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SHEMAMDOAH NATIONAL PARK
FISHERIES MANAGEMENT PLAN
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Submitted By:

David A. Hallett
Resource Management Specialist

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Date

Approved By:

David M. Weyer
Superintendent

6/12/87
Date

FISHERIES MANAGEMENT PLAN

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SHENANDOAH NATIONAL PARK
FISHERIES MANAGEMENT PLAN
1987

I. INTRODUCTION

The mountain streams found in Shenandoah National Park are one of the last completely protected strongholds of the native Eastern brook trout (Salvelinus fontinalis). The Park's cool forested slopes give rise to the clear waters and provide scenic backdrops for the waterfalls and cascades found along many of the larger streams. The scenic beauty of the area combined with an abundance of speckled-sided brookies has beckoned anglers to this area since early historic times. One could only speculate on what influence the presence of these fish had on the selection of this portion of the Blue Ridge mountains as a national park, but we do know that many of the people who were influential in this selection were ardent trout anglers. President Hoover established his camp on the Rapidan River as both a retreat to ease the pressures of political life and because of the excellent fishing in nearby streams. Since early historical times, anglers have sought the native trout for either a delicious addition to their mountain diet or for the sport and pleasure of fishing for them in these picturesque mountain streams. It is no wonder that today trout fishing is still viewed by many as a very enjoyable outdoor experience. This feeling will very likely become even more prevalent as local and regional populations increase and the number of native trout streams located outside of protected areas such as national parks, slowly decrease.

The trout fishery in Shenandoah National Park consists of numerous small to moderate sized mountain streams on which angling is permitted. The actual number of streams may vary depending on stream conditions, trout populations, and fishing pressure. However, under normal conditions there will be between 28 and 30 streams open for public angling. There are 19 or more other streams where limited trout populations exist but not in large enough or consistent enough numbers to permit harvest. Native brook trout populations are one of the Park's most heavily impacted resources and the only wildlife resources which can be legally harvested. Although trout fishing is considered by National Park Service policy to be an acceptable Park activity, it should be constantly kept in mind that this use must be in keeping with sound natural resource management principles.

Native brook trout are an essential component in the ecological integrity of park waterways. The type and magnitude of harvest must be consistent with the basic management objectives of protecting and maintaining natural aquatic ecosystems. It is the policy of the Park that trout harvest and associated impacts be permitted only when it is clear that the fishery can withstand

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these impacts without significantly altering the function of the aquatic ecosystems.

Early fisheries work in the Park was conducted by the U.S. Fish and Wildlife Service (USFWS) and the Virginia Commission of Game and Inland Fisheries (VCGIF). A study was conducted by Robert Lennon (USFWS) during the 1950's. His final report: The Trout Fishery in Shenandoah National Park, was published in 1961. In this investigation, Lennon found many of the stream's trout populations to be seriously threatened or in some cases completely lost. This condition was caused mainly by the preceding several years of severe drought. Later work by the USFWS (Sheridan, 1968-1973) on Park streams showed most trout populations to have recovered significantly. This was due to improved weather conditions resulting in increased streamflow, the stocking of several streams which had lost their native trout populations, the temporary closure of all streams to fishing during the late 1950's, and the enforcement of more restrictive fishing regulations. During the 1960's, both the USFWS and the VCGIF accomplished most of the fisheries work done in the Park. It was during this period that the current fishing regulations were developed and the fish-for-fun program was initiated on the Rapidan and Staunton rivers. The VCGIF conducted a statewide trout stream survey in the late 1970's. Most of the major Park streams were included in this survey. The final report (Mohn, 1979) included both habitat analysis and standing crop evaluations, and provided much needed baseline data for future fisheries work. During the 1970's, the USFWS became less active in the Park. The VCGIF continued to conduct stream surveys on an intermittent basis. Most of the current fishing regulations were adopted in 1961. National Park Service involvement in field monitoring and research was begun in 1982. There were several reasons for this increased involvement. The Park had begun to develop a comprehensive resource management program. An initial study of a representative sample of Park streams conducted in 1982 indicated that some streams had depressed trout populations. There was also a noticeable increase in fishing pressure and fish poaching. Fiscal restraints prohibited the USFWS and the VCGIF from increasing their involvement; and lastly, other environmental impacts such as acid rain began to threaten aquatic resources.

II. MANAGEMENT CONCERNS

Most of the Park streams provide good trout habitat. Water quality is generally good although most streams are only moderately productive. Excellent water temperature and physical stream parameters contribute significantly to the capacity for most streams to sustain good brook trout populations. However, periodic drought and flood cause drastic reductions in trout numbers. These conditions frequently prevent spawning or severely damage the eggs or young spawn, which results in the

nearly complete loss of a years production of trout. Brook trout in small mountain streams rarely live beyond three years of age (Lennon, 1961 and Jensen, 1971). Most fish harvested by anglers are between one and a half and two and a half years old. It is therefore easy to see how the loss of one or two years trout reproduction could greatly influence a streams overall trout population. Generally speaking, the smaller the stream the more severely these effects of drought and flood are felt (Hansen and Waters, 1966). The few moderate sized streams in the Park, (average streambed width greater than 10 feet), withstand these influences to some degree and maintain fairly stable trout populations. In years of good reproduction, the legal harvest of trout has little real impact on the future population; however, during years of spawning failure or when eggs have been destroyed by floods, the removal of a major portion of the available spawning age fish could have an adverse impact on the next years population. Just what percentage of these mature trout would have to be removed to seriously impact the next years young-of-year (YOY) recruitment would depend on many factors such as annual spawning conditions, amount of depredation on eggs, fry and YOY, and winter and spring water conditions. On very small streams with relatively few spawning size fish (10-20), the removal of only a few fish could greatly reduce the amount of spawn produced. The Parks's trout monitoring program has shown that in dry years the water flow is so reduced that the total trout population may be held in four or five remaining pools. Under these conditions, fish are extremely vulnerable to natural predation and to angler harvest. In other cases, the trout population may be spread out in the remaining small pockets of water. Mobility between these pockets is decreased as water levels drop during drought periods. When these conditions occur during the late fall spawning period, isolated fish are unable to find mates. In response to these harsh conditions native brook trout have evolved into a highly productive and hardy species. Even under the worst conditions at least a minimum number of fish successfully spawn, and the species is perpetuated. Even after several years of poor habitat conditions, the remaining population can rapidly rebound to previous levels when good conditions improve. It is only under very severe conditions that a native brook trout population is lost from a stream and usually human caused impacts contributed to the loss. However, this sometimes delicate balance can be disrupted by the removal of some of these last remaining fish by anglers. It is, therefore, important that the Park's policy on angling consider these factors.

Brook trout are an important part of the aquatic ecosystems of Park streams and also interact with the surrounding riparian ecosystems as well. They are the major stream aquatic predator and serve to keep other fish species in balance. In turn they become prey to mink, raccoons, water snakes, and predatory birds. The numbers of trout harvested by anglers should not reduce the population to the point of impacting the predator and prey species which depend on a minimum abundance of trout for

survival. The point at which this level of impact is reached will obviously be very difficult, if not impossible, to determine. It is very unlikely that the Park will be able to conduct the high level of research and monitoring that would be necessary to determine these ecosystem relationships on all streams in the Park. Therefore, a more subjective system of providing adequate protection to small streams will be necessary.

Fishing pressure has gradually increased over the years. Although only a few Park streams could be classified today as heavily fished, all streams receive some fishing pressure. As the number of anglers increase, the impacts which are seen on only a few Park streams today will become more widespread. In the past, we have relied solely on fishing regulations and their enforcement to provide adequate protection for trout populations. There may soon come a time when the harvest impacts become so great that some other type of harvest limits will have to be imposed. Brown and rainbow trout are found in several Park streams. These exotic species have caused serious disruptions to native brook trout populations in many streams throughout the east (Kelly, 1977). It has been a management concern for some time that these exotic species could displace the Park's native trout. Research into these possible impacts was initiated by the VCGIF in 1981. In the study titled, "An Evaluation of Sympatric Populations of Brown and Brook Trout in Four Virginia Streams," (Josephson, 1982), the brown trout population in four study streams was analyzed and an attempt was made to correlate the presence of this species to a habitat preference or requirement. In general terms, it was found that the brown trout were found primarily in the lower reaches of the study streams where large pools are common and water temperatures occasionally are higher than brook trout prefer. During the two-year study period, there was no appreciable upstream movement of brown trout. Recent stream surveys however, indicate that there still should be some concern about brown trout encroachment. A stream of special concern is the North Fork of the Moormans River. Josephson found so few brown trout in this stream that he dropped it from his study. In 1985 when trout were being collected on the Moormans to be used to stock the Doyle's River, 6 large brown trout up to 18 inches in length and over 15 YOY were collected and removed from the stream. These fish were not just found in the lower reaches of the stream but were found in all areas sampled. It is evident that brown trout have both increased their numbers and distribution on this stream. Brown trout have also been recently found in significant numbers on the Hughes River.

Backcountry patrols for the purpose of enforcing fishing regulations have not been completely successful in controlling fish poaching. Several streams each year show signs of severe adult trout population reduction which go beyond which is normally caused by legal harvest levels. The long-range effects of poaching can have serious impacts on trout populations. It is

possible that a combination of legal harvest, poaching and two successive years of spawning failure could result in the severe depletion of a trout population. Large-scale fish poaching must be adequately controlled.

In many of the mountainous areas of the mid-Appalachian region, streams which formally provided good trout habitat are now devoid of native brook trout. Many of these streams have been channelized, polluted by agricultural pesticides or industrial wastes, or otherwise altered to the point that brook trout can no longer survive. In other streams brook trout have been replaced by exotic rainbow or brown trout. Due to these factors and others, most of the trout fishing opportunities today are limited to angling for hatchery-reared trout which are stocked at intervals during the fishing season. Because of poor habitat conditions in many streams, these fish rarely overwinter or reproduce. The numbers and quality of native brook trout streams in the region have gradually declined. Yet the demand for native trout angling in a natural setting continues to grow. The protected trout streams located in the Park represent one of the largest native trout fisheries left in the mid-Appalachian region. Many anglers consider these streams to be the finest remaining brook trout streams in the Appalachians. It is of utmost importance that the exceptional quality of this fishery resource be protected and that angling practices and philosophies which result in minimum impacts to this resource be encouraged.

III. OBJECTIVES

The objectives of the Park's fisheries management program are twofold: (1) to preserve and perpetuate the native brook trout as an integral component of the Park's aquatic ecosystems; and (2) to allow for recreational angling on those Park streams that can consistently produce enough surplus brook trout for sustained harvest. The policies, regulations, and management actions included in this Plan are directed at achieving these objectives.

IV. BROOK TROUT BIOLOGY

The Eastern brook trout (Salvelinus fontinalis) is the only trout native to the streams of this Park. The species is especially well adapted to high, swift mountain streams. It is a small, vigorous fish that accepts a wide range of food and is highly productive. Adult fish rarely exceed twelve inches in length or four years of age. To compensate for their short life span the trout have a high reproductive potential. Both male and female fish reach sexual maturity when they are one and a half years old. Female trout produce between 200 and 1200 eggs depending on their size. In a normal population, the ratio of males to females is usually 1:1. Brook trout spawn in the fall. In the Park, most spawning is done during the last week of October. The female prepares a nest or redd by scooping or

faning out a depression in the stream gravel of a shallow riffle or near the tail of a pool. The eggs are laid and immediately fertilized by the male. The redd is then covered with two to four inches of gravel and the eggs are left to develop under the gravel. The eggs hatch sometime during late February depending on what the average water temperature was during the development period. The newly hatched trout wiggle up through the gravel and enter the water of the stream. By the following fall, the trout average 80mm in length. By the end of their second year, most fish have reached 160mm and by the fall of their third year over 220mm (8 1/4 inches). There is a great deal of variance between individual fish and some variation between streams. It is not unusual for a three-year old trout to reach 11 inches in length. Brook trout are prone to very few diseases. The major population limitations are food, space, predators, and waterflow. The difference in productivity between Park streams is due mainly to variances in streamwater alkalinity. The more alkaline the stream the greater the variety and abundance of macroinvertebrates which in turn support a more abundant aquatic ecosystem. The streams which have the highest alkalinity flow through the Catoctin geologic formation, while the lowest alkalinities are found in the streams derived from the Hampton and Erwin formations.

V. STREAM CHARACTERISTICS

There is a total of 48 Park streams or major tributaries which contain brook trout. Only a portion of these; however, provide adequate habitat for a large enough trout population to sustain a significant angler harvest. These streams usually maintain a viable trout population which produces enough large trout to sustain angling yet carry over enough breeding-sized fish to assure good reproduction. Of even greater importance is that population numbers in these streams will remain high enough to maintain natural ecosystem interactions. Based on data from our monitoring program, 27 of these streams meet this stream habitat and population criteria and have been selected as fishable waters.

The physical and chemical parameters of Park streams vary considerably. The most dominant factor is based on the type of bedrock which underlies the watershed. It is the mineral characteristics of the bedrock and derived soils that determine the chemical makeup and alkalinity of the streamwater. The most productive streams are derived from the Catoctin formation which is made up primarily of basaltic greenstone. The water of these streams contains many dissolved minerals and has alkalinity ranges from 100 to 200 ueg/L. Of moderate productivity are the streams flowing from the Pedlar and Old Rag granite formations which have alkalinities ranging from 50 to 100 ueg/L. The poorest stream ecosystem productivity is found on streams derived from the Hampton/Erwin formations. On these streams, alkalinities are very low, commonly less than 20 ueg/L, which results in almost sterile conditions. Streamwater alkalinity is

a measurement of the dissolved ions (minerals) found in the water. This measurement relates somewhat to pH but even more meaningful is its relationship to buffering capacity. Streams with high alkalinities can neutralize organic acids produced by natural processes and from atmospheric acid deposition. Fortunately, most of the Park's major trout streams have adequate alkalinity ranges that can withstand the impacts of acid deposition for some time. However, some of the streams derived from the Pedlar formation and all of the streams of the Hampton/Erwin formation are subject to acid deposition impacts. Recent findings of the Shenandoah Watershed Project (Galloway, 1985), show that in the study streams the measured pH has decreased rapidly during the study period (1979-1986). The current streamwater pH of 5.6 is at the upper range of where aquatic effects will start to occur. Below this pH level many of the smaller fishes such as Dace (Rhinichthys sp.) show signs of population stress. Most investigators have found that brook trout rarely maintain viable populations in waters with a sustained pH value of less than 5.0. It is at this level that numerous aquatic ecosystem components are impacted such as the survival of fish eggs and fry, the abundance of certain types of algae, and the community structure of stream invertebrates. Direct physiological harm to brook trout such as body salt imbalance, .02 deprivation due to a drop in blood pH or aluminum buildup in the gills may occur when pH levels fall below 5.0 (Altshuller and Linthurst, 1983; Baker and Schofield, 1980). A great deal of research has been done on the impacts of acid deposition on brook trout and aquatic habitats (Packer, 1970 and 1972; Robinson, 1976; Muniz, 1980). Unfortunately, much of this work has been done on lakes rather than streams. Research on sensitive Park streams is needed to fully understand and possibly predict future adverse impacts.

Park streams vary in size. The largest streams are four to five miles long, average fifteen to twenty feet wide and range in depth from one to four feet. The smallest permanent streams are one half to one mile long, three to five feet wide, and may contain pools up to two or three feet deep. Most streams in the Park fall about midway between these two extremes.

Physical parameters other than size also vary, although almost all streams could be classified as swift mountain streams. The ratio of pools and riffles is often equal. Flat water is uncommon except on the lower reaches of some streams. All streams have ample cover in the form of boulders, ledges, undercut banks, and fallen logs.

The most variable parameter is water flow. Actual flow rates have not been computed for most Park streams; however, historical data and current monitoring show that rates vary considerably between streams and with the same stream depending on rainfall patterns. Streamflow is dependent on two primary variables, rainfall and the number of permanent springs feeding

a stream. Streams which are dependent on runoff for most of their water supply are the most susceptible to short-term droughts. Trout populations are likely to also fluctuate widely in these streams in response to water levels. Streams that receive at least 50 percent of their flow from headwater springs are less susceptible to drought and have more consistent flow rates. It is on these streams that the largest and most stable trout populations are found.

VI. MANAGEMENT ACTIVITIES

A. Monitoring

The trout population in each stream will be monitored on a regular basis in order to develop an understanding of individual streams natural population fluctuations. Although many Park streams have similarities in physical characteristics and water quality, there are enough habitat differences that all streams do not respond in the same way to either natural or human-caused disruptions. It is only through this monitoring of trout population trends that an understanding of ecosystem dynamics can be gained. This knowledge will then allow more accurate determination of human-caused changes and needed management actions.

Designated trout streams will be sampled every two years. The streams on the east and west sides of the Park will be sampled on alternate years. A backpack mounted, gas-powered shocking unit will be used to sample stream sections. One hundred meter long sampling sections have been established on all trout streams. The number of sections varies from two to six depending on stream length. Section boundaries are marked with metal tags imprinted with "SNP Fisheries Transect". These same transects will be used each year in order to maintain sampling continuity. Stream sampling will be conducted between June 20 and August 20 to avoid periods of excessively high or low stream flow. In most cases, a four person crew is needed to adequately sample a stream. The crew can be made up of both Headquarters and District Resource Management staff; however, the crew leader will always be from the Headquarters unit. A methodical single pass method will be used. All trout captured will be held in a bucket until the end of the section or in the case where a lot of trout are captured, until a suitable barrier to upstream fish movement is found half way through the section. All trout captured will be measured to the nearest five millimeters. Scale samples may be taken when needed to accurately test the age structure on a particular stream. Other species of fish will be noted as to their relative abundance. All exotic species of trout captured will be removed from the stream. Sampling data will be used to construct age class distribution graphs for each stream section and for the total of the sections on each stream. When necessary, scale data will be used to verify the age class divisions used on the graphs. Graph data may also be converted from numbers of fish to pounds/acre of fish when data

of this format is needed. These data and graphs along with a narrative description of the field stream findings will be compiled into an annual stream survey report. Also included in this report will be an analysis of these data. If any management actions are necessary to mitigate or prevent resource damage, the decision to go forward with these actions will be based on and supported by the findings of the annual stream survey reports.

Water quality will be monitored on an as needed basis if there are suspicions that it may be affecting the aquatic ecosystem. Temperature, dissolved oxygen, and turbidity can be easily determined in the field. If information on dissolved minerals is needed, a water sample will be taken and submitted for lab analysis.

B. Management Actions

Management actions are those activities aimed at either protecting the resource from damage or mitigating past impacts. In most cases, these actions will be based on information gained from the monitoring program.

Regulation and Enforcement

The development and enforcement of fishing regulations is the leading method used by all fisheries managers to assure proper resource utilization. In many cases, the regulation of harvest is the only action needed to maintain adequate fish populations in most waters. However, regulations in themselves, must be either readily adaptable or easily changed in order to allow management to respond to changing conditions. The effects of regulation must be frequently assessed on a regular basis to assure that they are producing the desired results. The set of regulations in effect in the Park in 1985 were developed in the early 1960's. Since that time legal fishing pressure has increased substantially, and incidents of poaching seem to be increasing. The Park's two fish-for-fun streams have grown in popularity until on nice weekends the stream receives very heavy use. Brown and rainbow trout continue to be found in many of the larger Park streams. It was because of these concerns that several regulation changes were submitted to the rulemaking process. The following regulations are scheduled to go into effect beginning October 16, 1987.

36 CFR 7.15 (a) Fishing

(1) Open waters. All streams are closed to fishing except those designated by the superintendent as trout streams.

(2) Applicability. The provisions of paragraphs (a)(3) through (a)(7) and (a)(9) of this section apply to all designated trout streams except fish-for-fun streams and portions of streams that

form the Park boundary line. Fishing in fish-for-fun streams is subject to the provisions of paragraphs (a)(4), (a)(8), and (a)(9) of this section and fishing in portions of streams that form the Park boundary is governed solely by applicable State law.

(3) Season. The opening date of the trout season and the hours during which trout fishing is allowed are those established by applicable State law, trout season closes October 15 except for designated fish-for-fun streams.

(4) License. Fishing license requirements imposed by applicable State law apply to persons fishing in Park waters.

(5) Size limit. Trout eight (8) inches or longer may be retained. Trout under eight (8) inches in length shall be immediately and carefully returned to the water. There is no size limit on other species of game fishes.

(6) Creel limits. No person may retain more than five (5) trout per day nor have more than five (5) trout in possession. Creel limits on other species of game fishes are those established by applicable State law.

(7) Lures; bait. Fishing is restricted to an artificial fly or lure having a single hook.

(8) Fish-for-fun. Trout streams managed in the fish-for-fun program are designated by the superintendent. These streams are open to trout fishing all year. Fishing is governed by applicable State law except as follows:

(i) Fishing is restricted to an artificial fly or lure having a single barbless hook;

(ii) No trout of any size may be retained. All trout caught shall be handled carefully and returned immediately to the water; and

• (iii) All other species of game fishes may be kept. The season and creel limit for species other than trout are governed by applicable State law.

(9) The following are prohibited:

(i) Violating a fishing closure, designation, use or activity restriction or condition or limit established in this paragraph;

(ii) Violating a provision of applicable State law.

The majority of persons fishing in the Park obey the fishing regulations. However, there are always a small percentage that will and do violate the law. Although their numbers are thought

to be small, the impacts can be substantial. Illegal fishing with live bait is perhaps the most damaging illegal activity. Brook trout are easily taken on live bait. A population of trout in a small stream can be seriously reduced by bait fishing. Exceeding the legal limit by otherwise legal anglers is also damaging as it more quickly reduces the numbers of larger, breeding-aged fish. The enforcement of the fishing regulations is an important management action necessary to protect fish populations from excessive reductions. Patrols will be scheduled as to most effectively deal with cases of known or suspected fish poaching. These can best be accomplished by using various types of plain clothes and secretive patrols. These types of patrols should be concentrated on those streams where the monitoring data has shown an unusual or unexplainable reduction in the trout population. More visible, uniformed patrols will be used on popular streams to gain compliance to the regulations by the general fishing public. Interpretive programs, displays, and Park handouts will be used to educate and inform visitors about our fisheries management program and policies.

Stream Closures

The authority to close a Park stream to fishing rests with the Park Superintendent (36 CFR 1.5). A trout stream may be temporarily closed to fishing if the trout population falls below a level where recovery would be hampered by continued angler harvest. The decision will be based on data derived from annual stream monitoring. As a guideline, if a stream's trout population has a severely depressed age class two and three population and prevailing weather conditions indicate that spawning success may be marginal the following fall, the stream may be closed to fishing to protect the few remaining spawning-sized fish. An additional criteria will be the overall biomass or number of trout present in the stream. If a stream's trout population declines over a period of years for unexplained reasons to the point that the total numbers of fish or biomass (lbs/acre) represents less than 25 percent of the average population of the past three years, the stream may be closed. In this case, the stream will be studied to discover the cause of the decline. Streams temporarily closed will not be reopened until the trout population has returned to its past vigor. Closures will be recommended by the Superintendent. Public D-NRES by the Superintendent. Public releases and television interviews will be used to notify the public of a stream closure. In addition, signs will be posted at the top and bottom of the stream.

Research Streams

A selected number of streams (3-6) will be designated as research streams, and will be closed to public angling. Research streams are needed to provide fully protected waters where native brook trout can maintain natural population levels and interact freely with the ecosystem. They will serve some of

the needs of both the monitoring and research programs, and will provide the ultimate protection in the Park for this species gene pool.

Many fisheries biologists believe that the brook trout found in the Central Appalachians have evolved into a separate race of fish specifically adapted to the high, fast mountain streams of North Carolina, Virginia, West Virginia, Maryland and southern Pennsylvania (Holloway, 1945 and Lennon, 1960). During the late 1950's, when several Park streams lost their trout populations due to previous years drought, brook trout reared in the Great Smokies National Park were planted in Park streams. None of these fish survived; however, remnant native trout finally managed to eventually repopulate many of the streams. The only successful stocking that was recorded was when fish from nearby similar Park streams were used to stock the depleted waters. Just how much genetic difference exists between the brook trout found in the Park and in other areas may remain as speculation for some time. The important factor to be considered is the adequate protection of the natural gene pool. These research streams will form the core of this protection effort.

Public Education

The recreational fishing opportunities offered by the Park are exceptional. This is not just because the many Park streams contain some of the best remaining native trout populations left on the east coast but also because of the pristine natural condition of the watersheds. Most of the members of fish conservation organizations, such as Trout Unlimited (TU) plus a growing number of other anglers, have come to realize that with today's numbers of trout anglers a reduced harvest is necessary in order to maintain adequate trout populations. These far-sighted sportsmen advocate that catch-and-release programs be established on premier trout waters and that anglers voluntarily reduce the numbers of trout creel on other streams. This type of philosophy should be encouraged and enhanced by the National Park Service.

Park interpretive programs and literature will stress the experience of fishing on Park streams. Although Park regulations will continue to permit the harvest of trout on most streams, Park visitors will be encouraged to adopt a catch-and-release philosophy. Fish-for-fun streams will be carefully monitored and managed for maximum recreational opportunity.

Habitat Protection

In most cases, the Park provides excellent protection for stream trout habitat. Natural processes and severe weather fluctuations will continue to impact and in some cases, permanently alter stream habitat; however, native brook trout have adapted well to these natural fluctuations. Special attention should be

given to possible source of human-caused impacts. Since excessive stream siltation can prevent successful trout reproduction, of special concern is soil erosion from trail and dirt road surfaces. Special attention should be given to erosion problems in close proximity to stream crossings or where roads and trails parallel a stream course. Sufficient numbers and the proper placement of waterbars should be installed to reduce erosion and to direct runoff into areas where the silt can be filtered out before it enters a stream. This is especially critical of steep sections on administrative roads. These areas can generate large amounts of silt-laden runoff which, if permitted to enter a nearby stream, could seriously harm the trout population. In these areas, added attention should be given to proper drainage.

Some trout habitat disruption may result from gypsy moth defoliation. However, there is probably little that we can do to prevent this from occurring. These potential impacts can be monitored and possible controls discussed if current situations should warrant management action.

Regulations prohibiting stream-side camping will continue to be enforced in order to protect stream-banks from erosion.

C. Research

Future research needs should focus on harvest related impacts rather than on trout ecology since there currently exists a large body of literature on brook trout biology and population dynamics and also because of the excellent watershed protection provided by the Park. It is mainly because of this protection that these streams escape many of the impacts such as siltation, poor cover, and channelization which befall less protected waters. Most of the current human-caused impacts to Park streams are harvest related.

One exception is the threat of acid deposition. The current monitoring program should provide adequate data to manage harvest; however, long-term research will be necessary to assess potential impacts to aquatic ecosystems. The only other currently identified threat is that of gypsy moth defoliation and the effects this might have on stream cover and water temperature. The following research projects are identified as high priority needs: (1) Impacts of Acid Deposition on Aquatic Ecosystems; (2) The Impacts of Gypsy Moth Defoliation on Aquatic Resources; and (3) The Effects of Angling on the Trout Populations of Streams Managed Under the Fish-for-Fun program.

VII. ENVIRONMENTAL ASSESSMENT

Fisheries management as a basic resource protection and management program is included in the Environmental Assessment Matrix Summary for the Park's Resource Management Plan. The Fisheries Management Plan is an action plan based on the

This is not deemed to be a major federal action and other than certain fisherman restrictions deemed necessary to properly protect and manage native brook trout populations, there are no recognized adverse impacts to environmental quality. All actions included in this Plan provide added resource protection and; therefore, satisfy the intent and requirements of the National Environmental Policy Act (NEPA).

VIII. APPENDICES

- A. List of Trout Streams
- B. Fishing in Shenandoah National Park Visitor Information Handout
- C. Fish Species of Shenandoah National Park
- D. Stream Monitoring Schedule
- E. Annual Fisheries Reports by CY
- F. Literature Cited and References

APPENDIX A

SHENANDOAH NATIONAL PARK
FISHING STREAMS
1987

The following Park streams and their tributaries within the Park are open to fishing in accordance with regulations published in the Code of Federal Regulations (CFR) and the Virginia State Fishing Regulations. Fishing is prohibited on all other streams not listed.

<u>Stream</u>	<u>County</u>
Piney River	Rappahannock
Thornton River, North Fork	Rappahannock
Thornton River, South Fork	Rappahannock
Hazel River	Rappahannock
Hughes River	Madison
Hannah Run	Madison
White Oak Canyon Run	Madison
*Rapidan River	Madison
*Staunton River	Madison
Rose River	Madison
Hogcamp Branch	Madison
Brokenback Run	Madison
Cedar Run	Madison
Pocosin River	Madison
Conway	Madison/Greene
South River	Greene
East Swift Run	Greene
Ivy Creek	Greene
*North Fork Moormans River	Albemarle
Jeremy's Run	Page
Pass Run	Page
East Hawksbill Creek	Page
Little Hawksbill Creek	Page
East Branch Naked Creek	Page
West Branch Naked Creek	Page
~~Two-Mile Run~~	Rockingham
Madison Run	Rockingham
Big Run	Rockingham
Paine Run	Rockingham
Meadow Run	Rockingham

* Fish-for-Fun streams. Check special regulations.

May 1987

APPENDIX B

Fishing in Shenandoah National Park

The mountain streams found in Shenandoah National Park (SNP) are one of the last completely protected strongholds of the native eastern brook trout. Fish are the only forms of wildlife that can be legally harvested in the Park. Although fishing has long been a traditional and popular visitor activity, this use must be carefully regulated and monitored to assure the future protection and well being of the native trout populations. The Park's Fisheries Management Plan states two program objectives: (1) to preserve and perpetuate the native brook trout as an integral component of Park's aquatic ecosystems; and (2) to allow for recreational angling on those Park streams that can consistently produce enough surplus brook trout for sustained harvest. The various regulations and Park policies are designed to carry out these objectives.

(1) Open waters. All streams within Shenandoah National Park are closed to fishing except those streams listed in the Park's Fisheries Management Plan as designated trout streams.

(2) License. A person fishing within the Park must have in his/her possession a valid state fishing license. A 5-day non-resident license may be purchased at the Big Meadows Wayside and from local sporting goods stores.

(3) Lures, bait. Only artificial lures (such as artificial flies, spinners, or jigs) with a single hook shall be used.

(4) Season. The opening of the trout fishing season and permissible hours of fishing will conform with that of the State of Virginia, and will close October 15, except that fish-for-fun streams are open all year.

(5) Size limit. No species of trout under eight (8) inches in length shall be retained, but shall be immediately and carefully returned to the water. There is no size limit on other species of game fishes.

(6) Limit of catch. The limit of possession of each person fishing trout. The limit of catch on a not exceed that which is in eff

AT ALL?
SAME AS STATE'S?
IS IT LEGAL TO KEEP ANY
OTHER FISH SPECIES? all

(7) Fish-for-Fun. The Rapidan, Staunton, and N. Fork Moormans Rivers are fish-for-fun streams. Anglers who wish to experience native trout fishing at its finest are encouraged to visit these streams. The following regulations apply on these waters.

(i) Streams managed in the fish-for-fun program are listed in the Park's Fisheries Management Plan.

(ii) Fishing is restricted to artificial flies or lures with one barbless hook.

(iii) No trout of any size may be in possession at any time. All trout caught must be handled carefully and immediately returned to the stream. All other species of game fish may be kept. The creel limit for speck trout and brook trout all be the same as on adjacent State

(8) Streams (and to *THIS SHOULD BE CHANGED* ring the general season.

STREAM

COUNTY

Piney River	Rappahannock
Thornton River, North Fork	" "
Thornton River, South Fork	" "
Hazel River	" "
Hughes River	" "
Hannah Run	" "
White Oak Canyon Run	Madison
Rapidan River *	" "
Staunton River *	" "
Rose River	" "
Hogcamp Branch	" "
Brokenback Run	" "
Cedar Run	" "
Pocosin River	" "
Conway River	" "
South River	Greene
East Swift Run	" "
Ivy Creek	" "
North Fork Moormans River *	Albemarle
Jeremy's Run	Page
Pass Run	" "
East Hawksbill Creek	" "
Little Hawksbill Creek	" "
East Branch Naked Creek	" "
West Branch Naked Creek	" "
Madison Run	Rockingham
Big Run	" "
Paine Run	Augusta
Meadow Run	" "

* Fish-for-Fun Streams

Your cooperation is needed in order to assure the continued excellent angling opportunities in SNP. Please report any violations of fishing regulations promptly to the closest Park office or patrol ranger.

APPENDIX C

Fish Species of Shenandoah National Park

SCIENTIFIC NAME	COMMON NAME
Family Salmonidae	
<u>Salvelinus fontinalis</u>	Brook trout
<u>Salmo trutta</u>	Brown trout
<u>Salmo gairdneri</u>	Rainbow trout
Family Cyprinidae	
<u>Rhinichthys atratulus</u>	Blacknose dace
<u>Rhinichthys cataractae</u>	Longnose dace
<u>Clinostomus funduloides</u>	Redside dace
<u>Phoxinus erythrogaster</u>	S. Redbelly
dace	
<u>Phoxinus oreas</u>	Mtn. Redbelly
dace	
<u>Nocomis leptcephalus</u>	Bluehead chub
<u>Nocomis micropogon</u>	River chub
<u>Notropis cornutus</u>	Common shiner
<u>Semotilus atromaculatus</u>	Creek chub
<u>Semotilus corporalis</u>	Fallfish
<u>Campostoma anomalum</u>	Common
stoneroller	
<u>Exoglossum maxillingua</u>	Cutlips minnow
Family Catostomidae	
<u>Catostomus commersoni</u>	White sucker
<u>Hypentlium nigricans</u>	Northern
hogsucker	
<u>Moxostoma rhothoeca</u>	Torrent sucker
<u>Moxostoma erythrurum</u>	Golden redhorse
Family Cottidae	
<u>Cottus bairdi</u>	Mottled sculpin
Family Ictaluridae	
<u>Noturus insignis</u>	Margined madtom
Family Percidae	
<u>Etheostoma flabellare</u>	Fantail darter
<u>Etheostoma nigrum</u>	Johnny darter
<u>Etheostoma olmstedii</u>	Tessellated
darter	
Family Centrarchidae	
<u>Ambloplites rupestris</u>	Rockbass
<u>Micropterus dolomieu</u>	Smallmouth bass
Family Anguillidae	
<u>Anguilla rostrata</u>	American eel

APPENDIX D

Stream Monitoring Schedule

TROUT FISHING STREAMS

<u>STREAM</u>	<u>MILES</u>	<u>SECTIONS</u>	<u>YEARS SAMPLED</u>					
			<u>83</u>	<u>84</u>	<u>85</u>	<u>86</u>	<u>87</u>	<u>88</u>
<u>North District:</u>								
(W) Jeremy's Run								
(E) Piney River								
(E) Thornton River, N.F.								
<u>Central District:</u>								
(W) East Hawksbill								
(W) Little Hawksbill								
(W) E. Branch Naked Creek								
(W) W. Branch Naked Creek								
(W) Pass Run								
(E) Brokenback Run								
(E) Cedar Run								
(E) Hazel River								
(E) Hughes River								
(E) Hannah Run								
(E) Rapidan River								
(E) Rose River								
(E) Staunton River								
(E) Hogcamp Branch								
(E) South River								
(E) White Oak Canyon Run								
<u>South District:</u>								
(W) Big Run								
(W) Madison Run								
(W) Paine Run								
(W) Meadow Run								
(E) Ivy Creek								
(E) N. Fork Moormans River								
(E) East Swift Run								

Other Streams with Trout Populations

These streams will be surveyed every four years unless special concerns dictate more frequent attention. East and west side streams are to be done on an alternate two-year schedule.

<u>STREAM</u>	<u>MILES</u>	<u>SECTIONS</u>	<u>YEARS SAMPLED</u>					
			<u>84</u>	<u>86</u>	<u>88</u>	<u>90</u>	<u>92</u>	<u>94</u>
<u>North District:</u>								
(W) Lands Run-								
(W) Overall Run								
(E) Bolton Branch								
(E) Indian Run								
(E) Jordan River								
(E) Big Devils Stairs Run								
(E) Rush River								
<u>Central District:</u>								
(W) S. Fork Dry Run								
(W) N. Fork Dry Run								
(E) Pocosin Hollow Run								
(E) Broad Hollow Run								
(E) Berry Hollow Run								
(E) Ragged Run								
(W) Fultz Run								
(W) Crow Hollow Run								
(W) Big Creek								
(W) Lee Run								
<u>South District:</u>								
() Sawmill Run								
() Two-Mile Run								
() One-Mile Run								
() Lower Lewis Run								
() Doyles River								

APPENDIX E

Shenandoah National Park Fisheries Management Annual Summary - 1985

Overview

This was the third year since comprehensive stream surveys were begun in 1983. A great deal of progress was made this year in understanding population trends and fluxes brought about by both natural and man-caused impacts. In addition to the brook trout population surveys, this years program was enlarged to include incidental stream surveys, special stream investigations, survey and documentation of non-game fishes, and an evaluation of current regulations and policies pertaining to angling and trout harvest. This was a busy year but the program went smoothly. All equipment functioned well and the stream sampling crew worked efficiently. Seasonal Park Technician James Dexter did an excellent job of supervising the field operation and analyzing the sampling data. The Resource Management office computer was used to generate the length/frequency population graphs. As the data base increases, we will soon need to computerize summary stream data for long-term trend analysis.

This is a summary of the seasons activities. For details such as population data graphs, etc., refer to the 1985 Fisheries Monitoring Program book on file in the Resource Management library.

FIELD PROGRAM

Population Surveys

Brook trout population surveys were conducted on 21 Park streams. A total of 5,204 brook trout were collected from these streams. Length/frequency charts were computed for each sample section and for the total of all sections. Scale samples were taken from 526 fish on 9 of the sampled streams. These scales were used to age fish and compute growth rates. The least squares regression analysis was used to back calculate for annual growth increments. No estimates of standing crop or total biomass were conducted.

Brown trout were found this year in large numbers on the lower one-half of the North Fork Moormans River and the Hughes River. Lesser but still significant numbers of browns were found in the lower reaches of the Rose River. Numerous very large trout (up to 21 inches) were found to occupy many of the larger pools. Young-of-year were also very abundant, reflecting good spawning of browns last year. The total numbers of brown trout found in these streams has significantly increased during the past three years. The results of past research has indicated that brown trout are not a threat to native brook trout populations and

brown would continue to be found only in marginal trout habitat near the Park boundary. There is now evidence to show that this may not be entirely true. Brown trout populations should be carefully monitored in the future and steps taken, if necessary, to reduce their numbers.

Age and growth analysis of the sampled populations showed that all but four of the streams surveyed have good brook trout populations. All of the streams with the exception of Brokenback Run had very poor numbers of one plus-year old trout. This was caused by a severe flood during the February hatching period in 1984. The four streams which showed additional population abnormalities were Lands Run, Hazel River, Staunton River, and Overall Run. All of these streams have showed problems for two years or more.

All age classes were severely depressed in Lands Run. By mid-summer, it was feared that the remaining breeding age fish would not be able to provide enough reproduction this year to perpetuate the population. The stream was closed to fishing on August 10, 1985. The cause of this population decline is still not known.

The Hazel River has had very low populations of trout in the lower reaches of the stream in spite of what appears to be good trout habitat. Illegal poaching is suspected of contributing to this problem. Past studies, however, have shown that this same condition existed in 1959 and in 1975; therefore, either this stream has had a long history of fish poaching or there are also other unknown factors at work.

The Staunton River has shown a much lower number of adult fish than would be expected of a fish-for-fun stream. This is mainly true in the lower reaches near the confluence with the Rapidan. It appears like fish are being illegally harvested.

Overall Run contains very marginal trout habitat. The trout population is usually very low. There is a series of very large pools about mid-way on the stream which during periods of low flow hold perhaps the entire streams breeding population of trout. There is not any excess trout for harvest. During the fall, the few remaining trout are very susceptible to being caught.

Examination of scale annuli from all populations showed excellent growth rates. Compared to other studies done in Virginia and surrounding states, the growth rates calculated this year were approximately 10 to 20 percent greater than normally found. Although there is some variation, brook trout averaged 85mm their first fall following hatching, approximately 160mm at age one plus, 220mm at age two plus, and greater than 240mm at age three plus. Most trout reached legal size (205mm) sometime during the mid-summer of their second year and made up the bulk of the legal harvest during the mid- to late-fishing season. By

mid-summer, very few three plus year old fish were still present in the streams. This is expected as brook trout in these waters rarely live past their third winter due to natural mortality.

Incidental Stream Surveys

During past years, only the major Park streams have been surveyed. It was not known if trout existed in any of the smaller, often intermittent streams. The incidental stream survey that began last year was completed this fall. A total of 33 small streams were examined. Fourteen of these streams had sufficient flow to maintain at least a minimal native brook trout population. Eighteen streams did not contain any trout. One stream will need to be rechecked because the water was too high to complete the survey. For a list of these streams, refer to the 1985 Fisheries Monitoring Program book.

MANAGEMENT AND PLANNING

Fisheries Management Plan

Preliminary work has begun on Shenandoah's first Fisheries Management Plan. The first draft is expected to be completed by January 1, 1986.

Fish-For-Fun Program

The Rapidan and Staunton Rivers were surveyed this year. Trout populations in the Rapidan seem to correspond well to what would be expected. Higher than normal numbers of adult trout were found later in the season than on streams where harvest is permitted. The Rapidan continues to respond well to the no harvest regulation.

The Staunton River, however, showed a poor population of adult fish. The reason for this continued problem is under investigation.

An evaluation was done of other Park streams to see if any others would be good candidates to add to the program. Big Run, Jeremy's Run, Hughes River, and the North Fork Moormans were all considered. The North Fork Moormans was the only stream which met all the necessary criteria (good access, high trout populations, good administrative control, and ability to sustain large numbers of fishermen). This stream has been recommended to be included in the fish-for-fun program.

Regulation Changes

The Park fishing regulations which have been in effect since 1968 were reviewed. It is recommended that most of the general regulations be retained. It would have been desirable to allow a no-limit harvest of exotic brown trout; however, the Virginia

of enforcement problems this would create if a fisherman left the Park with more brown trout than state laws permit. It would be hard for the visitor to prove the fish were caught in the Park. However, brown trout will be allowed to be harvested on all fish-for-fun streams. The creel limit shall be six brown trout. Also recommended is that th
changed to include all game fishes
vested in adjacent state waters. A
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help to achieve this goal.

In addition to these regulation cha
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MANAGEMENT RECOMMENDATIONS

The fisheries monitoring program initiated in 1982 has provided us with a great deal of information about trout populations and the health of Park stream ecosystems in general. We have learned that some streams contain excellent native trout populations while others have naturally low populations or have been impacted by excessive harvest. Because trout are allowed to be harvested, this program must be adequately managed to assure that these valuable resources are protected from excessive impacts. It is recommended that the program which has been started be continued and be incorporated into the annual natural resource management program. Adequate funding and personnel must be allotted for this activity if the program is to be operated in a smooth and professional manner. Once developed, the implementation of the Fisheries Management Plan should receive high priority.

SHENANDOAH NATIONAL PARK
Fisheries Management Annual Report
1986

OVERVIEW

Prolonged summer drought resulted in very low stream flows throughout the Park. West side streams seemed to be effected more severely, especially those underlain by the Hampton/Erwin geologic formation. The streams most effected were temporarily closed to angling on August 9, 1986.

Work continued on drafting the Fisheries Management Plan and special regulation changes need to initiate the plan when approved.

The brook trout population in the South Fork Moorman's River is being threatened by encroachment by brown trout. Efforts were initiated this year to remove exotic brown trout from the stream. The possibility of erecting fish barriers at the Park boundary is being considered.

The trout population monitoring program was accomplished according to plans and on schedule. Nineteen streams, mostly on the west side, were surveyed.

MONITORING

Population Surveys

Brook trout population surveys were conducted on 19 Park streams. A total of 1986 brook trout were collected, measured, and released. Length/frequency charts were computed for each sample section and for the total of all stream sections. A computer file is being established for this data to facilitate long-term trend analysis.

Sampling results showed that young-of-the-year (YOY) survival was below normal due to the November 4, 1985 flooding. We expected the YOY population this year to be very poor due to scouring of the redds. Most streams showed low to moderate YOY recruitment, however, a few streams did show unexpectedly good YOY population. These were not high populations by any means but good enough to carry the age class through to maturity. It is possible that late spawners after the flood contributed to this better-than-expected population.

Most streams sampled showed fair to good population structures. Because of the several years of drought and two damaging floods in the past three years, no streams contain high trout populations.

Lands Run, closed to angling in 1985, is being sampled on an annual basis. The population is still not showing any signs of

recovery. Numbers of breeding age fish are so low that isolation during low water spawning periods may be preventing fish from finding mates. Two YOY's were found which shows that some reproduction took place last fall. This stream will remain closed until complete recovery is achieved.

Annual surveys are also conducted on Hazel Run because of repeatedly poor trout populations on that stream also. The population is not in jeopardy, however, it continues to decline and has been below what should be a normal population for three years. A thorough investigation of habitat and water quality is needed to try to determine what is causing this problem.

Streams with very low trout populations in addition to Lands Run are: North Fork Dry Run, Fultz Run, Pass Run, Big Run, Madison Run, Meadow Run, and Sawmill Run. These streams seem to be severely susceptible to the impacts of drought and flood.

For complete monitoring data on individual streams, refer to the annual monitoring program report.

MANAGEMENT ACTIONS

Doyles River Introduction

The Doyles River was sampled to check on the status of the trout introduced in the late summer of 1985. Large pools were randomly sampled. A total of 29 trout were found, two of these were YOY, indicating that some reproduction had taken place. Many of the fish were very large 250-300mm, and should have produced ample spawn this past fall. To date, this project has been very successful.

Exotic Species Removal

Exotic trout, brown and rainbow, were removed from all streams sampled. To date, only east side streams have contained any brown trout. Rainbow trout have been found in Pass Run and North Fork Moorman's River.

Brown trout encroachment has been an increasing problem on the North Fork Moorman's River. In an effort to assess the magnitude of the problem and remove exotic trout, the lower one mile of the stream was electrofished. Forty-five browns were removed. These fish ranged in size from 89mm to 457mm (18 inches).

This number of fish represents a large increase in the brown trout population. Although the numbers were greater near the boundary, browns were found over the entire section. It is felt that it will be necessary to continue the shocking for an additional mile upstream next year. It is unknown at this time how far upstream the brown trout have become established.

There was some complaint from Trout Unlimited that we destroyed the brown trout. We agreed that next year we would give them the fish for relocation elsewhere if they provided the manpower and resources to transport the fish.

Two large browns were moved from the North Fork Thornton River.

Moorman's River Fish Barrier

In an effort to keep exotic brown trout from entering the section of the stream above the Park boundary, some sort of fish barrier will be needed. A preliminary investigation is underway to determine the feasibility and desirability of constructing such a barrier. The U.S. Fish and Wildlife Service (USFWS) has been contacted and requested to consult on this issue.

Fisheries Management Plan

The final draft of the plan was submitted in December 1986. However, it cannot be fully implemented until the new regulations have been established.

New Fishing Regulations

The proposed new fishing regulations were published in the Federal Register on October 1. Four comment letters were received. The most prevalent complaint was on the proposal to close marginal trout streams. Everyone supported the addition of the North Fork Moorman's River to the fish-for-fun program. It is hoped that the final rulemaking will occur soon enough to put them into effect next fishing season. For additional information on the formulation of this new regulation proposal, refer to the Fisheries Management Plan.

RESEARCH

Although a great deal is known about brook trout population dynamics, there are some other areas of research that is less well understood. A major concern at the present is the impact of acid deposition on aquatic resources.

It is known that sensitive streams in the southwest part of the Park have started to acidify. We need to know what resources are in jeopardy and how soon will the impact be seen.

APPENDIX F

Literature Cited and References

- Alexander, Gaylord R., and James A. Ryckman. 1976. Trout Production and Catch Under Normal and Special Angling Regulations in the North Branch of the Au Sable River. Michigan Fisheries Research Report No. 1840. Michigan Department of Natural Resources.
- Allan, David J. 1980. Determinants of Diet of Brook Trout (Salvelinus fontinalis) in a Mountain Stream. Canadian Journal of Fish. Aquatic Science:38:184-192.
- Cooper, Edwin L. 1962. Growth Rate of Brook Trout at Different Population Densities in a Small Infertile Stream. The Progressive Fish Culturist.
- Elwood, Jerry W., and Thomas F. Waters. 1966. Effects of Floods on Food Consumption and Production Rates of a Stream Brook Trout Population. Paper No. 6673. Scientific Journal Series. Minn. Agricultural Experiment Station.
- Hanson, David L., and Thomas F. Waters. 1966. Recovery of Standing Crop and Production Rate of a Brook Trout Population in a Flood Damaged Stream. Paper No. 8322. Scientific Journal Series. Minn. Agricultural Experiment Station.
- Haskell, David A. 1982. An Evaluation of Trout Populations in Major Park Streams. Unpublished Report. SHEN-N-083.
- Hooper, Rickalon L. 1975. Flooding as the Result of Hurricane Agnes and Its Effects on a Native Brook Trout Population in an Infertile Headwater Stream in Central Pennsylvania. Trans. Amer. Fish Soc. 1975 No 1.
- Hunt, Robert L. 1974. Annual Production of Brook Trout in Lawrence Creek During Eleven Successive Years. Wisconsin Dept. of Nat. Res. Tech. Bull. No 82.
- Jensen, A. L. 1971. Response of Brook Trout (Salvelinus fontinalis) Populations to a Fishery. Journal Fish. Res. BD. Canada, 28:458-460.
- Josephsen, Dan. 1982. An Evaluation of Sympatric Populations of Brown and Brook Trout in Four Virginia Streams. Dingell-Johnson Project F-39-p-4. M. S. Thesis VPI&SU. SHEN-N-082.
- Kekluk, Theressa A. 1980. An Evaluation of Factors Influencing the Establishment of Self-Sustaining Populations of Brown Trout in Virginia Streams. M. S. Thesis VPI&SU. SHEN-N-057.

- Kelly, Alan G. 1977. Changes in Distribution of Trout Within the GSMNP Since 1900. USFWS Special Report.
- King, Willis. 1975. Wild Trout Management: Proceedings of the Wild Trout Management Symposium, Yellowstone NP.
- Lennon, Robert E. 1961. The Trout Fishery, Shenandoah National Park. Special Science Report No. 395. USFWS. 16pp.
- _____. 1967. Brook Trout of GSMNP. Bureau of Sport Fisheries Technical Report 15.
- McFadden, James T. 1960. A Population Study of the Brook Trout, Salvelinus fontinalis. Paper No. 2437. Journal of Pennsylvania Agricultural Experiment Station.
- McFadden, James T. 1967. Numerical Changes and Population Regulation in Brook Trout Salvelinus fontinalis. Dingell-Johnson Project F-27-R, Michigan. Journal of Fish. Res. BD. Canada, 24(7).
- Mohn, Larry and Paul E. Bugas. 1979. Virginia Trout Stream and Environmental Inventory. Dingell-Johnson Project F-32.
- Moore, Stephen, et.al. 1981. Changes in Standing Crop of Brook Trout Concurrent with Removal of Exotic Trout Species, GSMNP. Uplands Field Res. Lab. Research/Resources Mgmt. Report No 37.
- Neves, Richard J., and Garland B. Pardue. 1983. Abundance and Production of Fishes in a Small Appalachian Stream. Transcript of American Fisheries Society, 112:21-26.
- Pardue, Garland B., and Gerard A. Gray. 1979. Spacial Interaction Between Wild Brook Trout, Mottled Sculpin, Blacknose and Rosysided Dace. Fifth Annual Scientific Research Meeting, Gatlinburg, Tennessee.
- Pardue, Garland B., and Arthur C. LaRoche. 1979. Impacts of Hatchery Trout on Native Brook Trout Populations. Virginia Dingell-Johnson Project F-38-R-1.
- Phinney, Duane E. 1974. Repopulation of an Eradicated Stream Section by Brook Trout. Transcript of American Fisheries Society, No. 4.
- Schofield, Carl L., Jr. 1961. Water Quality in Relation to Survival of Brook Trout, Salvelinus fontinalis. Department of Conservation, Cornell University, Uthica, New York.
- Waters, Thomas F. 1983. Replacement of Brook Trout by Brown Trout Over 15 Years in a Minnesota Stream: Production and Abundance. Transactions of the Amer. Fish. Soc., Vol. 112, 2A.

Wydosky, Richard S. and Edwin L. Cooper. 1966. Maturation and
Fecundity of Brook Trout from Infertile Streams. Fish. Res.
BD. Canada, 23(5).