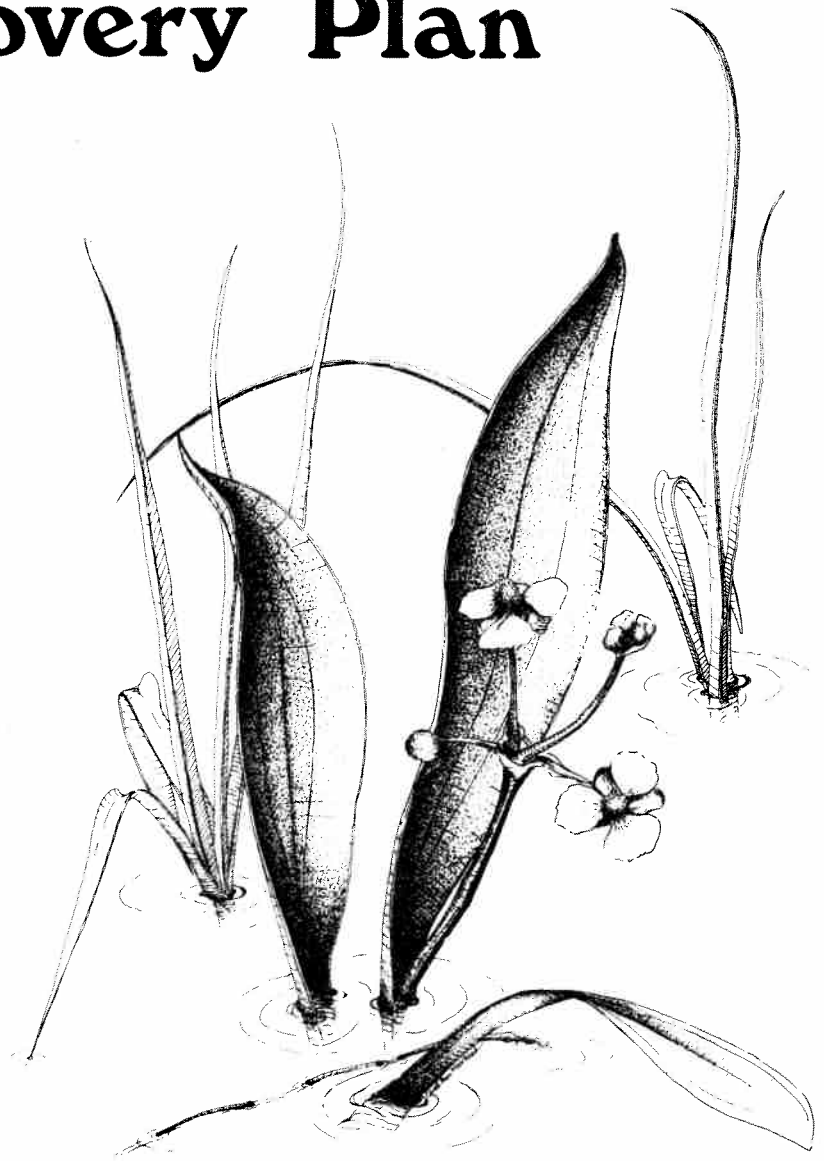


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# **Bunched Arrowhead Recovery Plan**





RECOVERY PLAN FOR THE BUNCHED ARROWHEAD

(Sagittaria fasciculata)

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For

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Atlanta, Georgia

Approved:

  
Regional Director, Southeast Region

Date:

September 8, 1983



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THIS IS THE COMPLETED BUNCHED ARROWHEAD RECOVERY PLAN. IT HAS BEEN APPROVED BY THE U.S. FISH AND WILDLIFE SERVICE. IT DOES NOT NECESSARILY REPRESENT OFFICIAL POSITIONS OR APPROVALS OF COOPERATING AGENCIES, AND IT DOES NOT NECESSARILY REPRESENT THE VIEWS OF ALL INDIVIDUALS WHO PLAYED A KEY ROLE IN PREPARING THE PLAN. THIS PLAN IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS AND CHANGES IN SPECIES STATUS AND COMPLETION OF TASKS DESCRIBED IN THE PLAN. GOALS AND OBJECTIVES WILL BE ATTAINED AND FUNDS EXPENDED CONTINGENT UPON APPROPRIATIONS, PRIORITIES, AND OTHER BUDGETARY CONSTRAINTS.

ACKNOWLEDGMENTS SHOULD READ AS FOLLOWS:

U.S. Fish and Wildlife Service. 1983. Bunched Arrowhead Recovery Plan.  
U.S. Fish and Wildlife Service, Atlanta, Georgia. 37 pp.

ADDITIONAL COPIES MAY BE OBTAINED FROM:

U.S. Fish and Wildlife Reference Service  
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Denver, Colorado 80205  
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## PART I. INTRODUCTION

Bunched arrowhead (Sagittaria fasciculata) is a rare plant species, endemic to a limited area in North and South Carolina. Currently there are five extant populations of this species within a 50-mile area between Greenville, South Carolina, and Asheville, North Carolina. Herbarium specimens show that historically an additional seven populations were present in North Carolina.

The rarity of the species and the vulnerability of its habitat led to its proposed listing as a federally endangered species on June 4, 1976 (Federal Register 41:24523 - 24572). On July 25, 1979, Sagittaria fasciculata was listed as endangered (Federal Register 44:43700 - 43701). During the same year the species was proposed as an endangered species of national concern by South Carolina (Rayner, et al., 1979). Bunched arrowhead is officially listed as endangered by North Carolina under the provisions of its Plant Protection and Conservation Act (General Statute 19b 106-202.12 through 202.19, North Carolina Plant Conservation Program, 1981).

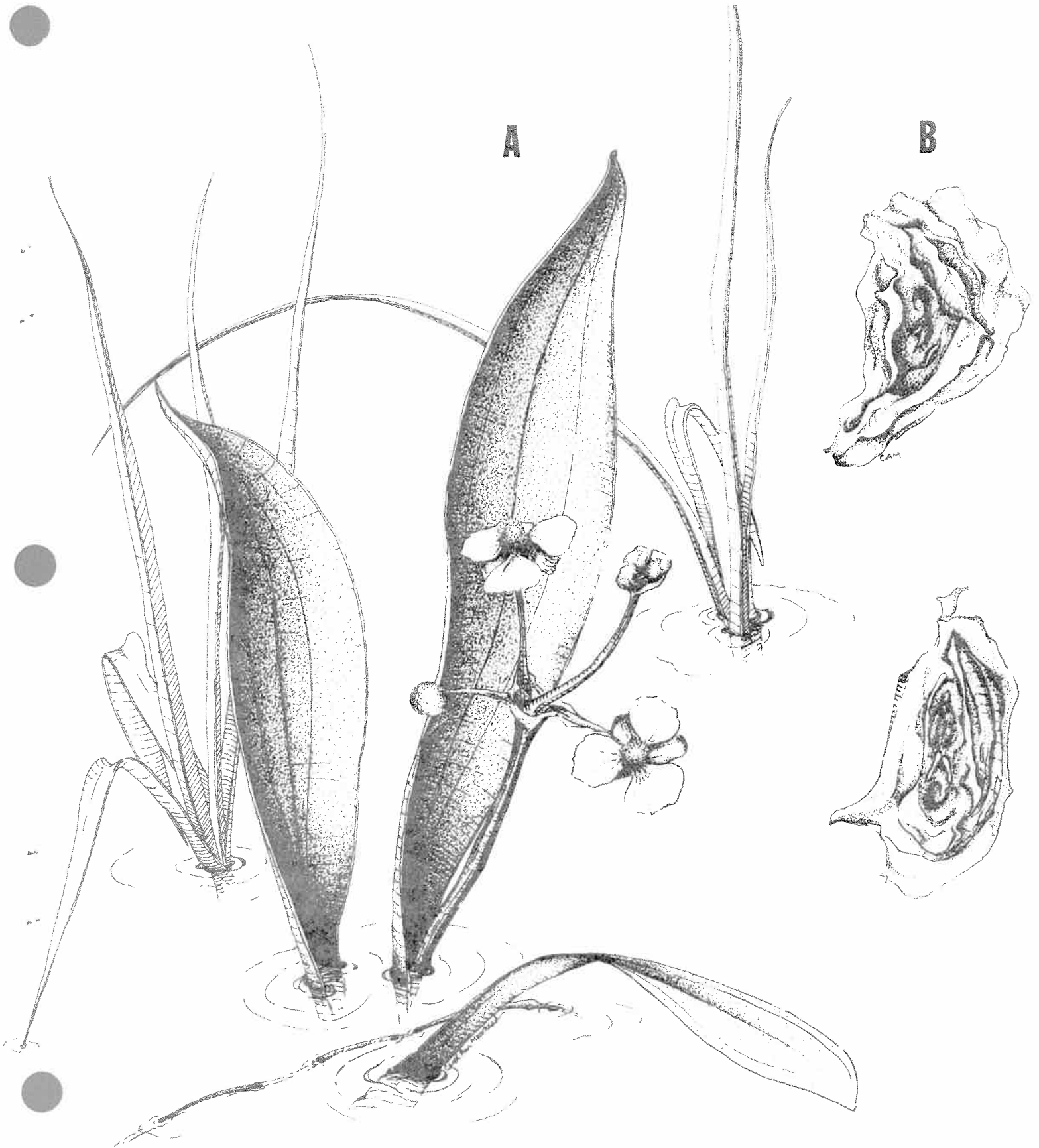
## DESCRIPTION AND TAXONOMIC BACKGROUND

E. O. Beal described Sagittaria fasciculata as a new species in 1960 (Beal, 1960). Previous to his treatment, specimens of S. fasciculata collected in Henderson and Buncombe Counties, North Carolina, were included with S. macrocarpa by J. G. Smith (1894) and by Small (1909), and in S. graminea var. macrocarpa by Bogin (1955). Both of these names were

misapplied, with Smith's S. macrocarpa a direct synonym of S. graminea var. graminea. However, even with the confusion of names most authors recognized the morphologically distinct and geographically isolated plants in southwestern North Carolina.

Sagittaria fasciculata is a small (to 4 dm in height) herbaceous plant growing in saturated to flooded soils (see Figure 1). Undisturbed sites are typically located just below the origin of slow, continuous seeps on gently sloping terrain in deciduous woodlands. Emergent leaves are spatulate in shape and up to 3 dm long and 2 cm wide. Winter rosette and submersed leaves are linear in shape and usually 1 cm wide and .5 to 1 dm long. Bunched arrowhead is monocious, the lower white petaled flowers of the inflorescence are pistillate while the upper flowers are staminate. Flowering begins in mid-May and continues to July. The fruit, an achene, matures a few weeks after flowering. The achenes produced by Sagittaria provide the most reliable means of identifying the species within the genus (Bogin, 1955; Beal, 1960). In addition to the characters listed above, Sagittaria fasciculata can be distinguished by its broadly winged achenes with multiple median resin ducts which are compacted and form a convoluted surface, small stamens and connate bracts. Bunched arrowhead is the only Sagittaria species in the Southern Appalachians with non-sagittate leaves. Wooten (1973) found that S. fasciculata had a mean of 40 percent pollen stainability, compared with over 80 percent in all other species in the S. graminea group, and that S. fasciculata exhibited low crossability with varieties of S. graminea and S. platyphylla. Wooten suggests that S. fasciculata has diverged genetically from other species of the S. graminea group during a period of long geographic isolation.

Drawing of Sagittaria fasciculata A. Plant in Flower B. Seeds



## CURRENT AND HISTORICAL DISTRIBUTION

The known distribution for Sagittaria fasciculata is illustrated in the following map and described in Table 1. There is one known North Carolina population. This Henderson County population is located in a seepage area bordering a railroad track in the French Broad River Valley of the Blue Ridge Mountain Province, south of Hendersonville. The Service recognizes four South Carolina populations located in the upper Piedmont Province in Greenville County: (1) the Enoree River population, (2) the Reedy River population, (3) Beaverdam Creek - Tyger River drainage population, and (4) Beaverdam Creek - Enoree River drainage population. A population, as defined in this plan, is a grouping of colonies related by drainage and by relatively close physical proximity. A colony, as used here, is a population unit confined to and continuous within one seepage site.

The historical North Carolina range of the bunched arrowhead includes only Henderson and Buncombe Counties, North Carolina. All records are from the French Broad River Valley from south of East Flat Rock north to Asheville. There are seven historical localities known other than the single extant population. The single Buncombe County location, from which the type specimen was collected, actually may not have been collected in Buncombe County (Wooten, personal communication). There is a possibility that it was collected from the vicinity of East Flat Rock.

Table 2 lists the existing herbarium specimens from which the historical North Carolina range has been determined.

Map of Historical and Presently Known Populations

Legend

① Approximate Location of Historical Population

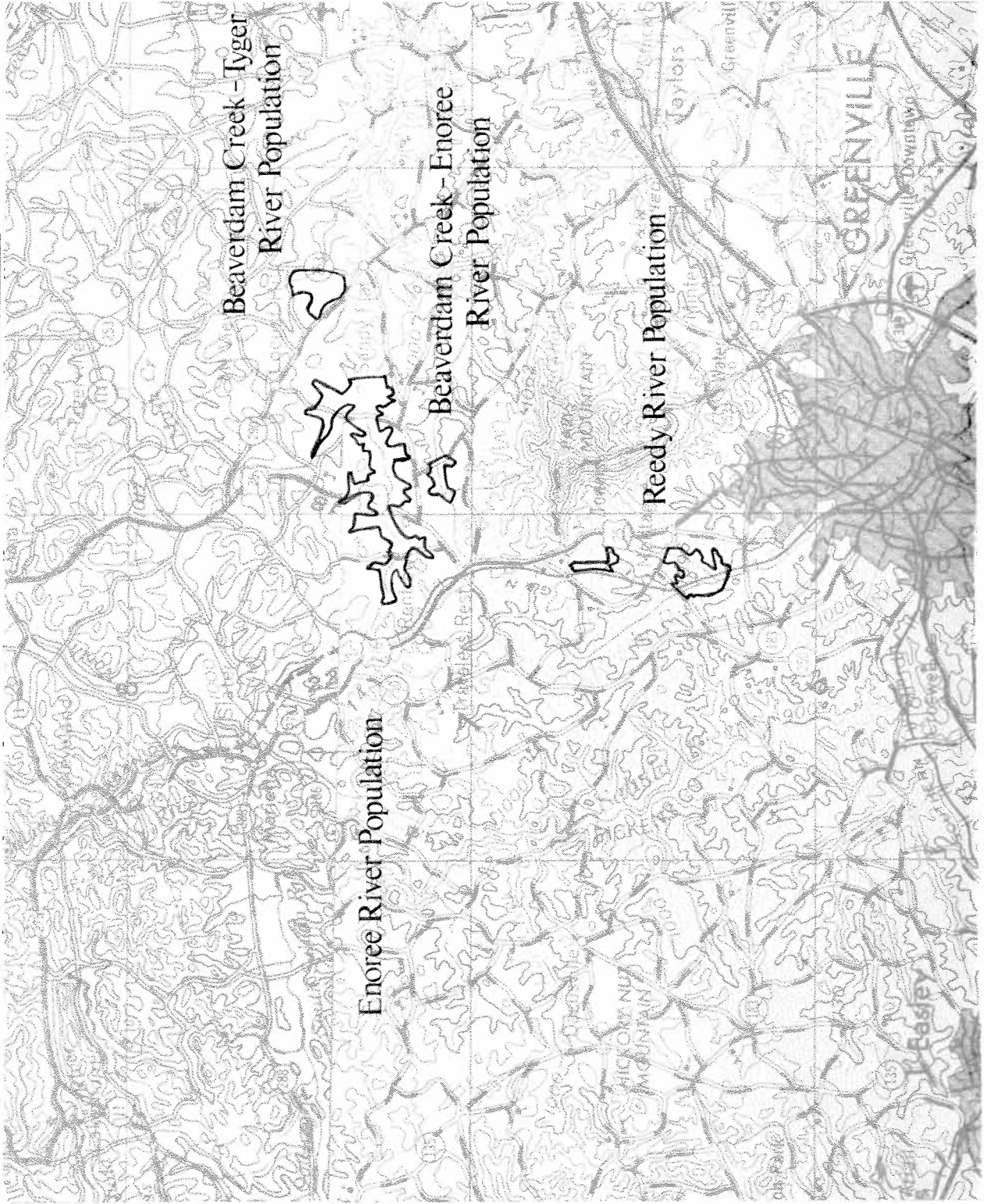




TABLE 1. Description of known extant populations.

<u>Number</u>	<u>Population Name/Location</u>	<u>Colonies</u>	<u>Ownership (Number of Colonies)</u>	<u>Dangers to Integrity</u>
1	East Flat Rock Henderson County, NC	2	Southern Railway Company (1) General Electric Company (1)	Changes in management of railroad right-of-way
2	Enoree River Greenville County, SC	21	Private (16) Duke Power Company (5)	Development of land to pasture or farmland, channelization, hydrological changes
3	Reedy Creek Greenville County, SC	3	Private (2) Furman University (1)	Development of land to pasture or farmland, channelization, hydrological changes
4	Beaverdam Creek - Tyger River Greenville County, SC	1	Private (1)	Development of land to pasture or farmland, channelization, hydrological changes
5	Beaverdam Creek - Enoree River Greenville County, SC	1	Private (1)	Development of land to pasture or farmland, channelization, hydrological changes

TABLE 2. Herbarium Specimens From Which The Historical North Carolina Range Has Been Determined.

1. Buncombe County: Biltmore Herbarium #897. May 26, 1896.  
Sluggish streams, Biltmore.  
(US, MO, NY).
2. Henderson County: H. J. Oosting #3674. June 28, 1936.  
RR N. of Henderson.  
(DUKE).
3. Henderson County: Herb. Edward Reed Memminger. May 1887.  
Flat Rock.  
(NCU).
4. Henderson County: D. Correll and H. L. Blomquist. June 6, 1936.  
In standing water, upland bog.  
(DUKE).
5. Henderson County: O. M. Freeman #57253. May 16, 1957.  
Swamp at East Flat Rock.  
(NCSU, NCU).
6. Henderson County: D. Correll #3359. In water of pasture  
swamp at East Flat Rock.  
(GH).
7. Henderson County: Biltmore Herbarium #897b. Shallow water  
near Hendersonville.  
(GH, MO, NY, US).
8. Henderson County: Mary Caughey #682. Bog East Flat Rock,  
5 mi. S. of Hendersonville.  
(MO).
9. Henderson County: E. T. Wherry. May 30, 1927. Bog 1.5 mi.  
S. of Flat Rock.  
(NY).
10. Henderson County: E. T. Wherry. July 17, 1932. Pool in open  
swamp along railroad 1 mi. S. of Flat Rock  
Station.  
(NY).
11. Henderson County: Blomquist and Cronce #16372. June 1, 1954.  
Wet, boggy ground.  
(DUKE).
12. Henderson County: S. W. Leonard #4897 and #4891. May 30, 1971.  
Infrequent in ditches along railroad and US 25,  
about two miles south of East Flat Rock.  
(NCU).



## HABITAT AND POPULATION LIMITING FACTORS

The primary factor determining the rarity of the bunched arrowhead is the current rarity of its required habitat. Sagittaria fasciculata occupies seepages in gently sloping bogs with a slow, continuous flow of cool, clean water (Rayner, 1981). Wooten (1973) reports that these bogs are underlain by a clay layer. Studies by Douglass (1981) mention that the seepages may be related to a long, linear fault which occurs in the four northwestern South Carolina counties. Additional data (Douglass, 1981) show variable water temperatures, soil and water pHs between 4.8 and 6.6, and constant water depths. Observations of the populations in an extreme drought year by the author verified the constancy of the seeps.

While an early management recommendation was to reduce the percent of shade in populations (Smith, 1978; Federal Register, 1979), the natural habitat of the species appears, in fact, to be shaded sites. Colonies are found in the open, only along a railroad right-of-way and in a transmission line cut. Shaded sites have larger, more vigorous plants.

The seepage habitat in which bunched arrowhead occurs is extremely threatened by the activities of man. The Hendersonville/East Flat Rock area in North Carolina once contained numerous bogs and seepages (Moore, 1982, personal communication) and had been known to contain many rare and widely disjunct plant species. Little remains of these habitats today. Many of the rare species such as Bog asphodel (Narthecium americanum), Sweet gale (Gale palustris), Linear pipewort (Eriocaulon lineare) and many species of orchids have been extirpated from the region. Many other species, native to

this area, are considered endangered in North Carolina, including Mountain sweet pitcher plant (Sarracenia jonesii) and Swamp pink (Helonias bullata). The expanding human population of Henderson and Buncombe Counties threatens the remaining bogs. Development of lands for pasture and residential homes threatens the South Carolina populations. Parts of three colonies in one population were destroyed last year in South Carolina by the filling of seepage areas for pasture.

#### CONSERVATION EFFORTS

The rarity and endangered status of the bunched arrowhead has attracted significant efforts to protect the species.

The South Carolina Heritage Trust Program has obtained registry agreements with landowners, protecting a number of colonies of the species. One registry is with Furman University, protecting a colony in the Reedy River drainage. The registry with one landowner in the Enoree River drainage was invalidated by the landowner's death. The new landowner has not registered any colonies but did work with the Heritage Trust Program to avoid destroying all of the bunched arrowhead during the clearing of a substantial section of his property. This demonstrates that registry is not permanent protection for a species and its habitat (Hoose, 1981), but it is an important step toward permanent protection. The South Carolina Heritage Trust Program has begun to implement a plan to acquire the best contiguous colonies in the Enoree River population and the Beaverdam Creek - Tyger River population.

The South Carolina Heritage Trust Program has also actively and cooperatively managed colonies of bunched arrowhead on a Duke Power transmission line. The management of three colonies (South Carolina Heritage Trust Program, 1979) includes allowing succession to proceed on some sites and permitting the usual transmission line maintenance on others. Permanent plots have been established in each area and have been monitored for three years. This management has provided important information on the effect of habitat changes on the species and what constitutes prime bunched arrowhead habitat.

The North Carolina population of Sagittaria fasciculata occurs on a railroad right-of-way owned by the Southern Railway Company and along an adjacent spur line owned by the General Electric Company. Previous management recommendations had been made for these sites (Smith, 1978). In 1981 The Nature Conservancy and the Southern Railway Company signed a Cooperative Management Agreement in an effort to protect the species in North Carolina. A management team was established consisting of representatives of the Southern Railway Company, the North Carolina Nature Conservancy, the U.S. Fish and Wildlife Service, the North Carolina Natural Heritage Program, the North Carolina Plant Conservation Program and a local botanical group. The agreement allows the management team to maintain the right-of-way containing the population and to protect and enhance the Sagittaria fasciculata population while maintaining the safety of Southern Railway's track. In 1982 the General Electric Company and The Nature Conservancy entered into a similar management agreement and a representative from General Electric has joined the management team.

The management team has been active in protecting the North Carolina site. As an example, the management team had an opportunity to review a proposal by a concrete company to construct a concrete block plant near the Sagittaria population. Southern Railway worked closely with the management team in designing a spur line to the proposed plant. The concrete plant itself will be located on land which currently drains away from the bunched arrowhead population. However, a cooperative effort in locating the spur line has ensured that the construction will not adversely affect the population.

The management team has also initiated some research and maintenance activities. A shading study was established in March 1982, with shading material placed over mapped 1 m quadrats along the railroad track. However, this study had been terminated due to vandalism of the shade structures. Permanent plots have been established at the site. The team also began maintaining the site, removing vegetation from the site and railroad tracks.

Other efforts to protect the species have been taken place over the last five years. In the fall of 1981 and the spring of 1982, the Plant Conservation Program transplanted 50 propagated bunched arrowhead plants to the Biltmore Estate in Asheville. There is currently a vigorous transplanted population at the North Carolina Botanical Gardens in Chapel Hill, North Carolina. This population was the source for the 1981-1982 transplants to the Biltmore Estate. A few plants transplanted to Western Piedmont Community College, Morganton, North Carolina, were eaten by ducks and it is unknown whether any individual plants survived. A population was established on Reems Creek in Buncombe County, North Carolina by Fred Huber.

In 1979 Mr. Huber transplanted approximately seven individuals from the East Flat Rock population to Reems Creek. In 1982 the Reems Creek population had expanded to between 30 and 40 individuals.

While many efforts have been made to protect Sagittaria fasciculata from decline and extinction, a cooperative, comprehensive recovery plan and effort are needed.



## PART II. RECOVERY

### A. Recovery Objectives

The primary objective of the bunched arrowhead recovery plan is to permanently protect sufficient colonies to ensure the continued survival of the species. The few known populations, the few colonies, the species' restricted distribution, and its occurrence in a vulnerable habitat demand that our efforts be directed toward protecting the species from extinction. At least three colonies in each of four of the five populations should be protected. If there are less than three colonies in a population, then all known colonies should be protected. The fifth population (the Enoree River population) is currently considered to be the center of distribution of the bunched arrowhead and contains at least seven times more colonies than occur in all other populations combined (Rayner, 1983). In light of the significance of this population, a minimum of eight colonies should be protected to ensure that the integrity and genetic diversity exhibited in the Enoree River population is maintained. These criteria result in the protection of at least one colony from each extant populations. Under these guidelines the following colonies should be protected: the two North Carolina colonies in the East Flat Rock population, the single colony in the Beaverdam Creek - Enoree River population, the single colony in the Beaverdam Creek - Tyger River population, all three colonies in the Reedy River population, and eight colonies in the Enoree River population. Protection of these sites would result in 15 colonies permanently protected and would

accomplish the goal of protecting the species from extinction. This could warrant a change in the species' status from endangered to threatened. The protection of these colonies above and an additional 11 colonies (or 93 percent of the known colonies) would be sufficient to consider delisting the species.

The goal of these guidelines is to protect the greatest amount of genetic diversity in bunched arrowhead. This can be accomplished by protecting colonies in different physiographic regions (the Blue Ridge of North Carolina and the upper Piedmont of South Carolina) and in the different drainages. Within each of the populations, sufficient colonies must be protected and located near enough to one another to ensure that there is normal gene flow between the colonies.

An equally important objective, necessary for the full protection of the species, is to conduct population and ecological research for the purpose of developing a management plan for the species. Management is necessary for the survival of the species by maintaining the habitat in optimum natural conditions and the species at optimum natural numbers and vigor. The effect of humans on natural ecosystems has resulted in the disturbance of groundwater and habitats, and the introduction of competitive weeds. These disturbances need to be recognized and the colonies managed to maintain their vigor and protect them from threats to their survival.

The Recovery Plan should be updated annually to consider the results of population searches, research studies and protection activities. With



new data the Service should reconsider the recovery objectives concerning downlisting, delisting, protection objectives, and study goals on a periodic basis.

B. Step-down Outline

1. Protect existing populations and essential habitat.

11. Survey to determine population/colony priority and landownership patterns.

111. Estimate current colony and population size and vigor.

112. Determine population/colony priority.

113. Determine landownership patterns.

12. Obtain the most appropriate and highest protection for each population or colony.

121. Protect by fee acquisition, conservation easement, or dedication.

122. Protect by registry, leases, or management agreements.

13. Manage the populations to ensure survival of the plants.

131. Retain shaded nature of site.

132. Protect seepage source.

133. Remove aggressive competitive plants.

134. Reevaluate management activities as data on management is obtained.
2. Conduct population and ecological studies.
    21. Conduct studies on the abiotic factors of the species' habitat.
      211. Study hydrology.
      212. Analyze soil.
    22. Conduct studies on the biotic factors of the species' habitat.
      221. Study effect of shading.
      222. Study effect of competing species.
    23. Conduct demographic studies.
      231. Establishment of permanent plots.
      232. Map individual plants.
      233. Record data on size, growth, phenology, flower number, seed set, and establishment.
      234. Study reproductive biology of the species.
    24. Search for additional populations.

241. Analyze soil and topographic maps for potential habitat.
  242. Develop a priority list for sites to search.
  243. Conduct ground searches.
25. Utilizing the data obtained in this section, determine the species' essential habitat.
26. Support further studies of the species.
3. Conduct transplant and propagation studies.
    31. Transplant studies.
      311. Identify sites to which the species could be transplanted.
      312. Obtain consent and protection of landowners.
      313. Transplant the species.
    32. Propagation studies.
      321. Determine what facilities could adequately propagate the species.
      322. Assist the facilities in propagation.
      323. Deposit seeds from each colony in the Macon Seed Bank.
4. Monitor colonies, populations, permanent plots, transplanted colonies, and propagation facilities at regular intervals.

41. Develop censusing techniques and monitoring schedule.  
 42. Monitor at least twice yearly, production objectives, and study goals.  
 43. Appoint local individuals to regularly monitor the sites.

5. Enforce laws and regulations protecting the species and its essential habitat.

6. Inform public of species' status and recovery plan objectives.

61. Prepare and distribute brochures on recovery plan objectives.  
 62. Provide information for press release.  
 63. Prepare articles for popular and scientific publications.

C. Narrative

The primary objective of the bunched arrowhead recovery plan is to permanently protect sufficient colonies to ensure the continued survival of the species. The few known populations, the few colonies, the species' restricted distribution, and its occurrence in vulnerable habitat demand that our efforts be directed toward protecting the species from extinction. At least three colonies in each of four of the five populations should be protected. If three colonies do not exist in a population, then all known colonies should be protected. This criterion results in the protection of at least one colony from each extant population. Under these guidelines the following colonies should be protected: The two North Carolina colonies in the East Flat Rock population, the single colony in the Beaverdam Creek - Enoree

River population, the single colony in the Beaverdam Creek - Tyger River population, all three colonies in the Reedy River population, and eight colonies in the Enoree River population. Protection of these sites would result in 5 colonies permanently protected and would accomplish the goal of protecting the species from extinction. This could warrant a change in the species' status from endangered to threatened. The protection of the colonies listed above and an additional 11 colonies (or 93 percent of the known colonies) would be sufficient to consider delisting the species.

An equally important objective, necessary for the full protection of the species, is to conduct population and ecological research for the purpose of determining a management plan to ensure the survival of the species. Information gained from the research and management studies will be used to maintain these populations in optimum conditions, at optimum numbers, and protected from threats to their survival.

1. Protect Existing Populations and Essential Habitat

This is the first priority of the recovery plan. Currently, these are five populations (as defined by this plan) containing 28 colonies of the species. Three colonies in two populations are covered by nonbinding protection agreements. All populations are on privately owned land.

Efforts should be toward obtaining the most appropriate and the highest degree of protection possible for each population or

colony (12). The experience of the South Carolina Heritage Trust Program with the nonbinding registry agreement illustrates the need for strong permanent protection. Fee acquisition, conservation easements, and dedication (121) are the strongest tools that can be used and should be utilized when appropriate and feasible.

Registration, leases, or management agreements (122) may be used in cases where the stronger protection concepts are not agreeable to the landowners or where adequate funding is not available. These concepts give moderate protection during the current year, but no guarantee of permanent protection. Frequently, however, they may be the only means immediately available for protecting the species.

Guidance on this subject can be found in a book by Hoose (1981), and in the experiences of the North Carolina Heritage Program and the Illinois Landowner Contact Program.

It is difficult to determine a priori which colonies have the highest value for protection. A survey of the colonies and determination of their priority is needed first in the plan along with determining landownership patterns (112, 113). As a start, however, based upon currently available information, the Service makes the following tentative unprioritized suggestions:

- a. The single known North Carolina population at East Flat Rock is located on a railroad right-of-way owned by Southern Railway Company and along a spur line owned by the General Electric Company. This population is extremely important to protect; being the nearest population to the type locality, and the only one in North Carolina. The current management agreement with Southern Railway and General Electric is the highest possible and most appropriate protection measure that can be taken.
  
- b. The Enoree River population includes the best developed and largest colonies of bunched arrowhead. Twenty-one colonies exist along a ten-mile stretch of the river, in seepages along the edge of the floodplain. At least eight of the most vigorous colonies should be protected. They should be located near enough to one another to ensure that normal gene flow is maintained between the colonies.
  
- c. The population along Reedy Creek, north of Greenville, South Carolina, consists of three colonies, one of which is currently protected by a registry agreement between Furman University and the South Carolina Heritage Trust Program. All three colonies should be protected. The Furman University site, with its registry agreement, may be adequately protected.

- d. It is important to permanently protect the single colony of the species in each of the two remaining drainages (Beaverdam Creek - Tyger River and Beaverdam Creek - Enoree River populations).

An assumption is made in this discussion that protection of a species includes the protection of its essential habitat. While acquisition, management agreements, and registry may occur before a biologically determined essential habitat is known, an estimate of what habitat is necessary for the species' survival will have to be made based on available information.

Once colonies are protected by one of the discussed techniques, the colonies need to be managed to ensure the survival of the species (13). Management activities will be necessary to mitigate human activities (dumping trash, right-of-way maintenance, future actions affecting the seep or the quality of water in the seep), and, in the case of severely altered populations, the natural processes of succession and competition from other plants. Without specific counter measures, some of these activities could severely threaten or extirpate colonies. In undisturbed populations the management decision may be to leave the site unmanaged. While specific data on management activities will not be available until research is completed (134), several actions can be initiated based on previous experience. These include retaining the existing tree canopy shade conditions at a site (131), protecting the seepage source (132), and removing



aggressive competitive plants (e.g., Salix sp., Rosa sp., rushes, and other woody herbaceous plants) in the North Carolina population because the site has been so altered that the population cannot naturally maintain itself.

## 2. Conduct Population and Ecological Studies

A solid basis of data on the population biology and the ecology of bunched arrowhead is necessary before making final management recommendations. Radford (1981) states "An environmental or habitat analysis of a site(s) is necessary for: The determination of component elements of maintenance, reproduction, and dispersion for the species; and the effective and efficient management of the species." Massey, in the same publication, discusses the Species Population, Habitat, and Threat Inventory which "may contribute to an identification and evaluation of threats to both population and habitat integrity, provide management and protection implications for a species and its habitat, and specific basic research problems." While some of these data are available (Douglass, 1981; Rayner, 1981; Wooten, 1973), a greater breadth and depth of analysis is needed. The information can be effectively obtained through studies on extant populations.

Studies on abiotic factors of the species' habitat should be conducted (21). The primary abiotic factor determining the distribution and occurrence of bunched arrowhead is the hydrology of its habitat. Observations have shown that bunched arrowhead

occurs in areas with a slow, continuous seepage of cool, clean water (Rayner, 1981). Douglass (1981) found a nearly constant water depth over the course of a year.

A seep, as defined by Health (1968), is an environment where groundwater discharge occurs in a diffuse manner either into a surface body of water or into soil from which it is removed by evapotranspiration. It is a very fragile habitat, connected with and dependent upon the surrounding lands for its source of water.

To adequately protect this species and the seeps in which it occurs, it is recommended that the hydrology of the seeps be determined. Surface factors such as water depth and water quality need to be monitored. Aspects of the local groundwater regime including the amount of water, the pattern of groundwater flow, the size of the recharge area, the rate of discharge, the chemical composition of groundwater, and the temperature of the groundwater need to be studied.

An analysis of the soils (211) in which bunched arrowhead is found can provide data necessary for population maintenance and establishment, identification of potential sites for transplanted populations, and identification of areas where undiscovered populations might occur. Soils analyses should include all the elements which characterize a soil series: particle size, texture, mineralogy, organic matter, structure, soil depth, pH, etc.

Studies should also be conducted on the biotic factors of the species' habitat. Investigations into the effect of other plant species (222), and the effect of different light intensities (221) on bunched arrowhead would provide information on those habitat manipulations necessary for protecting the species. Light intensity, while being an abiotic factor, appears to most directly affect bunched arrowhead populations through the increased growth of competitive species. For this reason it is included under biotic factors. The relationships between competing species, their densities, and the density and vigor of bunched arrowhead; competing species and light levels; and the hydrology to light levels need to be determined. Additional data should be collected on associated species in all colonies, including their cover and dominance.

Studies are also needed on the demography of bunched arrowhead (23). Demographic data (231) is best obtained through the establishment and subsequent study of permanent plots. Permanent plots should be established in a large number of colonies representing the total range of the species' characteristics (density and size) and habitat qualities (light level, water characteristics, watersheds). Individual plants should be mapped (232) and data on size, growth, phenology, flower number, seed set and establishment (233) recorded. Mapping can be done by photographic methods or drawings. Accurate mapping will permit documentation of seedling establishment. Data should be gathered on the reproductive biology of the species (234) to determine the

optimal numbers and spacing of colonies needed to ensure survival of the species.

The data obtained from the hydrologic and soil analyses may, through use of soil surveys and topographic maps, permit the location of additional populations of bunched arrowhead (24). Analyses of soil and topographic maps (242) will be the basis for thorough ground search (243). All searches must be conducted in a systematic fashion and thoroughly documented.

The data obtained from research will form the basis for the determination of the species' essential habitat (25). The essential habitat will be used in decisions regarding protection and management of each colony.

While a recovery plan directs its attention to the immediate research needs for the survival of a species, further scientific research should be supported and assisted (26). Several research problems may be revealed through the outlined studies.

Researchers may propose additional studies that should be done. The more detailed data obtained, the better the protection afforded the species.

### 3. Conduct Transplant and Propagation Studies

Transplanting bunched arrowhead (31) to areas within the species' known historical North Carolina range, if successful, provides

increased security for the species. These activities go beyond the recovery objectives outlined previously. Areas should be identified (311) by using the data obtained in 211, 212, and the analysis in 24. The owners of the sites must fully understand the implications of an endangered species population on their property and must consent to giving the population some form of protection (312). Plants then may be transplanted (313) to these sites. The preferred plants used for such transplants should be propagated, but not from a single parent or genetic type. Propagated plants should be used so that collection of plants from natural populations is minimized. The population source of all propagated material must be known. Transplanted populations should only contain plants from a single population of bunched arrowhead so that the crossing of individuals from different populations does not take place. For transplanted populations in North Carolina, only plants from the North Carolina population should be used. Transplanted populations should be monitored regularly.

Facilities which could adequately propagate the species should be determined (321). Assistance should be given by providing research data, stock material, and funding (322). Lastly, seeds should be regularly collected and deposited in the Macon Seed Bank (323).

4. Monitor Colonies, Populations, Permanent Plots, Transplanted Colonies, and Propagation Facilities at Regular Intervals

The status of existing colonies should be monitored at least twice yearly (42), in March to census population size and in May/June to observe flowering and seed set. Censusing techniques must be developed (41) and standardized such that subtle changes in population size and maintenance can be observed quantitatively. Potential disturbance to the essential habitat by monitoring activities should be a major consideration in developing any censusing technique. Data obtained through monitoring will be used to determine the species' status, population threats, and the success of management activities. Using the permanent plots established in 2, the population can be monitored with greater accuracy while obtaining continuous data on demography.

A local individual, knowledgeable and interested in the conservation of plant species, should be appointed to monitor the populations regularly throughout the year. That individual could discover threats which would be otherwise unknown. A local monitor would need to be appointed for the North Carolina site and one or more for the South Carolina sites.

5. Enforce Laws and Regulations Protecting the Species and Its Essential Habitat

A recovery plan should include assisting and cooperating with authorities to enforce state and Federal regulations that protect the species and its essential habitat. The Endangered Species Act, the Lacey Act, and North Carolina's Plant Protection and

Conservation Act are the major statutes directly affecting the species. These statutes forbid any movement or trade in wild collected plants of the species. Ownership of land for the conservation of the species adds further protective regulations including trespass laws. State and Federal authorities should be made aware of these regulations so that effective enforcement will be possible. Individuals working with the recovery plan should assist and cooperate with these authorities (52).

#### 6. Inform Public of Species' Status and Recovery Plan Objectives

Any recovery effort should include an active and positive education program to inform the public including brochures (61), news releases (62), and articles (63). These should stress the value and historical significance of bunched arrowhead as a representative of a unique habitat. The cooperation among Southern Railway, General Electric, Duke Power, U.S. Fish and Wildlife Service, state agencies, and The Nature Conservancy should also be publicized. Efforts to inform the public of the recovery plan also affect the perspective of the individuals involved in the project, by stressing that the purpose of such a recovery plan is for the benefit of all citizens--not only researchers and conservationists. Publicity, though, should be judiciously enacted. The exact location of the populations should not be made public.

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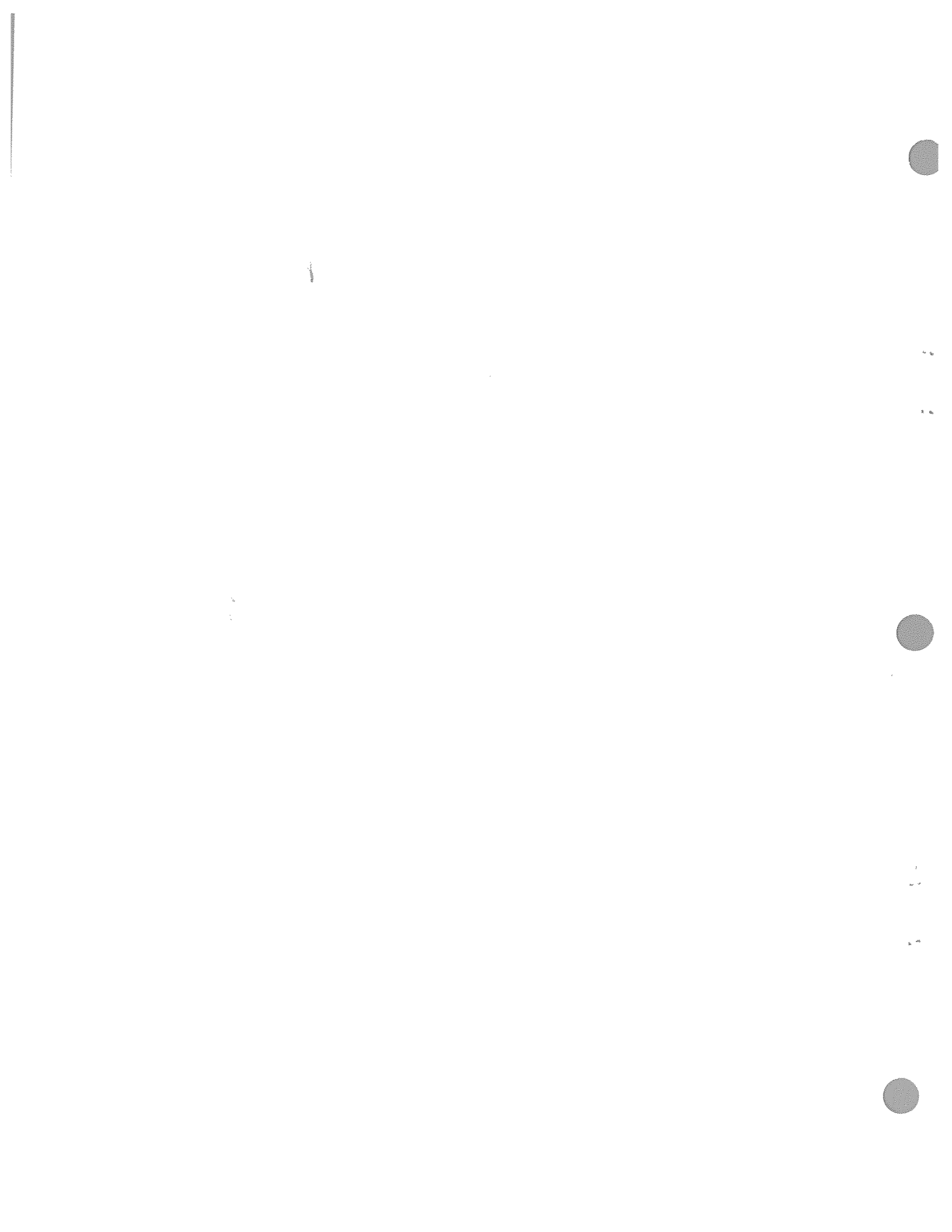
PART III.  
IMPLEMENTATION SCHEDULE

Priorities within this section (Column 4) have been assigned according to the following:

Priority 1 - Those actions absolutely necessary to prevent extinction of the species.

Priority 2 - Those actions necessary to maintain the species' current population status.

Priority 3 - All other actions necessary to provide for full recovery of the species.



Implementation Schedule \*2

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency		Estimated Fiscal Year Costs			Comments/Notes	
					FWS Region	*1 Other	FY 1	FY 2	FY 3		
I1	Estimate current colony and population size and vigor	111.	2	1 year	4	SE	South Carolina WMRD	1,500	--	--	*1. Other agencies' responsibilities would be of a cooperative nature or projects funded under a FWS contract or grant program. In some cases contracts may be let to universities or private enterprises.
I14	Determine population/colony priority	112.	2	1 year	4	SE	Same as above and North Carolina DOA, The Nature Conservancy, and North Carolina Sagittaria Management Team	500	--	--	*2 NOTE: ALL COST ESTIMATES ARE FOR FWS FUNDS ONLY.
A7	Determine land ownership patterns	113.	2	1 year	4	SE	South Carolina WMRD	1,500	--	--	
A1-A7	Obtain the most appropriate and highest protection for each population or colony	12.	1	Unknown	4	SE	South Carolina WMRD, North Carolina DOA, The Nature Conservancy, and North Carolina Sagittaria Management Team	---	Unknown---	---	



Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency		Estimated Fiscal Year Costs			Comments/Notes
					FMS Region	Program	FY 1	FY 2	FY 3	
M3, M4	Manage the population to ensure survival of plants	13.	2	Continuous	4	SE	Same as above	--	Unknown--	
R3, R4, R10	Study abiotic and biotic factors of species habitat	21. and 22.	1	3 years	4	SE	Same as above	3,500	3,500	3,500
R6	Conduct demographic studies	23.	2	3 years	4	SE	Same as above	3,000	--	--
I14	Search for additional populations	24.	2	1 year	4	SE	South Carolina WMRD and North Carolina DOA	3,000	--	--
R3	Utilize data collected in 2.1-2.4 and determine species' essential habitat	25.	3	1 year	4	SE	South Carolina WMRD, North Carolina DOA, The Nature Conservancy, and North Carolina Sagittaria Management Team	--	--	1,000
M1, M2	Conduct transplant and propagation studies and transplant where required to meet recovery	3.	3	3 years	4	SE	Same as above	1,000	1,000	1,000



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Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency		Estimated Fiscal Year Costs			Comments/Notes
					FMS Region	Program	Other	FY 1	FY 2	
I1	Monitor colonies, populations, permanent plots, transplants and propagation facilities	4.	3	Continuous	4	SE	Same as above	--	2,000	2,000
02-04	Enforce laws and regulations protecting species and habitat	5.	1	Continuous	4	SE ES LE	Same as above	1,000	1,000	1,000
01	Public education	6.	3	Continuous	4	SE PAO	Same as above	3,000	1,000	1,000



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## GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES\*

## Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

## Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

## Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

## Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

\*(Column 1) - Primarily for use by the U.S. Fish and Wildlife Service.



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## APPENDIX

## List of Reviewers

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