (3) evaluations of and recommendations for fishing regulations; and, (4) evaluations of angler use (Alston et al. 1984).

Unfortunately, native non-game fish species have received little attention since the park was established. Carl Hubbs made extensive fish surveys in the park in 1937 and 1940 (Simbeck 1990). Lennon published a fish species list in 1962 that contained 72 species. But work by the USFWS in the 1970s only documented 42 species; the reasons for the losses were not clear. Surveys in 1989 and 1990 identified 58 species of fish in park waters, of which 50 are strictly confined to stream systems.

In 1983, the first permanent NPS fishery biologist was hired. As a result, program priorities began to shift from a recreation-oriented mode to one of preservation. Currently, fisheries management priorities in order include: (1) the restoration and protection of threatened and endangered fishes; (2) protection and restoration of native brook trout range; (3) inventory and monitoring of native non-game species; and, (4) monitoring of sport fish populations and recreational use. In all cases, however, the overriding concern is maintenance of quality habitat. In so doing, individual components of the aquatic system can best be protected.

C. Fishery Management Goals

1. Preserve and restore native species and aquatic habitats and manage them as an integral part of the park ecosystem.
2. Provide park visitors with recreational angling opportunities for their enjoyment, consistent with NPS policies.

D. Fishery Management Objectives

The prioritized objectives listed below detail issues that must be addressed to respond to management goals.

1. Reintroduce Threatened and Endangered Fish - Continue reintroduction efforts for smoky madtom, yellowfin madtom and spotfin chub; monitor and evaluate the success of these efforts.
2. Reintroduce Extirpated Native Species - Prior to and including the 1957 reclamation of Abrams Creek, 58 species of fish were collected in that stream. Since then, only 32 species have been collected. Of the 26 missing species, 20 were collected from the two-mile reach now inundated by Chilhowee Reservoir. Habitat surveys for smoky madtom, yellowfin madtom and spotfin chub have shown adequate habitat exists for the reintroduction of these species, but habitat surveys must be conducted for the other three missing species. Two of these extirpated species, the dusky-tail darter and the Tennessee dace, are currently being considered for federal and state listing, respectively, as threatened species.
3. Native Brook Trout Restoration - Monitor brook trout populations to document changes in distribution. Identify and prioritize streams for restoration and determine appropriate restoration techniques.
4. Native Brook Trout Genetics - Research suggests that a unique strain or sub-species of brook trout exists in the park. This effort must be completed so that restored streams can be restocked with genetically endemic strains of native brook trout.

5. Large Stream Monitoring - This effort is intended to document annual variation in stream fish communities and angling pressure. Data from this monitoring provide valuable information for diagnosing ecosystem problems. It is also useful for regulating and gaining public support for fishery programs.
6. Impacts to Aquatic Systems - GRSM is downwind of the major sulfur and nitrogen emission regions of the nation. Water quality data in small headwater streams show high levels of sulfate and nitrate and depressed pH levels after major storm events. However, no data exist to show a cause and effect relationship between acid precipitation and impacts to aquatic systems.
7. Recreational uses, such as hiking, horse use, swimming and tubing activities, appear to be negatively impacting aquatic systems. Fine sediments have been observed entering park streams, primarily from heavily used horse trails, but the impacts on fish and aquatic macroinvertebrates is unknown. Visitors also swim and tube in most of the park's major streams. When water levels start to fall in early summer, this user group often channelizes and/or dams stream segments to enhance their swimming pleasure. The impacts of these activities on native fish and benthic communities are unknown, but must be addressed; a recent study (Simbeck, 1990) indicated a loss of biotic integrity in Deep Creek, a stream heavily impacted by tubing activities.

II. AQUATIC RESOURCES

In the mid-1950s, USFWS biologists estimated 733 fishable miles of stream in 28 major watersheds in the park. Parker and Pipes (1990), using the Geographical Information System technology of Earth Resources Data Analysis System (ERDAS) and hydrologically accurate watershed maps, identified 45 watersheds in the park. They also estimated that approximately 2115.47 miles of stream exist in the park. Obviously, many of these stream miles do not contain fish due to their small size, but biologists now believe that the number of miles of fishable streams is significantly greater than that estimated by the USFWS; however, an accurate estimate is not currently available. Parker and Pipes (1990) provide details on watershed size, the number of stream miles in each watershed and other pertinent information (Appendix 1).

Brook trout, rainbow trout, brown trout, smallmouth bass and rock bass are the five sport fishes found in the park. Possession of brook trout is currently prohibited. However, once questions concerning taxonomic status are answered and/or a sufficient number of streams have been restored, recreational angling for the species may again be allowed.

Rainbow trout are currently the dominant sport fish, being found in about 80 percent of the streams in the park (Alston et al. 1984). Brown trout

are the second most important game fish with self-sustaining populations primarily found below 2700 feet in elevation. However, these populations continue to expand and are continually being reported from new locations in smaller headwater streams. Smallmouth bass and rock bass are native species with distribution generally limited to the downstream portions of the park's largest streams.

When the location and elevation of the park is considered, the diversity of its ichthyofauna is more complex than may otherwise be expected. However, this diversity has been lowered by anthropogenic influences, particularly past logging and stream reclamation efforts. Table 1 provides a list of the fish species collected in the park prior to 1957 (74), 1977-79 (42) and 1988-89 (58). The 1970s survey was not as extensive as the other two surveys. This may partially account for the low number of species recorded in the 1970s. The Abrams Creek embayment was not sampled during the 1988-89 survey, but sampling data collected by Tennessee Wildlife Resources Agency from Chilhowee Reservoir were used to determine species composition.

Personnel from the National Park Service, U.S. Fish and Wildlife Service, and Tennessee Game and Fish Commission met on June 8 and 9, 1957, to treat the 14.6 miles of Abrams Creek downstream of Abrams Falls with Rotenone, a fish toxin. The objective of this effort was to eliminate fish species from that section so that rainbow trout would be the only fish species in the newly formed Chilhowee Reservoir and its tributaries (Simbeck 1990). This effort was by far the most devastating event to occur to fishes in the park. Fifty-eight species of fish were collected during the 1957 reclamation effort, but only 32 species have been collected since then. Three species, listed as federally endangered or threatened, are currently being reintroduced. Unfortunately, 20 species, which have not been collected since 1957, were only found in the lower two miles of the stream which is now inundated by Chilhowee Reservoir. It is highly unlikely that suitable habitat for these fish exists upstream of the embayment, thus they are likely lost from the park forever.

TABLE 1. Fish species collected in GRSM prior to 1957, the 1970s and the 1980s.

	1957	1978-79	1988-89
Petromyzontidae			
Mountain brook lamprey (<u>Ichthyomyzon greeleyi</u>)	X		X
American brook lamprey (<u>Lampetra appendix</u>)	X		X
Lepisostedae			
Longnose gar (<u>Lepisosteus osseus</u>)	X		
Clupeidae			
2 Gizzard shad (<u>Dorosoma cepedianum</u>)	X		X
Salmonidae			
1 Rainbow trout (<u>Oncorhynchus mykiss</u>)	X	X	X
1 Brown trout (<u>Salmo trutta</u>)	X	X	X
Brook trout (<u>Salvelinus fontinalis</u>)	X	X	X
Cyprinidae			
Central stoneroller (<u>Campostoma anomalum</u>)	X	X	X
1,2 Goldfish (<u>Carassius auratus</u>)	X		
Rosyside dace (<u>Clinostomus funduloides</u>)	X	X	X
Whitetail shiner (<u>Cyprinella galactura</u>)	X	X	X
4 Spotfin chub (<u>Cyprinella monacha</u>)	X		
Spotfin shiner (<u>Cyprinella spiloptera</u>)	X	X	
1,2 Carp (<u>Cyprinus carpio</u>)	X		X
6,5 Flame chub (<u>Hemitremia flammea</u>)			X
Bigeye chub (<u>Hybopsis amblops</u>)	X	X	X
Striped shiner (<u>Luxilus chrysocephalus</u>)	X		X
Warpaint shiner (<u>Luxilus coccogenus</u>)	X	X	X
River chub (<u>Nocomis micropogon</u>)	X	X	X
Emerald shiner (<u>Notropis atherinoides</u>)	X		
Tennessee shiner (<u>Notropis leuciodus</u>)	X	X	X
Silver shiner (<u>Notropis photogenis</u>)	X		X
Rosy face shiner (<u>Notropis rubellus</u>)	X	X	
Saffron shiner (<u>Notropis rubricroceus</u>)	X	X	X

	1957	1977-79	1988-89
Mirror shiner (<u>Notropis spectrunculus</u>)	X	X	X
Telescope shiner (<u>Notropis telescopus</u>)	X	X	X
Mimic shiner (<u>Notropis volucellus</u>)	X		
Fat lips minnow (<u>Phenacobius crassilabrum</u>)	X	X	X
Stargazing minnow (<u>Phenacobius uranops</u>)	X		
Tennessee dace (<u>Phoxinus tennesseensis</u>)	X		
Blacknose dace (<u>Rhinichthys atratulus</u>)	X	X	X
Longnose dace (<u>Rhinichthys cataractae</u>)	X	X	X
Creek chub (<u>Semotilus atromaculatus</u>)	X	X	X
Shortfin shiner	X		
Mountain shiner (<u>Notropis lirus</u>)	X		
Catostomidae			
White sucker (<u>Catostomus commersoni</u>)	X	X	X
Northern hog sucker (<u>Hypentelium nigricans</u>)	X	X	X
River red horse (<u>Moxostoma carinatum</u>)	X	X	
Black redhorse (<u>Moxostoma duquesnei</u>)	X	X	X
Golden redhorse (<u>Moxostoma erythrurum</u>)	X		X
Shorthead redhorse (<u>Moxostoma macrolepidotum</u>)	X		X
Ictaluridae			
2 Black-bullhead (<u>Ameiurus melas</u>)	X		
2 Yellow-bullhead (<u>Ameiurus natalis</u>)	X		X
2 Blue catfish (<u>Ictalurus furcatus</u>)	X		
2 Channel catfish (<u>Ictalurus punctatus</u>)	X		X
3 Smoky madtom (<u>Noturus baileyi</u>)			X
4 Yellowfin madtom (Bridled) (<u>Noturus flavipinnis</u>)			X

	1957	1977-79	1988-89
Stone cat (<u>Noturus flavus</u>)	X		
2 Flathead catfish (<u>Pylodictus olivaris</u>)	X		
Percidae			
Greenside darter (<u>Etheostoma blennioides</u>)	X	X	X
Greenfin darter (blue breast) (<u>Etheostoma chlorobranchium</u>)	X	X	X
Fantail darter (<u>Etheostoma flabellare</u>)	X	X	X
Duskytail darter (<u>Etheostoma catenotus</u>)	X		
Redline darter (<u>Etheostoma rufilineatum</u>)	X	X	X
Tennessee snubnose darter (<u>Etheostoma simotermum</u>)	X	X	X
(Blueside) Speckled darter (<u>Etheostoma stigmaeum</u>)	X		
Swannanoa darter (<u>Etheostoma swannanoa</u>)	X	X	X
(Spotted) Wounded darter (<u>Etheostoma vulneratum</u>)	X	X	X
Banded darter (<u>Etheostoma zonale</u>)	X	X	X
(Yellow) Tangerine darter (<u>Percina aurantiaca</u>)	X	X	X
Blotch logperch (<u>Percina burtoni</u>)	X		
Logperch (<u>Percina caprodes</u>)	X	X	X
Gilt darter (<u>Percina evides</u>)	X	X	X
Olive darter (<u>Percina squamata</u>)	X	X	
Sauger (<u>Stizostedion canadense</u>)	X		
1,2,6 Walleye (<u>Stizostedion vitreum</u>)	X		
Cyprinodontidae			
Northern studfish (<u>Fundulus catenatus</u>)	X		
Poeciliidae			
1,6 Mosquitofish (<u>Gambusia affinis</u>)			X
Atherinidae			
2,6 Brook silverside (<u>Labidesthes sicculus</u>)			X

	1957	1977-79	1988-89
<u>Percichthyidae</u>			
2,6 White bass (<u>Morone chrysops</u>)			X
<u>Centrarchidae</u>			
Rock bass	X	X	X
(<u>Ambloplites rupestris</u>)			
1 Redbreast sunfish (<u>Lepomis auritus</u>)	X	X	X
1 Green sunfish (<u>Lepomis cyanellus</u>)			X
2 Warmouth (<u>Lepomis gulosus</u>)	X		
Bluegill (<u>Lepomis macrochirus</u>)	X	X	X
2 Longear sunfish	X		
(<u>Lepomis magalotis</u>)			
Smallmouth bass	X		
(<u>Micropterus dolomieu</u>)			
Spotted bass	X		
(<u>Micropterus punctulatus</u>)			
<u>Sciaenidae</u>			
2 Freshwater drum	X		
(<u>Aplodinotus grunniens</u>)			
<u>Cottidae</u>			
Mottled sculpin (<u>Cottus bairdi</u>)	X	X	X
Banded sculpin	X	X	X
(<u>Cottus carolinae</u>)			
	<u>74</u>	<u>42</u>	<u>58</u>
1 Non-native spp.			
2 Embayment/large river species			
3 Federally endangered/currently being reintroduced			
4 Federally threatened/currently being reintroduced			
5 State listed species of special concern			
6 New record for park			

In addition to the rather diverse ichthyofauna, the streams and springs of GRSM are home to salamanders, frogs and aquatic macroinvertebrates. Twenty-seven species of salamanders and 13 species of frogs and toads are known to inhabit the streams and springs of the park. The least well-known aquatic life forms are the aquatic macroinvertebrates. Some studies have been done on a particular genus or family, but no comprehensive surveys have ever been conducted.

III. MANAGEMENT ACTIVITIES

A. Fish Population Monitoring

1. History of Monitoring Activities

Sportfish, and to a lesser extent non-game fish populations, have been monitored since the park was established. Initially, biologists relied on angling surveys or other reports to document sport fish distribution. Minnow nets were relied upon to capture non-game fish species and to document species composition and distribution. Beginning in the mid-1940s and continuing into the 1950s, USFWS biologists used a fish toxicant (creosol) to sample numerous streams to determine sport fish composition and abundance. During this time period, fishery management objectives were to maximize harvest and angler use. No thought was given to the protection and preservation of native species or pristine aquatic ecosystems. However, in the mid-1950s, changes in USFWS personnel stationed at the park and the appearance of electrofishing as a sampling tool initiated a change in sampling practices from a destructive to a non-destructive format. Interest in non-game fish species also increased. Unfortunately, early sampling locations were not documented, making it impossible to resample those areas for comparative purposes.

Beginning in the late 1970s, the USFWS began sampling the larger streams of the park and permanently marked and recorded the sites (Appendix 2). Individual length and weight were recorded for all game fish as well as the total number and weight of all non-game fish species captured in each sample site. The work provided an updated fish species list and the first evidence that past management practices had extirpated approximately 30 species of fish. However, the effort was not designed to monitor aquatic systems but only to provide an estimate of population size and diversity at a given point in time.

In 1983, the first permanent NPS fishery biologist assigned to the park attempted to continue the work started by the USFWS. A "sport fish management plan" was drafted which recommended that six streams be selected for rotational monitoring, with two streams being selected for monitoring each year. All species of fish collected in each site were to be recorded (Alston et al. 1984). This plan also called for creel surveys to determine angler use and harvest rates. However, the plan was weak because it assumed that variation did not occur in stream fish communities. In addition, sampling standards were not incorporated into the surveys. However, in 1986, sampling standards were incorporated and two large streams (Cataloochee Creek and Little River) were selected for monitoring on an annual basis. As a general rule, these streams have been monitored annually since 1986. However, inclement weather precluded sampling in Cataloochee Creek in 1989 and prevented sampling in two of three sites in Little River in 1990 and 1991.

2. Monitoring Protocol for Large Stream Fish Population Census

Major problems with fisheries monitoring in GRSM include the lack of study site descriptions, limited descriptions of sampling methodology, and little, if any, descriptions of data analysis techniques. To alleviate many of these problems, the following guidelines have been adopted for all quantitative sampling and data analysis for all species collected. These sampling protocols have been peer reviewed and will ensure continuity in the long-term monitoring program.

a. The following large (fourth and fifth order) streams have permanent sampling stations (Appendix 2) at strategic points along their length: Abrams Creek, Deep Creek, Cataloochee Creek, Hazel Creek, Oconaluftee River and Little River. However, since 1986, Cataloochee Creek and Little River have been the only large streams sampled. These two streams have been adopted as reference streams for annual sampling and monitoring for species composition and density, size and age characteristics of salmonids, and recreational angling trends (qualitative creel census data is also gathered). These sampling efforts are to be conducted in September or October, since these are normally low flow months, and fall is the accepted sampling period for assessing year class strength and survivorship of catchable size fish.

b. Prior to sampling, the following data will be recorded: pH, conductivity, air and water temperatures. Block nets will be set at each end of the sample section to meet the assumptions of the population estimators used.

c. Width measurements (meters) will be taken perpendicular to flow every 10m for 100m sections and every 20m for sections 200m in length. All widths are taken from water's edge to water's edge. Gradient (percent) is taken from one width measurement to the next.

d. One electrofishing unit is used for every 3m of stream width. One bucket/net person per shocker is recommended, and two to three people with dip nets to pick up stunned fish are spaced between shockers for the larger streams sampled. Three electrofishing passes are made in each section.

e. Collected fish are separated by species. Trout and bass are individually measured for total length (mm) and weight (grams). Data recorded for non-game fish are minimum and maximum length, total number and total weight. These data are recorded for each electrofishing pass and the run number recorded on each data sheet.

f. Computerized databases, managed by the fishery biologist, are used for data entry and basic data analyses. The computerized MICROFISH program provides population estimates, capture probabilities and total weight by species, plus additional useful information. Other analyses provide useful information on average length and weight of trout by size class. Additional analyses will

be indicated by project design and will utilize accepted statistical procedures.

3. Research

Research projects will be designed to meet the priorities identified in the park's Resource Management Plan. Examples of research needs include angler use patterns, rainbow trout and brown trout population dynamics, community ecology, influence of habitat on fish populations dynamics, and impacts of acid rain on aquatic ecosystems.

B. Native Non-Game Fish Distributions

Historically, non-game fish populations have been given little attention in GRSM. Research efforts have provided historical distribution records and some indications of abundance. Unfortunately, from 1957 until 1988 and 1989 no effort was made to assess changes in species composition, relative abundance, or distribution of these native fishes. (Simbeck 1990 provides information on historic monitoring efforts and historic sample site locations.) To alleviate this shortcoming, the following monitoring protocols have been developed.

1. Monitoring Protocol for Native Non-Game Fish Distributions

a. The distribution and relative abundance of native non-game fish shall be monitored every 10 years by electrofishing to maintain a minimally acceptable data base. Every five years is an ideal sampling schedule. If annual large stream samples (see Protocols, p. 18) indicate major changes in species composition and abundance, an immediate parkwide sampling strategy should be developed to determine if parkwide changes have occurred. If this proves to be the case, an annual to biannual sampling schedule may be called for to document reasons for change. One sample should be taken adjacent to the park boundary as species diversity will be highest in these areas. Additional upstream areas should also be sampled to determine longitudinal changes in composition.

b. Electrofishing will sample all habitat types in the area. Darters are best collected by shocking downstream through riffles into a 10-15 foot seine.

c. Species will be field-identified (if possible), enumerated, and most of the common species released. Reference collections of all species will be kept for each sample and stream. Fish which cannot be positively identified will be preserved for later identification by an ichthyologist at a local university.

d. Data will be analyzed and changes in species composition and distribution noted. A summary report will be prepared documenting these changes.

2. Research

Research projects will be designed to meet the priorities identified in the Resource Management Plan. Examples of research needs include habitat evaluations for extirpated species reintroductions, impacts of large non-native salmonids, and taxonomic status of sculpins.

C. Brook Trout Preservation

1. History of Decline

The brook trout is the only salmonid species native to the eastern United States. In the Southeast, its range has been dramatically reduced since 1900 (Seehorn 1978). The best documentation of this range loss is in the park. Prior to the establishment of the park in 1934, the area was heavily logged and brook trout disappeared from over 256 km of the 680 km of stream they are believed to have occupied in 1900 (Kelly et al. 1980, Power 1929, Moore et al. 1981). King (1937) listed logging and brush clearing, frequent fires, the building of railroads, exploitive fishing practices, and the introduction of rainbow trout as the major reasons for the disappearance of this species. Early park managers felt that as reforestation proceeded, brook trout would eventually reclaim lost habitat. However, surveys in the 1950s showed that brook trout range had declined an additional 61 km relative to King's surveys of the 1930s. Surveys in the 1970s by Jones (1975) and Kelly et al. (1980) demonstrated another 163 km of range loss, bringing total range loss to approximately 70 percent. This continual loss greatly concerned park managers, and, as a result, several research studies were initiated in the mid- to late-1970s. One effort studied the encroachment process of rainbow trout, another assessed genetic purity (see III.C.4.), and a third examined the feasibility of eradicating rainbow trout from mixed populations using backpack electrofishing techniques.

Brook trout distribution surveys by King (1937, unpublished map) and Kelly et al. (1980) looked at 59 common stream segments. Waterfalls and cascades isolated brook trout in nine of these streams with their distributions remaining unchanged. In three streams, the range of allopatric (one species living by itself) brook trout expanded from 4.6 km to 6.3 km. However, in the remaining 47 streams, allopatric brook trout range declined from 130.3 km to 33.8 km, a 74.2 percent loss. Overall, brook trout range declined from about 157.8 km to 63.6 km, and the range for rainbow trout increased 94.2 km in about 40 years.

Survey data in the 1970s showed that brook trout were generally restricted to short segments of high gradient (10-15 percent) streams above 1000m in elevation (Larson and Moore 1985). In comparison, King's findings show brook trout inhabiting streams down to about 600m in elevation with gradients as low as five percent. These data also showed that abundance and size structure of brook and rainbow trout changed during the encroachment process. Rainbow trout adults and fry decreased in abundance with increasing stream elevation, fry decreasing first, as brook trout abundance increased. The data also suggested two points: (1) the presence

of three or more adult brook trout or rainbow trout/100 square meters substantially reduced the density of age zero fish of the other species; and, (2) adult rainbow trout replaced adult brook trout in a 1:1 ratio, but the total biomass increased due to the larger mean body size of rainbow trout (Larson and Moore 1985).

2. Historic Restoration Efforts

Five streams (Beetree, Sams, Starkey, Silers and Taywa Creeks) with sympatric (two species living together in the same area) populations were electrofished annually from 1976 to 1981 to attempt to eradicate rainbow trout (Moore et al. 1981, 1985). At the end of the project, 1063 rainbow trout had been removed (relocated downstream), density had been reduced by an average of 89 percent, and recruitment virtually eliminated. Adult rainbow trout densities in the five streams were less than $1/100\text{m}^2$ (Moore et al. 1986). Brook trout densities and biomass increased following the reduction of rainbow trout but results varied between streams.

Based on the initial results of this work, the USFWS initiated a much larger effort to remove rainbow trout from larger park streams. In 1978, restoration efforts were conducted on Road Prong and Sams Creek, with attempts made on Desolation Creek and Lynn Camp Prong in 1979. Whitworth (1979) evaluated the Sams Creek effort. He concluded that in the downstream section with numerous deep large pools ($\geq 1\text{m}$), the density of rainbow trout had been reduced by about 78.7 percent. However, in the middle and upper sections where pool depth rarely exceeds 0.6m, the reductions were 92.7 percent and 98.2 percent. His data also showed that rainbow trout recruitment was limited to the downstream area. He indicated that stream morphology affected electrofishing efficiency and that alternative methods would need to be used in situations similar to those in lower Sams Creek. Habera et al. (in press), working in other park streams, supported these conclusions.

In 1986 and 1987, selected sections of the five streams electrofished by Moore et al. (1981, 1983) and three of the four streams (Lynn Camp Prong was not sampled) electrofished by the USFWS in 1978 and 1979 were resampled to evaluate the impact of these previous efforts on rainbow and brook trout populations. The results provided conclusive evidence that rainbow trout had been eliminated from Silers Creek and Taywa Creek (Moore and Larson 1989; West et al. 1991). These data also indicated that rainbow trout were beginning to redominate brook trout populations in the remaining streams.

Data collected by Whitworth (1979) and Moore et al. (1986) demonstrated that rainbow trout were not completely removed from the downstream areas of Sams Creek. The increase in density and biomass of rainbow trout in this stream appears to be the result of reproduction by the remnant rainbow trout population because immigration was prevented by a barrier falls. Rainbow trout population expansion in Desolation Creek also appears to be the result of incomplete removal with subsequent reproduction. However, due to the presence of a cascade that is about

2.0m in vertical height, the repopulation of Road Prong may be a combination of rainbow trout reproduction and reinvasion as the downstream cascades are not thought to be barriers to fish movement. Brown trout were found to have invaded Beetree Creek from Deep Creek and had replaced rainbow trout as the dominant exotic trout species.

Riley (1986) attempted to remove rainbow from nine streams without barriers to upstream movement. The objective of the project was to evaluate one, two, and three removals of rainbow trout from mixed populations as a possible management tool and to determine which was most efficient and cost-effective. This study did not provide conclusive results on the efficiency of the differing levels of effort but did show that some marked rainbow trout returned to areas from which they had been removed.

Moore et al. (1983) pointed out that reclamation by electrofishing is labor-intensive and time-consuming. A two-person crew will expend about a one-person day electrofishing a 100m section three times. The use of large crews and multiple electrofishing units appears to increase capture rates but does not lower labor costs (Larson et al. 1986). These data, coupled with the results of Riley's study (1986), conclusively show that brook trout restoration should not be attempted in streams without natural barriers to upstream migration. Experiences with backpack electrofishing techniques suggest the following precautions be considered before initiating a restoration project: (a) streams of an appropriate size must be selected subject to available manpower, and if larger streams with numerous deep pools are targeted for restoration, alternative removal techniques must be used; (b) stream restoration will be costly because several (5-6) years of effort will be required to eliminate non-native salmonids from each stream; (c) all segments targeted for restoration must include known barriers to upstream migration; and, (d) program continuity is essential to ensure long-term success.

3. Proposed Brook Trout Monitoring Program

a. Distribution

Historically, efforts to monitor brook trout range have occurred about every 20 years. Part of the reason for such spacing has been the difficulty associated with completing parkwide surveys and past emphasis on issues associated with sport fish populations. In addition, the surveys of King, Lennon, Jones and Kelly were not accomplished using the same techniques, nor were historic sampling sites established making it difficult, if not impossible, to replicate and compare these historic data.

Because a twenty-year time span between samples cannot reasonably measure population changes, the following monitoring effort is recommended. The intended protocol will establish sampling sites (2-3) along the length of all streams that have a brook trout population. If the sympatric zone is 1.0 km or more in length, one sample site will be located close to the downstream end where brook

trout comprise about 20 percent of the population. A second site should be located in the upper half of the zone where brook trout comprise at least 60 percent of the population, and a third site established where only brook trout are present, if such an area exists. If the sympatric zone is less than 1.0 km in length, then only two sites will be established; one in the center of the zone, and one in the upstream brook trout reach. Sample site locations will be determined by the conditions encountered in each stream. The following sampling procedures will be adhered to: (1) all watersheds having brook trout (20) will be sampled every 10 years (1-3 watersheds sampled each year); (2) physical, chemical and habitat data will be collected during each sample for each stream; (3) backpack electrofishing techniques will be used to collect fish; (4) one electrofishing unit will be used in streams up to 4.5m mean width (when mean width exceeds 4.5m, the guideline of one unit per 3m of mean width should be adhered to); (5) three pass depletion sampling will be conducted at each site and the MICROFISH population program will be used to calculate population parameters; (6) the downstream limit of allopatric brook trout populations will be documented; and, (7) a summary report will be prepared and submitted to the Superintendent at the completion of each monitoring cycle indicating changes in species distribution.

b. Impacts to Brook Trout Populations from Environmental Change

An intensive annual monitoring program is needed to assess the effects of global climate change, acid precipitation, sediment input, and changes in water quality on brook trout populations and aquatic communities in high elevation streams. Available data indicate variation in population structure but do not address this variation in relation to environmental change. Without documentation of these relationships, threats to these populations as well as downstream communities cannot be effectively articulated. Brook trout were chosen for this monitoring program because (1) they are the park's only native salmonid, (2) they are considered an indicator species, and (3) the streams to which they are restricted are the most susceptible to environmental change.

The following monitoring program is recommended to document responses of brook trout and associated stream biota to projected environmental change.

1. Select four to six streams for monitoring; all of these will contain the endemic strain of brook trout (see III.C.4). Approximately half of these streams will only contain brook trout. The other streams will have rainbow trout downstream, a sympatric population and an allopatric brook trout population upstream.
2. Determine the upstream limits of brook trout in all tributaries, establish the downstream limit of brook trout,

the upstream limits of rainbow trout and the extent of the sympatric zone.

3. Establish a permanent site for an automatic water quality data recorder on Bunches Creek. Data to be collected will include pH, conductivity, temperature, discharge and dissolved oxygen at a minimum. The recorder will have a radio or telephone computer hookup for downloading on a monthly basis.

4. In Bunches Creek, fish population sampling will be conducted at least twice per year, but quarterly samples may be preferred to document seasonal changes in population dynamics and production. Fish population sampling will be conducted annually in all other streams.

5. In Bunches Creek, sampling of benthic populations will be conducted on a monthly basis to document changes in this segment of the community and changes in food habits.

6. The vegetation and geology of each small watershed will be determined by on site inspection and from appropriate GIS maps.

7. Backpack electrofishing techniques will be used to sample all sites. The number of units used will be based on these guidelines: one unit will be used in stream sections where the mean width does not exceed 4.5m; one electrofishing unit per 3m of mean stream width will be used to provide reliable data in streams over 4.5m. Three electrofishing passes are to be made in each section.

8. Prior to sampling, the following data will be recorded: pH, conductivity, air and water temperature. Discharge (cfs or cms) will be taken prior to leaving the area. Block nets will be set at each end of the sample section to meet the assumptions of the population estimators used.

9. Width measurements (meters) will be taken perpendicular to flow every 10m and gradient (percent) taken from one width measurement to the next. All widths are taken from water's edge to water's edge. If an island is found in the section, its width will not be included as part of the total stream width.

10. Trout will be separated by species and individually measured for total length (mm) and weight (grams). These data are recorded for each electrofishing pass and the run number recorded on the data sheet.

11. Computerized databases, managed by the fishery biologist, will be used for data entry and basic data analyses. The computerized MICROFISH program provides population estimates,

capture probabilities and total weight by species, plus additional useful information. Other analyses provide useful information on average length and weight of trout by size class. Additional analyses will be indicated by project design and will utilize accepted statistical procedures.

12. Additional data requirements will be added to the program as other needs are identified. If potential impacts are identified from this effort, the methods can be expanded and adapted to downstream areas to monitor impacts on, and changes in, native non-game fish and sport fish populations.

4. Genetics Issues

Historically, anglers have stated that the brook trout in the Smokies are different from the fish stocked from local hatcheries. This belief is supported by information on life history characteristics and morphology (Holloway 1945; Lennon 1967; McGlade and MacCrimmon 1979). Genetic studies (Brussard and Nielsen 1976; Stoneking et al. 1981) suggest that brook trout at the southern extension of their native range may differ from northern brook trout at the subspecies or species level. However, the issue was clouded by the findings of Harris et al. (1978) which stated that no genetic differences in northern or southern populations could be found. Stoneking et al. (1981) took issue with the findings of Harris et al. (1978) who concluded that several loci were improperly scored, observed electrophoretic patterns were misinterpreted, and no data was collected from several loci. Stoneking et al. (1981) found several differences between northern and southern fish and stated that genetic similarity indices were in the range of those observed for subspecies. Unfortunately, these studies did not resolve the issue of genetic difference.

The discovery of historical stocking records in 1986 rekindled interest in the brook trout genetics issue. These records indicated that about six streams had never been stocked with brook trout. Discussions with Dr. Willis King, the first fishery biologist assigned to the park, revealed that many of the inaccessible headwater streams in the park were probably not stocked with northern strains of brook trout. This statement is consistent with an analysis of stocking records. Dr. King stated that many brook trout were stocked in park waters to supplement decimated or declining populations in streams impacted by logging.

These events led to the development of a cooperative effort between the University of Tennessee and the National Park Service to attempt to resolve the question of the genetic uniqueness of the original brook trout stock in GRSM. Research results to date agree with the data of Stoneking et al. (1981) for Bunches Creek and are supported by data from other unstocked populations as well. The effects of stocking northern hatchery strains of brook trout have also been addressed, and the data indicate that northern strain brook trout have hybridized with southern strain brook trout. These data also show that genetic markers of previously unstocked populations, hybridized populations and northern hatchery stocks

all cluster together, but are significantly different from each other. However, the data on populations that have hybridized tend to align with northern hatchery strains.

The issue of genetic uniqueness remains unresolved, but the current information has important ramifications for restoration. Restoration efforts should initially target streams that have known populations of southern Appalachian brook trout or circumstantial evidence to support this belief. Genetic identity should be attempted for all streams identified for restoration with the resultant information used to help establish restoration priorities.

5. Proposed Restoration Strategy

The implementation of preservation strategies are necessary to prevent any further loss of brook trout range due to the encroachment of non-native salmonids, to recover some of the range that has been lost, and to protect genetically unique strains of southern Appalachian brook trout. A prioritized list of streams needing brook trout preservation is detailed in Table 2 (p. 29). Streams having known barriers and "southern Appalachian" brook trout or "that can be restocked" (i.e., currently, all rainbow or very low densities of brook trout) with this strain, have the highest restoration priority (i.e., priority 1-7). Backpack electrofishing techniques will be used on most of these streams to collect and remove rainbow trout. However, in some streams in this group (examples: Lower Lynn Camp, Sams Creek and Indian Creek), alternative techniques such as toxins may be considered because of the number of deep pools and the complex channel morphology associated with them. This technique has been used successfully in other parks. An environmental assessment, combined with a literature review to determine the most viable removal options with the least environmental damage, would be conducted to assess the appropriateness of this strategy. The environmental assessment would be developed to address alternatives under circumstances where electroshocking is determined to be ineffective.

The second priority for restoration will be given to streams listed under the heading, "Barriers to be Evaluated," on Table 2 (priorities 8-22). Waterfalls and cascades located in these streams will be evaluated to determine the effectiveness of the obstruction in preventing upstream migration of non-native trout species. This determination will be made preferably by implementing mark and move experiments in conjunction with data generated from other ongoing barriers research. Brook trout populations in each stream will be evaluated for genetic uniqueness. Streams with waterfalls and cascades, which have been evaluated and found to be barriers as well as having genetically unique strains of brook trout, will be given a higher restoration priority.

Initial reclamation efforts will only occur in those streams that have known populations of genetically pure southern Appalachian brook trout (priority 1-3). If the genetic purity of brook trout in a stream is in doubt, a sample of approximately 25 fish will be collected and analyzed. If the analysis shows the brook trout to be hybridized with northern

strains of brook trout, or descendants of hatchery fish, then they will also be removed from the stream. These hybridized streams will then be restocked with brook trout from other streams that contain known genetically pure populations. Fish of all size classes will be collected and allowed to naturally repopulate the stream being restored. The number of fish to be collected from each stream will be determined by the staff fishery biologist and will be based on the density of fish in the source stream. However, if ongoing genetics research proves that northern genotypes will be slowly eliminated through continued reproduction with genetically unique southern Appalachian brook trout, then these streams will be stocked with genetically pure fish to speed the process.

The disposal of rainbow trout collected from these streams may be complicated by remoteness or other factors. The preferred method will be release back into the stream below a known barrier but will be determined on a case-by-case basis.

Table 2. Prioritized List of Streams to be Restored

<u>Stream</u>	<u>Watershed</u>	<u>Apx. mi. to be reclaimed</u>	<u>Downstream Barrier</u>	<u>Elevation</u>	<u>Priority</u>
<u>Streams with known barriers</u>					
✓Lost Bottoms	Cataloochee	2.2	yes	3320	1
✓Sams Creek	Little River	3.5	yes	2160	2
Lynn Camp Prong	Little River	5.5	yes	2160	3
Bear Creek	Forney Creek	2.5	yes	1900	4
Indian Creek	Deep Creek	6.0	yes	1880	5
~~Chasteen Creek~~	Oconaluftee	3.7	yes	2440	6
✓Mannis Branch	Little River	1.0	yes	1960	7
TOTAL		25.0			
<u>Obstructions to be evaluated</u>					
~~out~~ ✓McGinty Creek	Big Creek	0.6	evaluate	3480	8
Meigs Post	Little River	0.3	evaluate	3600	9
~~out~~ ✓Ekaneetlee	Eagle Creek	3.0	likely	2300	10
~~out~~ ✓Gunter Fork	Big Creek	1.5	likely	3320	11
Desolation	Hazel Creek	2.0	likely	2900	12
✓Slab Camp Branch	Forney Creek	1.0	likely	2520	13
✓Palmer Creek	Cataloochee	4.0	evaluate	3160	14
L. Cataloochee	Cataloochee	4.0	evaluate	2710	15
~~out~~ ✓Middle Prong-	Middle Prong-				
Ltl. Pigeon Rvr.	Ltl. Pigeon Rvr.	2.5	evaluate	2710	16
Jonas Creek	Forney Creek	3.5	evaluate	2560	17
~~out~~ ✓Proctor Creek	Hazel Creek	3.2	evaluate	3240	18
~~out~~ ✓Anthony Creek	Abrams	1.4	evaluate	2610	19
Mill Creek	Abrams	1.5	evaluate	2400	20
~~out~~ ✓Woody Creek	Cataloochee	0.5	evaluate	3450	21
~~out~~ ✓Rough Fork	Cataloochee	1.0	evaluate	3600	22
TOTAL		29.6			

Ashcamp -
Winding Star -

Cannon Ck
Lawe Ck

C. Threatened, Endangered and Extirpated Species

1. History of Extirpation

Perhaps the most devastating impact to the fish fauna of Great Smoky Mountains National Park occurred during the attempted reclamation of the lower 23.4 km of Abrams Creek. In June 1957, a joint action of the National Park Service, U.S. Fish and Wildlife Service, Tennessee Game and Fish Commission and the Tennessee Valley Authority treated this reach with Rotenone, a toxicant, to eliminate all fish so rainbow trout could be restocked and be the only species of fish in the newly formed Chilhowee Reservoir.

Thirty-one species of fish were eliminated from Abrams Creek during this effort, of which 20 were collected in a 3.2 km reach between Panther Creek and its confluence with the Tennessee River. This stream segment is now inundated by Chilhowee Reservoir with the habitat for these species destroyed. At the time of the rotenone treatment, upstream of this reach, two small catfish were collected. One of these was described as the brindled madtom, but is now thought to be the yellowfin madtom (federally listed as threatened) since this species had not been described at that time. The other madtom was an undescribed species that later became known as the smoky madtom (federally listed as endangered). This species was thought to be extinct until 1980 when it was accidentally rediscovered in Citico Creek (outside the park). The last known park population of spotfin chub (federally listed as threatened) was also eliminated from the park during the treatment. Five additional species, the blotchside logperch, the greenside darter, the banded sculpin, the mottled sculpin, and the duskytail darter were also eliminated from Abrams Creek. The only historical records of blotchside logperch and duskytail darter existing in the park are from the collections made during the attempted reclamation of Abrams Creek. The duskytail darter was originally identified as the fantail darter, but recent examinations of the collected specimens show them to be an undescribed species of duskytail darter. This species is proposed for listing as a federally threatened species.

The 27 species which have reestablished reproducing populations in Abrams Creek have done so by one of four possible methods: (1) repopulation from upstream areas; (2) access through the reservoir; (3) reintroduction by man; or (4) surviving the reclamation attempt.

2. Recent Reintroduction Attempts

In the mid-1980s, personnel from the University of Tennessee and Aquatic Specialists, a commercial aquarium shop in Knoxville, developed captive rearing techniques for madtoms. They approached the U.S. Fish and Wildlife Service, Endangered Species Office, to obtain support for their project. The U.S. Forest Service was contacted for support and to obtain permission to survey Citico Creek to collect egg masses of smoky and yellowfin madtoms for hatching and rearing in the laboratory. The National Park Service was then approached to secure permission to reintroduce the young madtoms back into their historic range. In 1986, a

recovery team, consisting of representatives of each agency, was organized and plans for egg collection and reintroduction formulated. Through 1991, 1391 smoky madtom and 1288 yellowfin madtom eggs or larvae were collected from 45 and 13 clutches, respectively, for captive rearing. From 1987 to 1990, 535 smoky madtoms and 387 yellowfin madtoms were released into Abrams Creek. To date, three smoky madtoms and no yellowfin madtoms have been observed during monitoring efforts.

In 1987, the recovery team decided to include spotfin chub in the reintroduction effort. Beginning in 1988, this species was collected from the Little Tennessee River and reintroduced into Abrams Creek. During the three years of reintroduction, 640 spotfin chubs were released into Abrams Creek. However, none of these fish were observed during monitoring efforts in 1989, 1990 or 1991.

3. Monitoring Strategy for Recent Reintroduction Attempts

a. Madtoms (Noturus baileyi and Noturus flavipinnis)

Prior to and/or during the spawning season each year, usually early to mid-June, the reintroduction area should be snorkled by trained specialists in an attempt to locate male madtoms guarding nest rocks or paired madtoms preparing to spawn under nest rocks. Best results usually occur at night.

Downstream areas should also be investigated to determine if reintroduced madtoms have migrated downstream.

b. Spotfin Chubs (Cyprinella monacha)

During the summer (July-August), the reintroduction site and several downstream sites should be seined to check for the presence of spotfin chubs. Also, as soon as possible, after 1991, Abrams Creek should be intensively surveyed from the campground downstream to the embayment. If spotfin chubs are not found, the recovery team for this species should determine if the reintroduction effort should continue.

4. Species Identified for Future Reintroduction Attempts

Five species of fish should be considered for reintroduction into their historic range in Abrams Creek. These species include the duskytail darter, the blotchside logperch, the greenside darter, the banded sculpin and the mottled sculpin.

Duskytail darter (Etheostoma catenotus sp.)

This species was eliminated from Abrams Creek in the 1957 reclamation attempt. Originally identified as the fantail darter, subsequent examinations of voucher specimens have shown it to be the duskytail darter (Simbeck 1990, Etnier, personal communication). This fish is currently being considered for threatened status under

the Endangered Species Act, and will most likely be listed by the spring of 1993.

The closest population of this species that could provide a source of fish for reintroduction is located in Citico Creek. Prior to reintroduction, habitat surveys must be conducted, a park recovery plan formulated and the potential for a captive rearing program evaluated. The adult population in Citico Creek is too small to attempt the transfer of adult fish.

Blotchside logperch (Percina burtoni)

Blotchside logperch were eliminated from the lower portions of Abrams Creek during the 1957 reclamation effort. This species is currently found in Little River outside the park and in the Hiwassee River system. Since there is limited distribution and limited numbers where found, this fish has been listed as a species of special concern by the state of Tennessee. Because of this concern, captive rearing procedures would have to be developed with a closely related but common species like the logperch (Percina caprodes). Habitat surveys and recovery plans must be completed prior to initiation of any recovery effort.

Greenside darter (Etheostoma blennioides)

The greenside darter is another species that was eliminated from lower Abrams Creek in 1957, but is fairly common in all other park streams. This fish is represented by the subspecies Etheostoma blennioides gutselli in the Little Tennessee River system. Fish from populations elsewhere in the park would be used for restoration. Prior to reintroduction, a habitat availability survey must be completed and a recovery plan drafted.

Banded Sculpin (Cottus carolinae) and Mottled Sculpin (Cottus bairdi)

The mottled sculpin is the most widespread of the two species in the park, with banded sculpins being common in the lower portions of Little River and the Middle Prong of Little Pigeon River. Historical records indicate that both species were present in lower Abrams Creek prior to the 1957 reclamation effort. However, these records indicate that the density of both species was low. Etnier (personal communication) believes that the low densities may be the result of competitive interactions with other species that were in the system. If this is true, and given the voracious feeding habits of sculpins, extreme caution should be exercised in reintroducing these species since they may compete with the threatened and endangered fish that are currently being reintroduced. The uncertainty that surrounds the taxonomic status of the sculpin is

complex. Sculpins should not be reintroduced until this issue is resolved to ensure that new genotypes are not introduced into the system.

Tennessee Dace (Phoxinus tennesseensis)

The Tennessee dace is part of a small guild of fishes that inhabit springs, spring runs or tiny streams. This habitat preference has led to selection for dispersal capabilities in this group of fishes. This species has only been collected in the park in lower Tabcat Creek and from Crying Creek, a small tributary to Cosby Creek (Simbeck 1990). The area in which the Tennessee dace was collected in Tabcat Creek appears to be inundated by Chilhowee Reservoir. The fish has been collected in Crying Creek since 1960, and has not been collected in the portion of Cosby Creek from Crying Creek downstream to the park boundary. Cosby Creek, downstream of the park boundary, has not been surveyed to determine if the species still exists in the stream.

5. Other Species of Special Concern

Flame Chub (Hemitremia flammea)

A tiny population of flame chubs exists in the springs at the west end of Cades Cove. This is the only population of this species in the entire Little Tennessee River system and could represent the loss of a unique gene pool if the species becomes extinct in the park. Current data indicate that this population is on the brink of extinction in the park. Shrinking populations throughout the state have resulted in the fish being listed as a species of Special Concern in Tennessee.

If possible, the habitat in which this fish lives should be improved by deepening some of the spring pools, opening the canopy to encourage the growth of aquatic macrophytes and maintaining a captive population in case of extinction.

E. Regulations, Enforcement and Education

1. Fishing Regulations

Prior to the mid-1970s, GRSM fishing regulations were established without the benefit of biological data. Regulation changes were made based on the perception that certain types of regulations working in other parts of the nation would work here, or because the angling public perceived that a change needed to be made, or a combination of both. Unfortunately, such changes did not consider the population characteristics of wild rainbow and brown trout in the Southeast.

In the late 1970s, data on fish population density, biomass and size characteristics were collected as part of a parkwide sampling effort. These data provided evidence that a nine-inch and twelve-inch regulation

on rainbow trout essentially created a catch and release fishery because a very small percentage (3-5 percent) of the rainbow trout ever exceeded nine inches. About 80 percent of the rainbow trout collected were less than seven inches in length, indicating a need for a reduction in size limits. Although low in number, about half of the brown trout collected were over seven inches in length and several fish were 14-27 inches in length. These data, and other information, indicate that the larger size limits were having little, if any, impact on the size structure of rainbow or brown trout. As a result, in 1983 the size limit was reduced to seven inches, the creel limit was raised from four to five fish daily, and closed seasons were eliminated. Fish population census data since that time indicate that these regulations have not altered the population size structure of rainbow and brown trout, nor have they altered the anglers catch.

Current fishing regulations and stream closures are listed in Title 36 of the Code of Federal Regulations and in the park's fishing brochure. Copies of these documents can be found at ranger stations and visitor centers.

Revisions to current fishing regulations will consider the following criteria:

1. Monitoring data has shown that park salmonid populations have wide fluctuations in population density due to weather (i.e., droughts and floods). Low densities of trout following such events are to be expected. Regulations should not be changed based solely on density data.
2. If monitoring data show that population densities have declined, or are declining for other reasons, such as increased angling pressure and harvest, then more restrictive regulations may be considered. Changes, such as increased minimum size limits, decreased daily creel limits, or complete closures, are viable management considerations.
3. The possession and use of bait is currently prohibited. This regulation should remain in effect to prevent the possibility of introducing additional exotic species. Such a regulation will also prevent the digging of worms and other baits from along stream banks, the degradation of stream side bank habitats as a result of this activity, and the disruption of natural processes in aquatic macroinvertebrate communities.
4. The possession of brook trout is prohibited, and any brook trout caught must be returned to the water immediately. If restoration efforts are successful, anglers may be allowed to fish for this species in the future.

Regulations should be designed to: (a) provide for recreational angling opportunities; (b) allow harvest of rainbow and brown trout; and, (c) protect the populations from overharvest and maintain

normal population resiliency. Current regulations appear to meet these criteria because they are based on biological criteria. All future regulation changes should have the same credibility.

2. Enforcement

Brook trout protection should receive the highest fishery-related law enforcement priority. Other illegal fishing activities should be the next priority. These, and other enforcement needs, are addressed in the park's law enforcement needs assessment and in the park's Compendium to the Code of Federal Regulations. Impacts to federally listed endangered and threatened fish species in the park are not usually related to illegal fishing activities.

3. Information and Education

- a. Develop informational and educational materials utilizing appropriate interpretative media that address fisheries management. Materials should address brook trout decline, restoration efforts, fishing regulations, and threatened and endangered species reintroduction.
- b. Work with the media to disseminate various fishery messages to the public. This may include news releases, newspaper and magazine articles, radio and television interviews, and taped phone messages. Written materials will be provided to the media when available.
- c. Park interpreters will be kept abreast of fishery management issues by the fishery biologist through the Interpretive Division resource information specialist, and interpretive programs will provide fishery information when appropriate.
- d. Fisheries research and management data will also be disseminated through presentations to groups such as Trout Unlimited, Federation of Fly Fishermen, and university fishery and natural resource classes. Programs will include information on current research projects and management actions.
- e. Post fishing regulations and closures at appropriate locations on all major streams.
- f. Present a fisheries research and management information program at all seasonal training. Produce reports and updates on fish populations, brook trout restoration, and threatened and endangered fish reintroduction available to all employees throughout the year.

APPENDICES

APPENDIX 1

WATERSHEDS OF GREAT SMOKY MOUNTAINS NATIONAL PARK
(Parker and Pipes, 1990)

		Area (km ²)	Shape	Elevation Low - High (meters)	Drainage Density (km/km ²)
1	Cosby Creek	27.80	1.68	500 - 1804	2.34
2	Greenbriar Creek	6.73	2.06	546 - 1804	1.88
3	Indian Camp Creek	12.31	1.81	585 - 1942	1.79
4	Dunn Creek	6.71	2.26	634 - 1797	2.26
5	Ramsey Creek	6.04	1.65	475 - 1463	1.65
6	Soak Ash Creek	6.42	1.24	427 - 1219	2.17
7	Copeland Creek	5.45	1.74	390 - 890	1.72
8	Mid. Prg. Little Pigeon	123.97	1.89	418 - 2018	1.40
9	Dudley Creek	12.79	1.71	451 - 1355	1.64
10	Roaring Fork	18.17	2.03	475 - 2010	1.28
11	Baskins Creek	5.12	2.60	463 - 1378	1.44
12	LeConte Creek	11.37	2.49	475 - 1998	1.38
13	West Prong Little Pigeon	90.35	2.79	402 - 2010	1.37
14	East Prong Little River	159.41	2.56	354 - 2025	1.78
15	Middle Prong Little River	75.21	1.92	354 - 1685	1.53
16	West Prong little River	45.11	1.74	354 - 1685	1.91
17	Little River (Lower)	3.27	1.83	341 - 719	2.65
	Little River (Combined)	283.00	1.90	341 - 2025	1.74
18	White Oak Sinks	4.33	1.52	518 - 1122	1.57
19	Hesse Creek	30.36	2.34	341 - 1148	2.69
20	Cane Creek	10.79	1.92	372 - 639	1.98
21	Abrams Creek	197.72	2.38	266 - 1684	1.76
22	Panther Creek	28.97	3.15	266 - 1508	1.70
23	Shop Creek	5.81	1.53	266 - 708	1.21
24	Tabcat Creek	15.02	1.80	266 - 843	1.26
25	Parson Branch	20.59	1.49	331 - 1442	1.47
26	Twentymile Creek	41.94	1.41	389 - 1442	1.60
27	Lost Cove Creek	9.46	1.49	521 - 1341	1.85
28	Eagle Creek	59.75	1.75	521 - 1685	1.42
29	Hazel Creek	121.29	1.72	521 - 1616	1.51
30	Pilkey Creek	9.82	1.19	521 - 1463	1.45
31	Chambers Creek	13.91	1.39	521 - 1477	1.68
32	Forney Creek	75.12	1.62	521 - 2025	1.34
33	Noland Creek	56.96	1.93	521 - 2025	1.42
34	Peachtree Creek	5.60	2.16	521 - 1304	1.70
35	Deep Creek	111.60	1.72	549 - 1890	1.35
36	Cooper Creek	11.02	1.69	780 - 1573	1.41
37	Oconaluftee River (Lower)	31.84	2.06	616 - 1540	1.74
38	Oconaluftee River (West)	56.43	1.98	671 - 1895	1.64
39	Bradley Fork	56.52	1.64	671 - 1800	1.42
	Oconaluftee River (Comb.)	144.79	1.80	616 - 1895	1.58
40	Raven Fork	54.50	1.63	829 - 1956	1.54
41	Straight Fork	58.11	2.21	780 - 1900	1.26
42	Stillwell Creek	8.36	1.92	853 - 1795	0.97
43	Bunches Creek	14.90	2.09	963 - 1820	1.15
44	Cataloochee Creek	161.26	1.53	707 - 1876	1.48
45	Big Creek	90.29	1.74	474 - 2018	1.66

Description of permanently marked, large-stream sampling sites.

ABRAMS CREEK

Watershed: Abrams Creek

County: Blount

State: Tennessee

Quadrangle: Cades Cove, Calderwood

Station 1

Downstream Tag: AID

Upstream Tag: AIU

Elevation: 336m

Landmarks: Section begins approximately 5m downstream of Rabbit Creek Trail.
Tag ID is on a small alder in the right side of the creek.

Station 2

Downstream Tag:

Upstream Tag:

Elevation: 475m

Landmarks: Section is located downstream of the big shoe and ends about 20m downstream of where Stony Branch enters Abrams Creek.

Station 3

Downstream Tag: A4D

Upstream Tag: A4U

Elevation: 521m

Landmarks: This section ends at the downstream end of the pool at the confluence of Abrams and Mill Creek.

Station 4

Downstream Tag: A5D

Upstream Tag: A5U

Elevation: 523m

Landmarks: This station ends about 25m downstream of the bridge that crosses Abrams Creek just before the road to the falls parking lot.

Cataloochee Creek

Watershed: Cataloochee

County: Haywood

State: North Carolina

Quadrangle: Cove Creek Gap

Station 1

Downstream Tag: Cat 1D

Upstream Tag: Cat 1U

Elevation: 749m

Landmarks: The section ends about 100m downstream of the confluence of Little Cataloochee Creek with Cataloochee Creek. Tag Cat 1D is on a sycamore tree on the right side of the creek and tag Cat 1U is on a dogwood on the left side of the creek.

Station 2

Downstream Tag: Cat 2D

Upstream Tag: Cat 2U

Elevation: 779m

Landmarks: Section begins at the steel truss bridge downstream of the Palmer house. Tag Cat 2D is on a maple tree on the right side of the stream and Cat 2U is on a maple tree on the right side of the stream.

Station 3

Downstream Tag: Cat 3D

Upstream Tag: Cat 3U

Elevation: 826m

Landmarks: Station is located 300-400m downstream of the Palmer church. Tag Cat 3D is located on a black birch on the right side of the stream and tag Cat 3U is located on a green ash on the left side of the stream.

Station 4

Downstream Tag: Cat 4D

Upstream Tag: Cat 4U

Elevation: 861m

Landmarks: Sections end at the junction of Davidson Branch trail with the Palmer Creek trail. Tag Cat 4D is on a basswood on the right side of the stream and Cat 4U is on a yellow birch on the left side of the stream.

DEEP CREEK

Watershed: Deep Creek

County: Swain

State: North Carolina

Quadrangle: Bryson City

Station 1

Downstream Tag: 321

Upstream Tag: 18D

Elevation: 542m

Landmarks: Section begins at the bridge at the entrance to the campground.

Station 2

Downstream Tag: 16D

Upstream Tag: 320

Elevation: 602m

Landmarks: Station begins at the end of the road about two miles upstream of the campground. Tag 16D is on a yellow birch on the right side of the stream.

Station 3

Downstream Tag: 116D

Upstream Tag: 315U

Elevation: 671m

Landmarks: Section is located about 1 km downstream of McCracken Branch, where trail is adjacent to stream. Tag 116D is in a hemlock on the left side of the stream.

HAZEL CREEK

Watershed: Hazel Creek

County: Swain

State: North Carolina

Quadrangle: Tuckasegee

Station 1

Downstream Tag: 243/184D

Upstream Tag: 242/21U

Elevation: 529m

Landmarks: Section begins just downstream of the Proctor bunkhouse and ends about 5m upstream of the bridge. Downstream tags are on a white oak on the left side of the stream, and the upstream tags are on a dogwood on the left side of the stream.

Station 2

Downstream Tag: 152D

Upstream Tag: 161U

Elevation: 540m

Landmarks: Section ends approximately 0.4 km downstream from the Hazel Creek-Rowan Branch confluence upstream and is marked by a large bedrock outcrop that extends across Hazel Creek and forms a verticle drop of about 1.0 m.

Station 3

Downstream Tag: 398D

Upstream Tag: 165U

Elevation: 686m

Landmarks: Section ends at the downstream end of the pool formed by the confluence of Bone Valley and Hazel Creeks.

LITTLE RIVER

Watershed: Little River

County: Blount, Sevier

State: Tennessee

Quadrangle: Gatlinburg, Silers Bald, Wear Cove

Station 1

Downstream Tag: No tag

Upstream Tag: No tag

Elevation: 329m

Landmarks: Station begins at the downstream end of a large pool at the park boundary in Townsend.

Station 2

Downstream Tag: P509D

Upstream Tag: P508U

Elevation: 518m

Landmarks: Station begins 0.25 miles upstream of the entrance to Metcalf Bottoms. Tag 509D is on an ironwood on the right side of the stream and tag 508U is on a sycamore on the left side.

Station 3

Downstream Tag: P506D

Upstream Tag: P507U

Elevation: 610m

Landmark: Station begins at the top of a riffle at the upper end of the parking area known as Milsap Bottoms and extends upstream to the next parking area.

Station 4

Downstream Tag: IRV4D

Upstream Tag: IRV4U

Elevation: 750m

Landmarks: The station begins about 0.25 miles downstream of Huskey Branch.

APPENDIX 3. Fishery Management Program

ACTIVITY	YEAR					
	1	2	3	4	5	6
Large stream ¹ monitoring	X	X	X	X	X	X
Native non- ² game fish distribution	X					X
Monitor brook ³ trout distribution	X	X	X	X	X	X
Impacts of ⁴ environmental change on brook trout populations	X	X	X	X	X	X
Barriers ⁵	X		X			X
Brook trout ⁶ restoration	X	X	X	X	X	X
Threatened ⁷ and endangered species monitoring	X	X	X	X	X	X
Reintroduction ⁸ of extirpated native species			X		X	

1. Three streams, Little River and Cataloochee Creek annually, plus one of the following: Deep Creek, Hazel Creek, Oconaluftee River or Abrams Creek (These streams will be sampled on a 4-year rotation). Projected number of days: 12-15 (crew size, 15-20 people).

2. The downstream portion of every major watershed will be surveyed every 5 years. Projected number of days: 28-30 (CPSU subagreement, consisting of 5-7 people).

3. One to three watersheds per year. Projected number of days: 21-28/watershed for large watersheds (crew size, 6-8 people).

4. Four to six of the following streams: Sams Creek, Rock Creek, Bunches Creek, Flat Creek, Straight Fork, Silers Creek, Beech Creek and Taywa Creek will be sampled annually. Site descriptions can be found in West, et al. (1990) or in the stream files in the fisheries office. Projected number of days: 15-20 (crew size 6-8 people).
5. Mark and move experiments on two obstructions initiated at two-year intervals, alternate years will be used for evaluation. Projected number of days: 6-10 (crew size 6-8 people).
6. One to two streams per year dependent on the length of stream to be restored. If stream segments are short (≤ 1000 m), two streams a year will be done; however, if over 2000 m of stream are to be restored, only one stream will be attempted. Projected number of days: 14-28 (crew size 6-8 people).
7. Annual monitoring to assess distribution and stability of reintroduced fishes. Projected number of days: 2-4 (interagency effort, consisting of 6-8 people).
8. One species every three years in Abrams Creek, monitoring every year. Projected number of days: 2-5 (interagency effort, consisting of 6-8 people).

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